GOULBURN
CITY COUNCIL

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

Volume I

Floodplain Risk Management Study Executive Summary and Report

March
2003



SMEC

GOULBURN CITY COUNCIL

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

VOLUME ONE FLOODPLAIN RISK MANAGEMENT STUDY EXECUTIVE SUMMARY AND REPORT

March 2003

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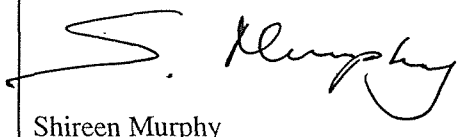	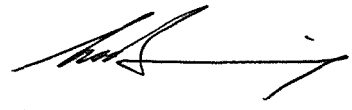
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EXECUTIVE SUMMARY

Introduction

Flooding is a relatively infrequent occurrence in the Goulburn LGA and the impacts of flooding, when it occurs, are significant to the community. The earliest recorded flood was in 1870, and a number of other significant events were recorded in 1900, 1925, 1942, 1950 1952, 1959, 1961, 1974 and 1990. The 1961 event is reported to be the highest flood in recorded history on the Wollondilly River at Goulburn. Between May 1962 and June 1977 a stream gauging station was located on the Wollondilly River at Marsden Weir, allowing detailed information on flooding during this period. **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 the impact of flooding from the Wollondilly River and Mulwaree Ponds on the Goulburn community, the Goulburn City Council has recognised the need to develop an integrated Floodplain Risk Management Plan to manage flood hazard in the community.

Following engagement by Council in 2001, SMEC Australia undertook a detailed Floodplain Risk Management Study and the preparation of a draft Floodplain Risk Management Plan, under the direction of the Floodplain Working Group (FWG), which includes members of the community. The Study and Plan have been prepared in accordance with the principles and guidelines in the NSW Flood Prone Land Policy and its attendant Manual.

Methodology

The Study process followed five basic stages consisting of:

Stage One: INCEPTION

- Meetings with Council, FWG and other Agencies
- Initial Community Consultation
- Data Collection and Review

Stage Two: PRELIMINARY MANAGEMENT OPTIONS

- Flood Definition and Mapping
- Flood Damage Assessment
- Assessment of Land Use Zoning
- Assessment of Social and Environmental Issues
- Preliminary Identification of Floodplain Management Options

Stage Three: ASSESSMENT OF OPTIONS

- Further community consultation
- Modelling/Assessment of Selected Management Options
- Assessment and Recommendation of Flood Planing Levels and Management Options
- Draft clauses for LEP, DCP
- Preparation of Draft Floodplain Risk Management Study Report
- Preparation of Draft Floodplain Risk Management Plan

The completion of this draft Study and Management Plan marks the completion of Stage Three of the Process. The final Stages involve:

- Stage 4 - Public Display and Comments;
- Stage 5 - Assessment of Comments and Finalisation of Report and Plan.

The Study Area

The City of Goulburn is located in the southern tablelands of NSW, 220 km south-west of Sydney, at the confluence of the Wollondilly River and Mulwaree Ponds. The City Council covers an area of 43 km^2 and has a population of 20884 (2001 census). The surrounding districts boost the catchment population by a further 15,000 people. The City supports a strong rural community as well a wide-ranging commercial and industrial sector.

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. It rises in the Great Dividing Range just south of Tarago and flows northwards to Goulburn. Its 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 1.2** and the City of Goulburn in **Figure 1.3** of this report.

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 Chain of Ponds floodplain but not vice versa.

Social and Ecological Issues

Demographic Characteristics

In determining the most suitable floodplain management options it is important to have an understanding of certain characteristics of the population. This enables a merit assessment of each option, based on its suitability for a particular population. The assessment of these characteristics is expanded in the Demographic Assessment in Section Two. Briefly, the principal characteristics are:

- Goulburn's population has generally been declining, with a 2.6% decrease since the 1991 census;
- Goulburn's population is relatively young, with 28% of the population between the ages of 25 and 44 years, and 64% of the population below 44 years of age. However, there is an aging trend evident in the population data;
- The cultural background of Goulburn LGA is predominantly Anglo-Saxon, with the two most common ancestries identified in the 2001 census being Australian and English. 6.6% of the population were born overseas.
- English was stated as the only language spoken at home by 89% of the population in 2001.
- Goulburn's indigenous population was 1.9% of the total population in 2001; and

- Of the 7444 private dwellings in Goulburn 63% are either being purchased or fully owned and 30% are rented. Of these, 83% were separate houses, 6.7% were semi-detached, terrace or townhouses and 7.5% were apartments.

Biological and Physical Environment

It is equally important to examine aspects of the biological and physical environment, to determine whether the range of floodplain management options can or cannot be supported by the surrounding terrestrial and aquatic environments. Options for floodplain management must protect or enhance, rather than threaten such environments. These factors are further expanded in the Physical and Environmental Assessment in Section Two. Briefly, the physical and biological environment in Goulburn exhibits the following characteristics:

- Transport access to Goulburn is by road, rail and air;
- Goulburn has a mean elevation of 648 m above sea level. The general alignment of the city is topographically influenced by moderate to steeply sloping ridges, interspaced by the broad Mulwaree Ponds floodplain, and cut by the east-west channel of the Wollondilly River;
- Goulburn is situated on Upper Silurian and Lower Devonian sediments and metamorphosed sediments comprising sandstone, siltstone, shale, breccia, slate and claystone;
- Four principal soil landscapes, as defined by the NSW Soil Conservation Service, occur in the Goulburn LGA - Blakney Creek, Collector Creek, Midgee and Monastry Hill;
- Goulburn experiences a cool temperate climate, with annual mean maximum and minimum temperature of 20.1^{0}C and 7.3^{0}C respectively and an average annual rainfall of 665.7mm;
- Monitoring of water quality along the Wollondilly River and Mulwaree Ponds indicates that water quality ranges from poor to satisfactory, with samples often not satisfying the ANZECC Guidelines for Water Quality Criteria. Pollution in the Mulwaree Ponds is substantially more severe;
- The Goulburn LGA is a highly modified landscape that has been subject to extensive clearing and exotic weed invasion;
- Three vegetation communities are found within the Goulburn LGA - Low Open Forest, Open Woodland and Open Grassland. The NPWS Wildlife Atlas indicated there are no threatened flora species. Thirty-two noxious weed species have been identified as either occurring within the LGA or its vicinity;
- The Goulburn district supports at least 22 native mammals and 179 bird species. Three fauna habitat types are present in the study area - Forests/woodland, Grassland and agricultural landscapes, and Riparian vegetation. NPWS Wildlife Atlas indicated there are no threatened fauna species;
- Riparian vegetation within the Goulburn LGA provides an important habitat for aquatic fauna;
- The flow of water within the Wollondilly River and the Mulwaree Ponds is moderately impeded by siltation and aquatic vegetation;
- One threatened fish species, Macquarie Perch *(Macquaria australasica),* has previously been recorded in the Wollondilly River;

- Wollondilly River and the Mulwaree Ponds, and their associated riparian vegetation provides a picturesque natural setting and is considered to have a high level of visual quality;
- Urban development of Goulburn consists of residential and commercial buildings, and industrial and transport facilities. Many aspects are of heritage value; and
- The LGA contains areas of agricultural production, where the productive soils of the floodplain are used for livestock grazing and cropping purposes.

Human Environment

The human environment of Goulburn LGA must also be considered in a determination of appropriate flood management options. Aspects of built, natural and cultural heritage are important to this consideration, for the preservation of valued landscapes and significant sites. Consideration of Goulburn LGA's human environment must therefore entailed:

- conservation of European heritage items and their curtilage;
- protection of the rural urban interface; and
- extensive consultation with the Local Aboriginal Land Council, prior to any works being undertaken.

Existing Planning Controls

A review of the current planning and development controls for floodplain management in the Goulburn LGA revealed that the current controls relate to:

- land use management on land subject to flooding;
- consideration of flood risk for various land uses;
- development on flood liable land;
- the application of a flood planning level; and
- facilitating and encouraging the natural operation of waterways

Other planning controls relevant to this study relate to the current development pressure being experienced within the LGA and the need to preserve the unique rural, heritage and visual characteristics of the area. Planning documents recognise that historically growth has occurred within flood affected areas and there is a need to develop strategies for addressing the risks associated with this development.

Flood Damages

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.

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 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 this Volume and the equations used to calculate the potential damages are also discussed further in **Appendix H** (Volume Two). The results of these calculations for existing conditions are summarised in Table 1 below.

Table 1 Potential Flood Damages – Existing

Event	Residential Damages	Commercial / Industrial Damages	Infrastructure Damages
20%	$9,635	$2,555	$2,142
10%	$40,080	$14,087	$5,161
5%	$481,890	$123,800	$40,740
2%	$1,573,420	$1,446,592	$206,840
1%	$4,426,440	$4,324,064	$740,519
0.5%	$7,709,390	$10,216,718	$2,519,179
0.2%	$12,016,210	$12,980,568	$3,639,558
Extreme	$43,611,770	$40,976,295	$16,822,576
Average Annual Damage	**$189,140**	**$179,095**	**$46,790**

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.

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. Examples of the range of measures are shown in Table 2 below.

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.

Table 2 – Floodplain Management Measures

Flood Modification Measures	Property Modification Measures	Response Modification Measures
Flood Control Dams	Zoning	Community Awareness
Retarding Basins	Building and Development Controls	Community Preparedness
Levees	Voluntary Purchase	Flood Prediction and Warning
Bypass Floodways	House Raising	Flood Plans
Channel Improvements/ Environmental Enhancement	Flood Proofing Buildings	Evacuation Arrangements
Flood Gates	Flood Access	Recovery Plans

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. The options suggested are discussed in detail in Sections 8 and 9 of this Report. Through consultation with the community, the FWG adopted an integrated and effective mix that is appropriate to the specific circumstances of the flood prone community. Each option was assessed using Multi-Criteria Analysis against social, economic and environmental criteria, presented in Section 8, and a recommendation made as to whether the measure should be investigated in detail for inclusion in the FRMP.

The outcome of this assessment was:

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 further.

Impacts of Proposed Measures

Flooding has severely impacted some of the residents of Goulburn in the past, while others consider themselves invulnerable to any impact of flooding. Many of the latter have not lived in the area during flood conditions or live above areas that are regularly affected by flooding. The apparent apathy of the latter group must be addressed by flood awareness programs.

Impacts of the potential floodplain management measures were investigated in detail and documented in Section 9 of this Report. In summary, the proposed floodplain management measures aimed at reducing the existing, continuing and future flood risks are:

- Floodplain Environmental Enhancement (channel improvements);
- Zoning LEP, Development Control provisions in DCP;
- Flood Warning and Emergency Plans;
- Evacuation & Recovery Procedures;
- Community Awareness & Preparedness;
- Voluntary purchase; and
- Voluntary house raising.

The above measures 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; and

- consideration of the impact of any works on the significance of European heritage items and their curtilage.

Economic Impact of Property Modification Measures

As shown in Table 3 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 63% 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 3: 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.

Benefit/Cost Ratio of Property Modification Measures

As evident from Table 3, 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 annually.

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:

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

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.

Economic Impact of Response Modification Measures

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 4** 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 4: Potential AAD with Recommended Flood Warning and Prediction System

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

Benefit/Cost Ratio

From **Table 4**, 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 5, the costs of implementing the total scheme are $80,000, plus there will be an estimated ongoing maintenance costs of approximately $8000 p.a.

Table 5: 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**

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:

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

Combined Economic Benefit

Using the estimates presented for the economic analysis of property modification measures and response modification measures in Sections 9.3.2 and 9.4.5 respectively, a combined benefit/cost has been derived for the property modification and response modification measures and is presented below:

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

Recommended Measures

The outcomes of the detailed investigations (Section 9) were the final recommendations on floodplain management measures for inclusion in the FRMP. These recommendations are summarised in Table 6.

Table 6: Assessment of Potential Floodplain Management Measures

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 development above flood planning levels in flood affected areas	Yes	Sections 8.3.3 and 9.3.2
Flood Proofing	Minimises the potential impacts of flooding	Yes	Sections 8.3.4 and 9.3.2

Management Option	Objective	Recommended for inclusion in the FRMP	FRMS Reference
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

Floodplain Risk Management Plan

A Floodplain Risk Management Plan forms the heart of an effective floodplain management process. It addresses the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy, based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land. It represents the considered opinion of the local community on how to best manage its flood risk and flood prone land; and it provides a long-term path for the future development of the community.

In formulating such a plan, three specific flooding problems need to be addressed:

- the control of flood damage and hazard to the existing community and properties at risk (the existing problem),
- the control of flood damage and hazard in areas yet to be developed (the future problem), and
- the control of flood damage and hazard associated with mitigation measures being overwhelmed by a larger than the design flood and/or those areas outside the "protected" area (the continuing problem).

A Floodplain Risk Management Plan should aim to achieve an appropriate and integrated mix of control measures that address each of these three problems.

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.

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

With these constraints in mind, a detailed Floodplain Risk Management Plan has been prepared for the Wollondilly River and Mulwaree Ponds. This Plan is presented in detail in Volume Three of this Report and is summarised below in Table 7.

Table 7: Summary of Recommended Floodplain Management Options

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 determined in this FRMS 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
▪ Building and 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	Include the wording presented in Section 9.3.1(v) on Section 149 Certificates	Sections 8.3.2 and 9.3.1	High

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
	property			
▪ 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 impact. Develop a house raising 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
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	Sections 8.3.4 and 9.3.2	Medium

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
		appropriate to achieve flood proofing.		
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
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

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
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

GLOSSARY

GLOSSARY OF ACRONYMS

AAD	Average Annual Damages
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
DCP	Development Control Plan
DLWC	Department of Land and Water Conservation
EMA	Emergency Management Australia
EC	Environment Committee
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FWG	Floodplain Working Group
GCC	Goulburn City Council
LEP	Local Environmental Plan
LGA	Local Government Area
NPWS	National Parks and Wildlife Service
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SEPP	State Environmental Planning Policy
SES	State Emergency Service
VES	Vegetation Enhancement Strategy

GLOSSARY OF TECHNICAL TERMS

Annual Exceedance Probability (AEP) the likelihood of occurrence of a flood of a given size or larger in any one year, usually expressed as a percentage. For example, a 1% AEP flood has a 1% or 1 in 100 chance of happening each and every year.

Australian height datum (AHD) survey height datum adopted by the National Mapping Council of Australia as the reference datum for defining reduced levels (0.0 m AHD is approximately mean sea level).

Average annual damage (AAD) the average cost of flood damage per year to a nominated development situation caused by flooding over a long period.

Average Recurrence Interval (ARI) a statistical estimate of the average period in years between the occurrence of a flood of a given size or larger, e.g. floods with a discharge as big as or larger than the 100 year ARI flood event will occur on average once every 100 years.

Catchment the area of land draining to a particular site. It always relates to a specific location and includes the catchments of tributary streams as well as the main stream.

Critical storm duration the duration of the storm event of nominated severity (e.g. the flood) that produces the largest flood discharge at the location of interest. Critical storm duration depends upon catchment size, topography and land use and on the temporal pattern of the rainfall events.

Dambreak flooding flooding caused by the breaching of a dam embankment.

Detention basin a generally small self-draining storage constructed on a creek or drain that mitigates downstream flood discharges and flood levels by providing temporary storage to floodwaters.

Development the erection of a building or the carrying out of work, including the placement of fill; or the use of land or a building or work; or the subdivision of land.

Discharge the rate of flow of water, as measured in terms of volume per unit time, e.g. 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. Improved flood forecasting systems and warning delivery systems increase the available warning time.

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.

Flash flooding sudden and unexpected flooding caused by local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain that causes flooding.

Flood relatively high water levels caused by excessive rainfall, storm surge, dambreak or a tsunami that overtop the natural or artificial banks of a stream, creek, river, estuary, lake or dam.

Flood awareness the ability of flood-affected community to defend themselves, their property and their community from flood threats and to effectively evacuate themselves and their possessions when necessary, i.e., an appreciation of the risk of flooding, the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. In communities with a high degree of flood awareness, the response to flood warnings is prompt and effective. In communities with a low degree of flood awareness, flood warnings are liable to be ignored or misunderstood, and residents are often confused about what they should do, when to evacuate, what to take with them and where it should be taken.

Flood compatible materials building materials that are resistant to damage when inundated by floodwaters.

Flood fringe the remaining area of land inundated by a flood event after floodway and flood storage areas have been defined.

Flood hazard potential loss of life, injury and economic loss caused by future flood events. The degree of hazard varies across the floodplain due to different flood conditions (such as depth, velocity etc)

Flood level the flood level associated with a specified flood event.

Floodway area those areas of the floodplain where significant discharge or storage of water occurs during a specific flood event. Floodways are areas that, if filled or even partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often aligned with naturally defined channels and are often, but not always, areas of deeper flow or areas where higher velocities occur. It is important to note that each flood event has a floodway and that the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may experience much greater and more hazardous flows during larger floods (see defined flood fringe).

Flood storage areas those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

Flood damage the tangible and intangible costs of flooding. Tangible costs are quantified in monetary terms, e.g. damage to goods and possessions, loss of income or services in the flood aftermath, etc. Intangible damages are difficult to quantify in monetary terms and include the loss of personal property that has no intrinsic value (photos, memorabilia), and the increased levels of physical, emotional and psychological health problems suffered by flood affected people and attributed to a flooding episode.

Flood Plan an official sub-plan of a Local Disaster Plan, dealing specifically with flooding. It contains an agreed set of roles, responsibilities, functions, actions and management arrangements to deal with flood events of all sizes. It involves arrangements to prepare for flooding, respond to flooding and recover from flooding. A local Flood Plan forms an essential complement to a Floodplain Risk Management Plan.

Floodplain area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by floods up to and including the probable maximum flood event, i.e. flood prone land.

Environment Committee committee formed and chaired by local agency(s) or other appropriate body(s) to oversee the development and implementation of a Floodplain Risk Management Plan. The committee should include representatives of all stakeholder groups and all agencies responsible for floodplain management, living in, using or undertaking developments on the floodplain.

Floodplain management measures the full range of measures available to prevent or reduce flood hazard and disruption, as canvassed in a Floodplain Risk Management Study.

Floodplain management options measures that might be feasible for the management of a particular area of the floodplain. Preparation of a Floodplain Risk Management Plan requires a detailed evaluation of management options.

Floodplain Risk Management Study and Plan the recommended means of assessing and managing the flood risk associated with the use of the floodplain for various purposes. Usually includes both written and diagrammatic information describing how flood prone land is to be developed and managed to achieve defined objectives. Plans need to be reviewed at regular intervals to assess progress and to consider the consequences of any changed circumstances that have arisen since the last review.

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 that determines the flood planning area. In Goulburn, the FPL has been set as the 1% AEP flood event.

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

Flood prone land land subject to inundation by the probable maximum flood (PMF) event. Floodplain Risk Management Plans should encompass all flood prone land, rather than being restricted to land subject to defined flood events.

Flood proofing combination of measures incorporated in the design, construction and alteration of individual flood-liable buildings or structures to reduce or eliminate flood damage.

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. However, freeboard **should not be relied upon** to provide protection for flood events larger than the design flood.

Frequency measure of likelihood expressed as the number of occurrences of a specified event in a given time. For example, the frequency of occurrence of a 5 year ARI flood event is once every 5 years on average.

Habitable room any living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom, or any area in an industrial or commercial establishment used for offices or use to store valuable possessions susceptible to flood damage.

High hazard areas large trucks, boats or helicopters are required for the evacuation of people from high hazard areas (see negligible, low and medium hazards).

Hydraulics the study of the flow of water in waterways. In particular, the evaluation of flow parameters such as water level and velocity.

Hydrograph a graph which shows for a particular location, the variation with time of discharge (discharge hydrograph) or water level (stage hydrograph) during the course of a flood.

Hydrology the study of water and its constituents as they move through the natural processes that constitute the hydrological cycle (rainfall, runoff, evaporation, infiltration, etc.).

Likelihood of occurrence the likelihood that a specified event will occur. The likelihood of occurrence of flooding can be measured in terms of Annual Exceedance Probabilities (AEPs) and Average Recurrence Intervals (ARIs).

Low hazard areas fit adults can wade to safety (from low hazard areas), but children and the elderly would have difficulties wading. Evacuation by sedan-type motor vehicles is possible in early stages of flooding, then 4WD vehicles or trucks are required (see negligible, medium and high hazards).

Mainstream flooding inundation of normally dry land that occurs when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.

Mathematical/computer models the mathematical representation of the physical processes involved in runoff generation and stream flow. Due to the complex nature of these mathematical relationships, computers are often used to solve the underlying equations.

Medium hazard areas fit adults have difficulty in wading to safety from medium hazard areas. Motor vehicle evacuation possible only with 4WD vehicles and trucks. Boats or helicopters may be required (see negligible, low and high hazards).

Minor, moderate and major flooding the State Emergency Services and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic bridges may be covered.

major flooding: extensive rural areas are flooded with properties, villages and towns isolated and/or appreciable urban areas are flooded.

Negligible hazard areas there are no significant evacuation problems from negligible hazard areas. Elderly people and children would have no undue difficulty with evacuation by walking. Evacuation by sedan-type motor vehicle possible (see low, medium and high hazard).

Peak discharge the maximum discharge occurring during a flood event.

Probability the likelihood of a specific outcome, as measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between zero and unity, zero indicating an impossible outcome and unity indicating an

outcome that is certain. Probabilities are commonly expressed in terms of percentage. For example, the probability of 'throwing a six' on a single roll of a die is 1 in 6, or 0.167, or 16.7%.

Probable maximum flood (PMF) the largest flood that could conceivably occur at a particular location. **The PMF defines the extent of flood-liable land.** Generally, it is not physically or financially possible to provide general protection against this event. It is difficult to define a meaningful annual exceedance probability for the PMF event. It is commonly assumed to be of the order of 10^{-4} to 10^{-7}, i.e. a flood risk of 1 in 10,000 to 1 in 10,000,000.

Rainfall severity a qualitative indication of the intensity of rainfall and its potential to cause flooding.

Risk the likelihood of something happening that will have an adverse impact on objectives; a measure of potential loss. Risk is specified in terms of both consequences and likelihood. For example, if the 50 year ARI flood event causes $20 M in flood damage, the risk of a flood causing $20 M damage is 1 in 50 in each and every year. The risk of such an event occurring over a longer period is much higher. The table below provides more detail on the increasing risk of a flood of a particular size occurring.

Probability of Experiencing a Given Size Flood One or More Times in a Lifetime (70 Years)

Likelihood of Occurrence in any Year (AEP)	Percentage Probability of Experiencing in a 70 Year Period	
	At least Once	At Least Twice
10% (1 chance in 10)	99.9%	99.3%
5%(1 chance in 20)	97.0%	86.4%
2%(1 chance in 50)	75.3%	40.8%
1%(1 chance in 100)	50.3%	15.6%
0.5% (1 chance in 200)	29.5%	4.9%

Continuing flood risk the remaining level of flood risk that a community is exposed to after floodplain management measures to reduce risk have been implemented, i.e. 'untreated' flood risk. Residual risk vary with flood severity and may be substantial for flood events that are larger than the defined flood events adopted for planning purposes or for the design of structural works.

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.

Risk management the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring flood risk. Flood risk management is undertaken as part of a Floodplain Risk Management Study. The Floodplain Risk Management Plan reflects the adopted means of managing flood risk.

Runoff the amount of rainfall that drains into the surface drainage network to become streamflow, also known as rainfall excess.

Stage equivalent to 'water level'. Both are measured relative to a specified datum.

Stage hydrograph a graph that shows how the water level at a particular location changes with time during a flood. The stage hydrograph must be referenced to a particular datum.

Stormwater flooding inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow.

Velocity of floodwaters the speed of floodwaters, measured in metres per second (m/s).

1 INTRODUCTION

1.1 BACKGROUND

Sections of the City of Goulburn are highly susceptible to damage and disruption from floodwaters from both the Wollondilly River and Mulwaree Chain of 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 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" and one major component of the Floodplain Risk Management Plan (FRMP) must be a detailed program to raise the level of community awareness.

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 a FRMP for the City. This FRMP will be developed in accordance with the NSW Flood Prone Land Policy and the principles and guidelines in the Floodplain Management Manual 2001.

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 in developing a FRMP 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. This report presents the draft Floodplain Risk Management Study and a draft Floodplain Risk Management Plan for the Goulburn LGA.

1.2 DEFINITION OF STUDY AREA

The City of Goulburn is located in the southern tablelands of NSW, 220 km south-west of Sydney, at the confluence of the Wollondilly River and Mulwaree Ponds. The City Council covers an area of 43 km^2 and has a population of 20884 people (2001 census). The surrounding districts boost the catchment population by a further 15,000 people. The City supports a strong rural community as well a wide-ranging commercial and industrial sector.

The Wollondilly River rises in the Great Dividing Range east of Crookwell and drains the south-western section of the Hawkesbury River Basin. Its 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. 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 1.2** and the City of Goulburn in Figure 1.3.

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 Chain of Ponds floodplain but not vice versa.

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 **Figure 1.1**). 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.

A number of areas in Goulburn are affected by floods up to the 1% AEP flood. These include:

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

Previously, no studies have assessed the impact of greater floods other than the dambreak studies for Pejar and Sooley Dams. Extreme floods up to and including the Probable Maximum Flood (PMF) will affect areas with no experience of flooding. It is anticipated that extreme floods in the Wollondilly River may cut through residential/commercial areas around Union Street to join the Mulwaree Chain of Ponds upstream of the current confluence.

The nature of flooding in this study has been assessed using hydraulic modelling, based on the HEC-2 hydraulic model developed in the Flood Study (DLWC, 1986) and updated for current catchment conditions and the revised flood frequency analysis. Details of the modelling are provided in Section 3.

1.3 PROJECT METHODOLOGY

The methodology for preparation of the Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) has involved several stages of documentation review, collection and analysis of data, modelling and consultation with the Environment Committee (EC) and the Goulburn community. The overall methodology for the project is summarised in **Figure 1.4** below.

1.4 REPORT FORMAT

The Report of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Study and Plan is divided into four Volumes, the Main Report, the Appendices and Mapping, the Draft Floodplain Risk Management Plan and the Vegetation Enhancement Strategy.

This **Volume One**, the Main Report, consists of:

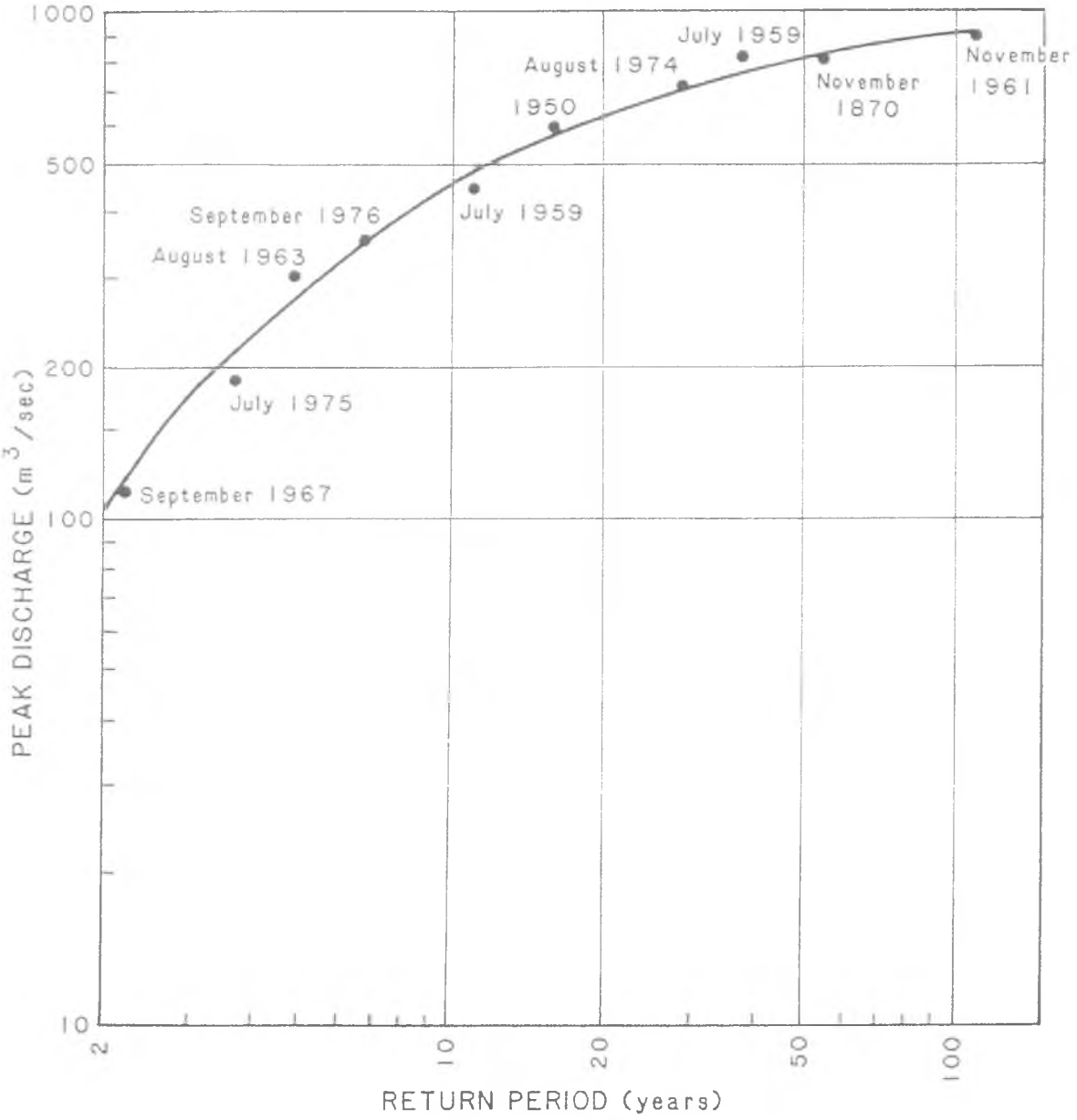
- Section 1, which introduces the Report;
- Section 2, a description of the area covered by the Study, current planning policies and regulations, its climate, flora and fauna and the population demographics;
- Section 3, a description of the flooding regime, the revised flood frequency analysis, hydraulic modelling, and the hazard categories determined;
- Section 4, a review of planning and regulatory provisions covering the Study area;
- Section 5, a description of the community consultation activities undertaken during the Study;
- Section 6, an assessment of the social impact of flooding;
- Section 7, an assessment of the economic impact of flooding;
- Section 8, a description and assessment of potential floodplain management measures for the Study area, and an assessment of impacts of those recommended for further investigation;
- Section 9, a detailed investigation and final recommendation of floodplain management measures for the Study area; and
- Section 10, Conclusions.

Volume Two of the report contains the Appendices associated with the Main Report. The Appendices are:

Appendix A – *Review of Technical Reports and Studies*
Appendix B – *Review of State and Commonwealth Legislation and Planning Policies, and Local Planning Instruments*
Appendix C – *Heritage Items*
Appendix D – *Flood Frequency Analysis & Hydraulic Model Results*
Appendix E – *Community Consultation Survey Form*
Appendix F – Appendix G – *Minutes of Public Meetings*
Appendix H – *Flood Damages*
Appendix I – *Assessment of Management Options*
Appendix J – *Eastgrove and Victoria Street Levees*
Appendix K – *Schedule of Flood Compatible Building Materials*

Volume Three of the Report presents the Draft Floodplain Risk Management Plan as a stand-alone document that is supported by the findings of the companion Volumes.

Volume Four of the Report presents the Vegetation Enhancement Strategy.



PEAK DISCHARGE -FREQUENCY CURVE FOR WOLLONDILLY RIVER AT MARSDEN WEIR

Note : The above curve was only used to check the regional flood frequency and was not adopted for the Goulburn Flood Study.

Source: Goulburn Flood Study Report, WRC 1986

SMEC
Level 5
118 Walker Street
North Sydney 2060

Goulburn City Council
Civic Centre
184-194 Bourke Street
Goulburn 2580

Wollondilly River & Mulwaree Ponds Floodplain Risk Management Study & Plan

Figure 1.1: Regional Flood Frequency Curve

Wollondilly River Catchment

Mulwaree Ponds Catchment

Source: DLWC, Surface Water Quality Assessment of the Hawkesbury Nepean Catchment 1995-1998

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Figure 1.2: Wollondilly River & Mulwaree Ponds Catchments

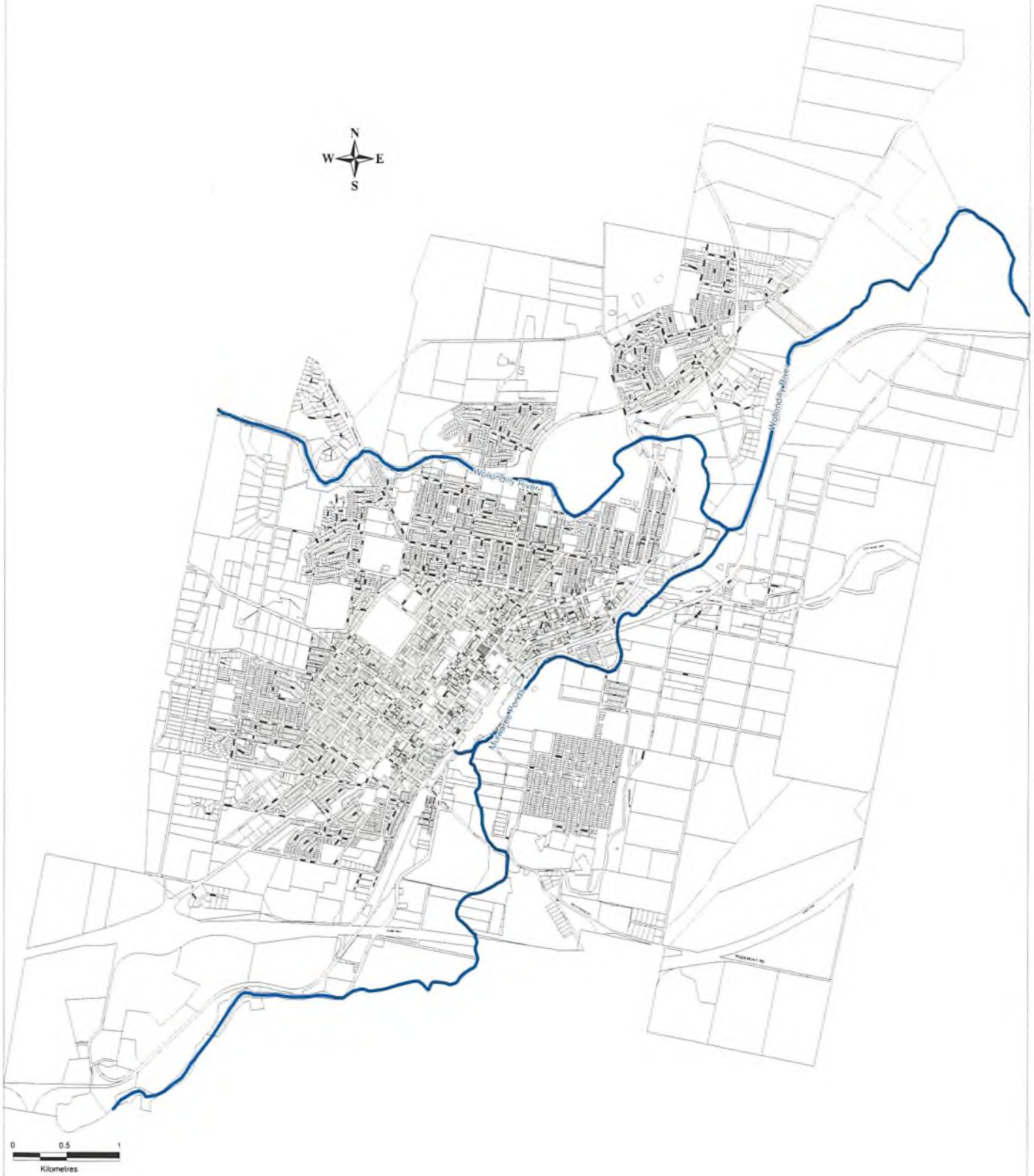

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Figure 1.3: Map of the City of Goulburn

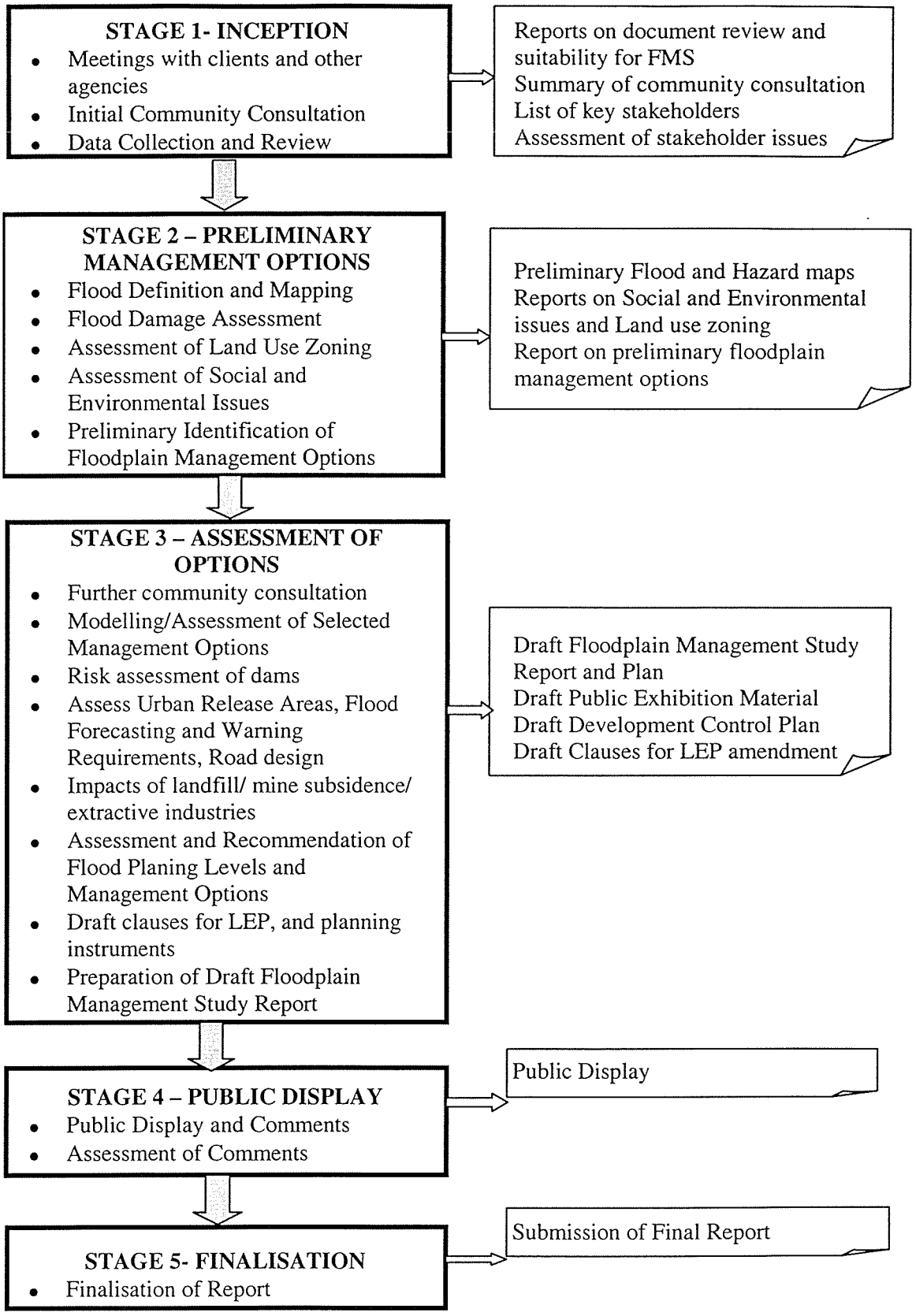


Figure 1.4: Project Methodology

2 THE STUDY AREA

2.1 UNDERSTANDING THE STUDY AREA

A review of technical reports and studies was undertaken to prepare a picture of the study area and to gain an understanding of the flooding issues currently affecting Goulburn. An outline of these documents is contained in **Appendix A**. The general physical, biological and human environment characteristics of the study area are summarised below.

2.2 PLANNING AND REGULATION REVIEW

As part of this Study, current planning controls and policies relevant to management of flood liable land in Goulburn has been reviewed and assessed. This information has been presented in Section 4, together with discussion on relevant land use issues and objectives. A summary of documents reviewed is included in **Appendix B**.

2.3 DEMOGRAPHIC CHARACTERISTICS

In determining the most suitable floodplain management options, it is important to have an understanding of certain characteristics of the population. This enabled a merit assessment of each option, based on its suitability for a particular population. The information presented below supplemented the social surveys (refer Section 5) and was used when considering the social impacts of mitigation measures.

2.3.1 Population

i Population growth

From the census results presented in **Table 2.1**, it can be seen that Goulburn's population has generally been declining. The 1991 census results indicated that the total population was 21451 and by 1996 this had decreased to 21293. The 2001 census results just released show a further decline to 20884. This represents a decrease of 0.7% and 1.9% respectively, thus it would appear from the results that the rate of decline in population has increased. This trend is in line with that being experienced by many inland centres in New South Wales.

Table 2.1: Population of Goulburn LGA

	1991 Census	1996 Census		2001 Census	
	Population	% Change (ave 5 yrs)	Population	% Change (ave 5 yrs)	Population
Male	10 992	-1.4%	10 833	-2.4%	10 574
Female	10 459	0.0%	10 460	-1.4%	10 310
Total	*21 451*	*-0.7%*	*21 293*	*-1.9*	*20 884*

ii Age Distribution

Goulburn's population is relatively young, with 28% of the population between the ages of 25 and 44 years, and 64% of the population below 44 years of age. However, there is an aging trend evident in the population. There has been a 3.2% decrease in the proportion of the population under 15 years old and the medium age of people in Goulburn in 2001 was 35 years, compared with 32 years in 1996 and 31 years in 1991. The relevant figures, as per the 2001 census, are given in **Table 2.2**.

Table 2.2: Age Distribution of Goulburn LGA

	0-14 years	15-24 years	25-44 years	45-64 years	65 years and over	Total
Male	2 226	1 604	3 134	2 341	1 257	*10 562*
Female	2 048	1 446	2 789	2 295	1 706	*10 284*
Total	*4 274*	*3 050*	*5 923*	*4 636*	*2 963*	*20 846*
	21%	*15%*	*28%*	*22%*	*14%*	*100%*

iii Cultural Composition

The cultural background of Goulburn LGA is predominantly Anglo-Saxon, with the two most common ancestries identified in the 2001 census being Australian (9921 people, or 48%) and English (7231 people or 35%). Additionally, in the same census, 18000 people (86%) stated they were Australian-born. This compares to 18959 people (89%) in 1996 and 19630 (92%) in 1991. The number of people born overseas was 1377 (6.6%) compared with 1406 (6.6%) in 1996 and 1421 (6.6%) in 1991. Of those born overseas, the three main countries of birth were the United Kingdom, New Zealand and Germany.

English was stated as the only language spoken at home by 18652 people (89%) in 2001. This compares with 19611 people (92%) in 1996 and 19961 people (93%) in 1991. The three most common languages spoken at home other than English were Greek (85 people, or 0.4%, Chinese languages (71 people or 0.3%) and Italian (42 people or 0.2%).

Goulburn LGA's indigenous population numbered 390 people in the 2001 census, or 1.9% of the total population. This had increased by 17% since 1996 and 85% since 1991.

2.3.2 Dwelling Structure and Tenure

i Housing

The 2001 census indicated that there were 7444 private dwellings within the Goulburn LGA. Of these, 63% are either being purchased or fully owned and 30% are rented. Of these, 6490 were separate houses (83%), 526 semi detached, row or terrace houses and townhouses (6.7%),

587 flats, units or apartments (7.5%) and 141 other dwellings (1.8%). This compares to 7433 private dwellings in 1996 and 7113 in 1991.
To come

ii Families and Households

The 2001 census indicated that 2204 of families consist of couples with children. This is 42% of all families occupying private dwellings. There were also 1892 couple families without children (36%), 1047 one parent families (20%) and 81 other families (1.6%). 417 people occupy private dwellings in share households, and 2107 people are in single person households.

2.4 THE BIOLOGICAL AND PHYSICAL ENVIRONMENT

It is equally important to examine aspects of the biological and physical environment, to determine whether the range of floodplain management options can or cannot be supported by the surrounding terrestrial and aquatic environments. Options for floodplain management must protect or enhance, rather than threaten such environments.

A desktop study was conducted to obtain relevant environmental information pertaining to the Goulburn Local Government Area (LGA). This involved a review of the following documents:

- Department of Public Works and Services (1999). *Goulburn Sewerage Effluent Reuse at Kenmore Environmental Impact Statement.*
- Bureau of Meterology (2001). *Climate Averages for Goulburn.* http://www.bom.gov.au/climate/averages/tables/cw_070037.shtml; accessed September 2001.
- ERM Mitchell McCotter (1998). *Draft Goulburn Land Capability Study.* For Goulburn City Council.
- Goulburn City Council (1983). *Goulburn Heritage Study.*
- Goulburn City Council (1989). *Local Environment Study.*
- Goulburn City Council (1994). *State of the Environment Report.*
- Goulburn City Council (1998). *Supplementary State of the Environment Report.*
- Goulburn City Council (1999). *Goulburn Sewerage Scheme Environmental Impact Statement Proposed Construction of a 600ml Wet Weather Storage Facility.*
- Goulburn City Council (1999). *Supplementary State of the Environment Report.*
- Land Systems (1998). *Goulburn City Riverways Wollondilly River and Mulwaree Ponds (Landscape and Ecological Study). Draft Plan of Management.* Final Report to Accompany a Presentation to the Goulburn City Council.
- NSW Soil Conservation Service (1988). *Reconnaissance Urban Capability Survey Goulburn City.* Prepared for Goulburn City Council.
- NSW Soil Conservation Service (1991). *Soil Landscape of the Goulburn 1:250,000 Map Sheet.*

- Sinclair Knight & Partners (1985). *Hume Highway Environmental Impact Statement – Goulburn Bypass National Highway Number 31.*
- Woodlots and Wetlands (1998). *Goulburn Waterways Study 1998. A Resource inventory and Action plan.*

In addition, relevant vegetation maps, and the National Parks and Wildlife Service's (NPWS's) Aboriginal Site Register and Wildlife Atlas were also consulted.

2.4.1 General Description

Goulburn is located in the southern highlands of NSW, some 200km from Sydney and 95 km from Canberra. Established in 1833, and proclaimed a city in 1859, Goulburn is Australia's oldest inland city. Goulburn has a population of 20884 (2001 census) with marginal decreases expected in the future.

The City lies at the confluence of the Wollondilly River and Mulwaree Ponds within the upper reaches of the Hawkesbury Nepean catchment. The Wollondilly River rises in the Great Dividing Range east of Crookwell and drains the south-western section of the Hawkesbury River Basin. This catchment occupies an area of 720m^2 above Goulburn. It is within hilly country and steep slopes occur along both riverbanks. Typically, the floodplain is well defined and narrow through Goulburn LGA.

Mulwaree Ponds is one of the largest and southernmost tributaries of the Wollondilly. It rises in the Great Dividing Range immediately south of the Tarago and flows northward to Goulburn. This catchment comprises an area of 750m^2, bound to the west by steep slopes and to the east by undulating country.

The areas adjacent to these two waterways have been repeatedly affected by flooding since European settlement, with two recent major floods disrupting the City. 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 slightly greater than a 1% Annual Exceedance Probability (AEP) flood event (see **Figure 1.1: Regional Flood Frequency Curve (Figure 5.4 of Goulburn Flood Study, 1986)**). The most recent major flood occurred in 1974, and according to the Flood Study, was slightly greater than a 1:30 year event. A detailed description of flood behaviour is given in Section 3.

i Access

Transport access to Goulburn is by road, rail and air. The main access points servicing Goulburn are:

- Hume Highway, linking Goulburn to Sydney and Melbourne;
- Taralga Road, linking Goulburn to Taralga and Oberon ;
- Braidwood Road, linking Goulburn with Braidwood and the Queanbeyan region;
- Goulburn Street, linking Goulburn to Crookwell;
- Main Southern Railway line, with regular services to Sydney, Canberra and Melbourne; and

- Goulburn Regional Airport.

2.4.2 Relevant Legislation

Relevant environmentally based legislation includes:

- Goulburn Local Environmental Plan 1990 (LEP);
- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act);
- NSW *Native Vegetation Conservation Act 1997* (NVC Act);
- NSW *Fisheries Management Act 1994* (FM Act);
- NSW *Threatened Species Conservation Act 1995* (TSC Act);
- NSW *Rivers and Foreshores Improvement Act 1948* as amended (RFI Act);
- NSW *Water Management Act 2000* (WM Act);
- NSW *Heritage Act 1977;*
- NSW *National Parks and Wildlife Act 1974* (NPW Act); and
- Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

A brief description of each Act, and its relevance to this study is provided in **Tables B.1 to B.5** in **Appendix B**.

2.4.3 Topography

Goulburn has a mean elevation of 648 m above sea level. The general alignment of the city is topographically influenced by moderate to steeply sloping ridges, interspaced by the broad Mulwaree Ponds floodplain, and cut by the east-west channel of the Wollondilly River. The eastern edge is contained by the steep Mt Gray ridgeline, a steep crescent shaped formation extending from Governors Hill (731m) to Mt Wood (821m). To the immediate west is a parallel and intermediate ridge some 2.5km long, peaking at Rocky Hill (725m) in a rocky bluff, and creating an extended valley between the two ridges.

Topography generally rises westward from the Mulwaree Ponds floodplain through a series of small hills and low undulating ridges in the central and northern areas to a steeper sloping ridgeline paralleling the western city boundary. A number of prominent knolls to the north (Kenmore 706m) and south (Mt Marion 670m) add definition to the physical form.

2.4.4 Geology

Goulburn is situated on Upper Silurian and Lower Devonian sediments and metamorphosed sediments comprising sandstone, siltstone, shale, breccia, slate and claystone. The Upper Silurian sediments also include extensive outcrops of limestone. Teschenite intrusions that have penetrated the Upper Silurian sediments include metamorphosed mudstones, basalts and dolerite. Quaternary alluvial deposits including sand, silt, clay and gravel occur in association with the Mulwaree and Wollondilly Rivers.

2.4.5 Soils

Four principal soil landscapes, as defined by the NSW Soil Conservation Service, occur in the Goulburn LGA. A brief description of each is provided below.

➢ *Blakney Creek Soil Landscape*
Associated with undifferentiated Ordovician and early Silurian sediments, wherever they occur in conjunction with foot slopes and valley floors, or other landform patterns with slope gradients less than 10% and elevation between 600 and 900m. Generally consist of acid to neutral yellow duplex soils with bleached A_2 horizons.

➢ *Collector Creek Soil Landscape*
These soils occupy the narrow floodplain of the Mulwaree Ponds. They have formed on colluvial and alluvial deposits of Quaternary and Cainozic clay, silt and sand. They generally consist of moderately deep, grey and yellow mottled duplex soils with bleached A_2 horizons and neutral to alkaline reaction trends.

➢ *Midgee Soil Landscape*
This soil landscape is associated with Ordovician and some Devonian and Lower Silurian sediments and metasediments in hilly terrain. These sediments are heavily folded with the result that both deep and very shallow soils may occur within one landform element depending on the resistance of the rock strata at the surface. These soils are almost always stony, acid and highly infertile.

➢ *Monastry Hill Soil Landscape*
This soil landscape occurs to the immediate west of Goulburn City, with slope gradients less than 10% and elevations between 670 and 700m. The landscape has formed on teschenite (dolerite) intrusions. On crests and side slopes are duplex orange coloured soils with acid to alkaline reaction, no development of A_2 horizons and massive to moderately structured B horizons.

2.4.6 Climate

Goulburn is located in the north-eastern area of the Southern Highlands physiographic region. The city experiences a cool temperate climate, with annual mean maximum and minimum temperature of 20.1^0C and 7.3^0C respectively. Average annual rainfall is 665.7mm, with warmer months receiving slightly more rainfall. Frosts occur in the locality for an average of 70 days per annum. Westerlies are the predominant winds through the year, with northerlies and north-easterlies also common in the summer months.

2.4.7 Water Quality

Goulburn City Council has undertaken a detailed study of urban water quality since 1993. Monthly sampling has occurred at seven points along the Wollondilly River and four points along Mulwaree Ponds. Results of the monitoring indicate that water quality ranges from poor to satisfactory, with samples often not satisfying the ANZECC Guidelines for Water Quality Criteria. Pollution in the Mulwaree Ponds is substantially more severe.

The major threats to water quality in the Goulburn LGA are from: urbanisation, removal of forests and native ground covers, stock access to waterways, the installation of weirs and dams to store water and regulate flow, and contamination from the Goulburn Sewage Treatment Plant and industrial sites such as saleyards and the abattoirs. Goulburn City Council has taken a number of steps to improve water quality in the area through activities such as:

- park creation along the edges of the waterways;
- gradual upgrading and improvement of sewage treatment;
- development of an effluent irrigation farm to minimise the city's sewage;
- community education programs aimed at reducing littering and stormwater contamination; and
- supporting community environmental activities such as revegetation.

2.4.8 Ecology

The Goulburn LGA is a highly modified landscape that has been subject to extensive clearing and exotic weed invasion. Relative few scientific studies have been conducted to determine the native species remaining, the species diversity, ecosystem diversity or their conservation significance.

i Flora

Vegetation Communities

Three vegetation communities are found within the Goulburn LGA. A brief description of these communities is provided below.

- *Low Open Forest*

Low open forest is characterised by small trees with a 30-70% projective foliage cover. This community originally covered extensive areas of the hill ridges and lower slopes, although it has now been extensively cleared and modified. Remnant and regenerative areas are principally confined to hill ridges and steep slopes along the western face of Mt. Gray, Governors Hill, upper portions of Rocky Hill Ridge, and west of Cathcart Street between Clinton and Mary Streets. The Scribbly Gum (*Eucalyptus rossii*) and Brittle Gum (*E. mannifera*) are the two dominant trees of the community, with the herbaceous and shrub strata considerably pronounced.

- *Open Woodland*

Open woodland is characterised by trees of 10-30m with a very sparse projective foliage cover. Although this community has been substantially cleared, extensive areas remain on the lower slopes of the southern, western and eastern perimeters. Scribbly Gum (*Eucalyptus rossii*), Brittle Gum (*E. mannifera*), Yellow Box (*E. melliodora*) and Apple Box (*E. bridgesiana*) dominant the canopy, with grasses such as Wallaby grass (*Danthonia* spp) and Wire grass (*Aristida* spp) dominating the lower strata.

- *Open Grassland*

This community is characterised by almost total grass/ground coverage, and a scattering of trees and shrubs. It contains many native species and introduced pasture grasses. Extensive

areas exist to the south-east and north of the Wollondilly River, with a sizeable community between Kenmore and Werriwa Streets.

Threatened Species

A search of the NPWS Wildlife Atlas revealed that no threatened flora species are known to occur in the LGA.

Noxious Weeds

Thirty-two noxious weed species have been gazetted as occurring either within the LGA or its vicinity (**Table 2.3**). Weeds are a major disturbance to the ecological environment. As they rapidly colonise a site, weeds have the ability to out-compete native flora species leading to changes in floristics and community structure. Consequently, habitat for fauna species is also modified and often reduced.

Flooding of the study area can actually promote weed invasion by encouraging dispersal and colonisation. It is therefore vital that the control of weeds, especially those listed as noxious, is implemented within the study area on an ongoing basis.

Table 2.3: Noxious weeds gazetted for the Goulburn LGA

Scientific Name	Common Name	Control Category
Alternanthera philoxeroides	Alligator Weed	W1
Cannabis sativa	Indian Hemp	W1
Carduus nutans	Nodding Thistle	W2
Cassinia nutans	Sifton Bush	W3
Cestrum parqui	Green Cestrum	W2
Conium maculatum	Hemlock	W2
Cortaderia spp	Pampas Grass	W2
Cuscuta spp.	Dodder	W2
Cystisus scoparius	Scotch/English broom	W2
Echium spp.	Paterson's Curse	W2
Eichhornia crassipes	Water Hyacinth	W1
Eqisetum arvense	Horsetail	W1
Eragrostis curvula	African Love Grass	W3
Erythroxylum coca	Coca Leaf	W1
Gymnocoronis spilanthoides	Senegal Tea Plant	W1
Hypericum peroratum	St. John's Wort	W2
Kochia scorparia	Kochia	W1
Lagarosiphon major	Lagarosiphon	W1
Lycium ferocissium	African Boxthorn	W2
Marrubiium Vulgare	Horehound	W3
Nasella trichotma	Serrated Tussock	W2
Onopordum spp	Scotch/Illyrian/Stemless Thistles	W2
Papaver somniferum	Opium Poppy	W2
Parthenium hysterophorus	Parthenium weed	W1
Pistia stratoites	Water Lettuce	W1
Rosa rubinosa	Sweet Briar	W2
Rubus fruticosis	Blackberry	W2
Salvinia molesta	Salvinia	W1
Sencio madagascariensis	Fireweed	W2
Toxicodendron succedaneum	Rhus Tree	W2
Ulex europaeus	Gorse	W2
Xanthium spp.	Cockle Burrs	W2

Source: Goulburn City Council (1996)

W1 Presence must be notified to the local control authority and they must be "fully and continuously suppressed and destroyed".

W2 Must be fully and continuously suppressed and destroyed".

W3 Must be prevented from spreading and their numbers and distribution reduced.

ii Terrestrial Fauna

The Goulburn district supports at least 22 native mammals and 179 bird species. Considering the limited number of habitats within the region and their relatively disturbed nature, this number of species is relatively high.

Habitat and Corridors

Three fauna habitat types are present in the study area:

- *Forests/woodland*

Much of the original low open forest and open woodland communities have been cleared and modified. However, extensive areas remain on the hill ridges and steep slopes, and the perimeters of the LGA. These areas provide a number of crucial resources, such as hollows for nesting and refuge sites, leaf litter, tall grasses and fallen logs, which provide habitat for a range of native species. Both the Eucalypt and Acacia species present in Goulburn produce nectar rich flowers that serve as a vital food source for many native birds, mammals and insects, including butterflies and caterpillars, which in turn attract insect eating birds. Several of the Eucalypts, especially the Yellow Box, are excellent sources for hollows, which provide important nesting sites for many mammals and birds.

- *Grassland and agricultural landscapes*

Naturally occurring grasslands and modified agricultural landscapes provide important habitat for a range of species. In particular, a number of species will move into these areas to feed, before moving back into more continuous areas of vegetation to ensure safety from predators.

- *Riparian vegetation*

Most of the original vegetation adjacent to the Mulwaree Ponds and the Wollondilly River has been cleared and relaced by exotic species. However, as this vegetation is surrounded by agricultural and developed areas and forms a relatively continuous corridor, it is vital for the movement and dispersal of native fauna. It also acts a refuge for many species that may feed in the cleared areas but require this vegetation for protection and breeding purposes.

Threatened Fauna

A search of the NPWS Wildlife Atlas revealed that no threatened fauna species are known to occur in the LGA.

iii Aquatic Fauna

Habitat

Riparian vegetation provides important habitat for aquatic fauna as it offers shade and protection, an insect source, and fallen branches for snags. Snags are often vital for many fish species as they offer egg-laying sites.

The flow of water within the Wollondilly River and the Mulwaree Ponds is moderately impeded by siltation and aquatic vegetation, with vegetation being encouraged by the excessive sediment. This sediment and some nutrients (particularly phosphorous) are carried to streams in the overland flow of water. Clearing, soil disturbance, agricultural activities and urban development promote substantial increases in erosion and sedimentation. These can have negative impacts on aquatic fauna, especially fish species, as they alter in-stream habitat by reducing the depth of the water, increasing turbidity and congesting the flow of water.

Threatened Species

One threatened fish species, Macquarie Perch *(Macquaria australasica),* has previously been recorded in the Wollondilly River (J. Pursey NSW Fisheries, 11/9/01 *pers. comm.*).

Macquarie Perch is listed as Vulnerable under Schedule 5 of the *Fisheries Management Act 1994.* This species has been recorded from south-eastern Australia, at moderate to high altitudes in rivers and reservoirs, and was once abundant in the upper sections of the Lachlan River (Fisheries Scientific Committee 2000). This species could occur in the study area but detailed aquatic surveys would need to be conducted to verify its presence.

2.4.9 Visual Quality

The visual quality of Goulburn can be described as having three principal elements:

1. Urban Areas

Up until the 1940's Goulburn was a bustling city of substantial regional importance. It has since experienced somewhat of a decline, due to the loss of employment opportunities in agriculture and the development of neighbouring centres, particularly Canberra.

Urban development of Goulburn consists of residential and commercial buildings, and industrial and transport facilities. Many aspects are of heritage value, with Goulburn having a number of items listed on various heritage registers. Heritage is discussed further in Sections 2.4.10 and 2.4.11.

2. Watercourses and Associated Riparian Vegetation

Wollondilly River and the Mulwaree Ponds, and their associated riparian vegetation provides a picturesque natural setting and is considered to have a high level of visual quality. This vegetation provides many visual benefits not only because of their own aesthetic value but also in attracting a variety of birds, preventing soil erosion along the creek banks, and improving water quality.

3. Rural Areas

Although Goulburn has developed into a moderate sized city, the LGA still contains areas of agricultural production, where the productive soils of the floodplain are used for livestock grazing and cropping purposes. The maintenance of these rural areas contrast with the urban nature of the city centre and increases the aesthetic appeal of the city.

2.4.10 European Heritage

i History

The region around Goulburn was first discovered by Europeans in 1798 by John Wilson and two companions, who explored as far south as Mount Towrang, which is east of the present city and overlooking the Goulburn Plains. In 1818, Hamilton Hume and John Meehan passed the site and named it the Goulburn Plains after Henry Goulburn, Under Secretary for War and the Colonies.

By the 1820's the area surrounding Goulburn Plains was being used for stock stations, and following initial Government grants, landowners and settlers also moved into the area. The name Goulburn Plains gradually took over the name of the entire area, although when the first plan of allotments was drawn up, the colonial secretary proposed to call the town Lorn. The Surveyor General rejected the proposal and retained the name of Goulburn. In 1828, a few allotments were surveyed for the township of Goulburn Plains, and the next year more extensive subdivision was approved. After a visit in 1832, Governor Bourke selected a new site for the settlement further south above the Mulwaree Ponds, with the new township gazetted in 1833. The town grew with the completion of the Great South Road and the development of the local wool industry. Wool quickly became the region's chief product and Goulburn became one of the colony's finest wool growing areas with a large export market to Europe. By 1850 Goulburn had become a Government centre with the establishment of a courthouse.

In 1863 Goulburn was the last settlement in the British Empire to become a city by the Virtue of Royal Letters Patent creating the new Bishopric of Goulburn. The proclamation was gazetted in 1864, thereby establishing Australia's first inland city. In 1869, the railway from Sydney reached Goulburn, heralding the boom years which lasted through to the mid 1890's. Goulburn remained a railhead until 1875, commercial and manufacturing industries grew and Government functions multiplied. There was an unprecedented land and building boom until the depression of the 1890's when Goulburn's population growth began to drop relative to other centres.

Federation and World War I saw economic recovery and a great deal of building and further development of the local wool industry. From the 1940's Canberra emerged as a competing centre and today exerts influence over the region formerly focussed on Goulburn.

ii Current Heritage Listings

The Goulburn region currently has a number of heritage items listed on the following registers:

- State Heritage Register;
- State Heritage Inventory;
- Register of the National Estate; and
- Local Environmental Plan.

The significance of these listings is described below. The complete schedule of items listed on these heritage registers is illustrated in **Appendix C**.

Register of the National Estate

The Register of the National Estate is maintained by the Australian Heritage Commission, which is the National body for the protection of heritage. This register contains heritage items of significance to Australia, as well as any items owned or managed by the Commonwealth Government.

Entry of a property or other heritage item into the Register of the National Estate means that the entered item is protected under the *Australian Heritage Commission Act 1975*. Section 30 of that Act provides that the Commonwealth Government must not take any action that would adversely affect an item on the Register, unless there is no other alternative. Listing on the Register does not place any restrictions or requirements on property owners, local or state government bodies.

State Heritage Register

The State Heritage Register is a list of places and items of State heritage significance endorsed by the Heritage Council and the Minister. Items listed on the State Heritage Register are recognised as having heritage significance of state-wide importance due to their historical, scientific, cultural, social, archaeological, architectural, natural, or aesthetic value. These items are protected by the State Government under the *Heritage Amendment Act 1998*. No action that may harm an item listed on the State Heritage Register is permitted under this Act.

State Heritage Inventory

The State Heritage Inventory is a listing maintained by the Heritage Office of New South Wales, and contains any items that are listed in LEPs, REPs or the State Heritage Register. Listing on the State Heritage Inventory itself does not give an item legal protection, but does indicate that the item is protected by another legal instrument.

Local Environmental Plans

The Goulburn City LEP 1990 contains schedules of heritage items and heritage conservation areas that are afforded legal protection under the *Environmental Planning and Assessment Act 1979*. The LEP regulates development affecting these listed heritage items and heritage conservation areas through a series of planning controls.

2.4.11 Aboriginal Heritage

i History

Prior to European settlement, the area around Goulburn was something of a cross roads for Aboriginal people, with six or more different bands (tribes) within a days travel of the present city site. The absence of physical barriers meant that travel within the region was relatively

easy, although travel generally followed the boundary of each band's territory. The area was rich in resources, with exploitation centred on the Wollondilly River and Mulwaree Ponds.

The local Aboriginal population was rapidly displaced and reduced with the arrival of Europeans to the area and the subsequent impacts of land alienation and transmitted diseases. By the mid 1860's the Aboriginal population had virtually disappeared from the region.

ii Aboriginal Sites

Consultation with the Local Aboriginal Land Council was initiated, requesting permission to utilise the data held on the NPWS's Aboriginal Site Register. Goulburn City Council is currently negotiating a data licence agreement with NPWS for the release of information held on the Aboriginal Site Register. Assuming permission is granted, a search will be conducted of the Register, and results incorporated into this document as soon as they become available.

Further consultation with the Land Council will be required prior to any proposed activities being undertaken as a component of the FRMP.

3 FLOODING AND HAZARD

3.1 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 to 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. 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 1.2** and the City of Goulburn in Figure 1.3.

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 a straight concrete gravity dam located on Sooley Creek, a minor tributary of the Wollondilly River. The dam is part of the Wollondilly catchment upstream of Goulburn. It has a capacity of 4520 ML and is normally kept as full as possible (PWD 1991).

Pejar Dam is an earth and rockfill dam built in 1979 by PWD. The dam is located on Wollondilly River and is about 70 km upstream of Goulburn. It has a full supply capacity of 9000ML and a catchment area of 142 km^2 (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. Prior to this being constructed, a number of hydraulic investigations were carried out. These are discussed in Section 3.3.1 below. 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. The issues are discussed further in Sections 3.3.7; 8.2.5 and 9.2.1 respectively.

3.2 FLOOD BEHAVIOUR

3.2.1 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**). 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 3.1** lists historical floods where the flood level exceeds 2.0 m at Marsden Weir (WRC 1986).

Table 3.1: 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	n/a	n/a

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.

3.2.2 General 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**, this

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

- Eastgrove, where a large number of residential properties are affected (Mulwaree Chain of Ponds);
- Residential areas along Braidwood Road (Mulwaree Chain of Ponds);
- Residential area in the vicinity of May Street and Lower Sterne Streets (Mulwaree Chain of 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 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.

3.3 FLOOD IMPACTS

3.3.1 Previous studies

The Goulburn Flood Study was undertaken in 1986 by on behalf of the NSW Department of Land and Water Conservation (DLWC). As part of this study, a HEC-2 hydraulic model of the rivers was developed. This model extends from a just upstream of Marsden Weir on the Wollondilly and from a couple of hundred metres of where the Bypass is now located on Mulwaree Ponds to several hundred metres downstream of the confluence of the two rivers.

Floods assessed in the 1986 study were the 5, 10, 20, 50 and 100 year ARI events. An extreme or Probable Maximum Flood (PMF) was not estimated.

In 1989, Lyall & Macoun undertook the study *State Highway No. 2 - Hume Highway Proposed Bridges over Mulwaree River & Gundary Creek Floodplain* for the RTA. During this study a MIKE-11 hydraulic model was developed for the Goulburn Bypass. The MIKE-11 modelling was commissioned to provide a new assessment of the effects of the by-pass on upstream

properties, following landholder representations to the RTA. The MIKE-11 model improved the accuracy of estimations of hydraulic characteristics reported by the previous HEC-2 models, as MIKE-11 accounts for the storage and an additional branch was incorporated to allow for Gundary Creek. For the 1 in 100 year flood, the bridge waterway requirements; expected afflux for the current and recommended proposal and expected velocities were assessed.

The original (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% design flood was 0.28 m and 0.26 m for the 5% event. The flood profiles for the 20%, 5% and 1% events were presented, to a distance 1.3 km downstream of the bypass.

It had been envisaged that the information presented in this report could be used in lieu of being able to review the MIKE-11 model developed for this study, as the model has not been able to be located. However, cross-sectional information was not presented.

In 1993 Water Resources Consulting Services undertook a Hydraulic Assessment of Goulburn Racecourse Flood Protection Options. This study was commissioned to undertake a hydraulic impact assessment of flood mitigation options for the Goulburn racecourse. Goulburn Racecourse is located to the west of Mulwaree Ponds immediately upstream of Bungonia Road. The floodplain is approximately 1 km wide at that location, and is defined by the Main Southern Railway embankment to the west and natural high ground to the east. The racecourse complex occupies approximately 70% of the floodplain. Most of the racecourse is located on low-lying ground and is therefore subject to inundation by flood events as small as the 20% AEP event (5 year ARI).

Adjacent to the racecourse, between Braidwood Road and the railway embankment, is an area of existing residential development. Much of this residential development is currently subject to inundation, and has the potential to be adversely affected by any flood protection measures considered for the racecourse.

The study assessed the hydraulic impacts of two main options – "Ring" levee and "U" levee for which five different levels of protection, i.e. levee crest levels for floods of various magnitudes ranging from a 20% AEP event to the 1% AEP event. The hydraulic impacts are mainly the changes in flood level and flood velocity due to the different levee options. The HEC-2 hydraulic model developed for the Goulburn Flood Study (WRC, 1986) was used in the hydraulic assessment. However, the model was amended to assess only the Mulwaree Ponds branch and included the original design of the Goulburn-Bypass.

As the analyses indicated that all levee options investigated had an adverse effect on flooding in the vicinity of the racecourse and that these effects extended a significant distance upstream, no official approval has been granted by DLWC for levee protection of the racecourse to proceed.

3.3.2 Hydraulic Modelling

The HEC-2 models used by DLWC in the 1986 Flood Study and in subsequent assessment of the Goulburn Bypass and the racecourse levee options were made available to SMEC for the

purposes of this study. The relevant sections from these models were put together to form a set of cross sections representing the existing catchment formation. This was imported into HEC-RAS, the hydraulic modelling program that has superseded HEC-2.

A site inspection was carried out in August 2001 to undertake a visual inspection of the rivers and floodplain areas. The purpose of this inspection was to assess the current state of the catchment and compare it with the data in the hydraulic model, with particular focus on hydraulic channel roughness parameters and the bridge crossings. Photographs of the bridges, channels, and floodplains were taken, and relevant features and dimensions of each of the bridges recorded.

This information was used to modify and update the model as necessary, extending it further downstream, and where bridges had been modelled using cross sections only, these were updated to use the HEC-RAS bridge routine. Data gathered during the site inspection was used to provide the additional information required in this routine, and cross sections were interpolated upstream and downstream of the bridges as necessary.

Flood Frequency Analysis

In the 1986 Flood Study, peak design flows were estimated from a regional flood frequency analysis. As some time has passed between that study and the preparation of the FRMS&P, another flood frequency analysis was undertaken. This was done, as results that are more accurate should be derived through more years of data being available for gauging stations within the region. This study considered stations used in the 1986 study, and considered a number of additional stations. The stations, locations and years of available data are given in Table 3.2. A map showing the stations and their locations is given in Figure 3.1.

Table 3.2: Location of Regional Gauging Stations

Station	Location	Years of Available Data
212002	Wollondilly River at Upper Burragorang	30/10/1925 - 28/01/1959
212009	Wingecarribee River at Greenstead	30/06/1954 - 23/03/1979
212012	Wollondilly River at Goulburn	15/05/1962 - 01/12/1977
212020	Tarlo River at Swallowtail Crossing	22/09/1971 – ongoing
212027	Wollondilly River at D/S Pejar Dam (Calamondah)	25/10/1973 - 14/12/1982
412025	Boorowa River at Rockvale	15/02/1921 - 31/01/1948
412027	Lachlan River at Reids Flat	03/12/1930 - 31/12/1968
412028	Abercrombie River at Abercrombie	09/12/1930 – ongoing
412029	Boorowa River at Prossers Crossing	18/03/1938 – ongoing
412031	Hovells Creek at Hovells Creek (Jerringomar)	23/03/1938 - 01/01/1978
412050	Crookwell River at Narrawa North	21/01/1955 – ongoing
412054	Bolong River at Golspie	02/02/1955 - 01/01/1982
412063	Lachlan River at Gunning	20/05/1960 – ongoing
412065	Lachlan River at Narrawa	09/06/1960 – ongoing
412066	Abercrombie River at Hadley No.2	20/06/1960 – ongoing
412067	Lachlan River at Wyangala	03/12/1908 – ongoing
412074	Isabella River at Ballyroe	16/09/1966 - 04/08/1981
412084	Lachlan River at U/S Blakney Creek	06/05/1968 - 26/09/1984

An annual series analysis was performed on each station for which data of acceptable duration and quality from which to derive a series and the mean annual flood (MAF) determined. A plot of the mean annual flood against the catchment area is given in **Appendix D**. In addition, the ratio of the mean annual flood to the 100 year was determined to be 0.85. Using the two values, a plot of design flows against AEP was determined for the Wollondilly River and Mulwaree Ponds catchment at Goulburn. This is also presented in **Appendix D.**

From the revised flood frequency, the discharges adopted for the Wollondilly River and Mulwaree Ponds at Goulburn are given in **Table 3.3** below

Table 3.3: Peak Design Discharges

Flood Event (% AEP)	Peak Discharge (m^3/s)
1	2185
2	1585
5	1000
10	661
20	398

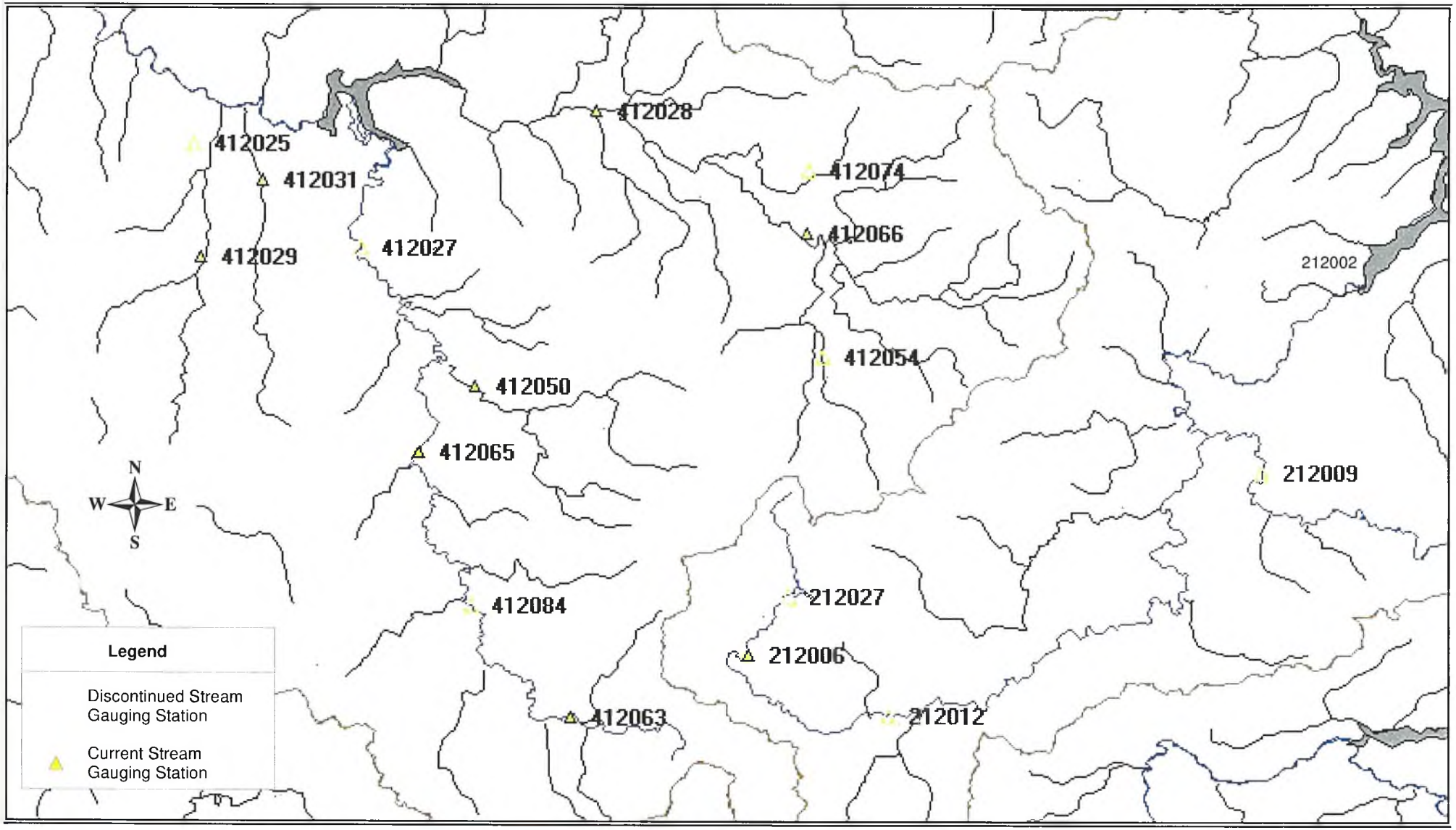
i Extreme Floods

The 1986 Flood Study did not calculate an extreme flood, as the Policy of defining flood prone land as land affected by the PMF was a requirement implemented in 2001, with the introduction of the Floodplain Management Manual. Therefore, to meet the requirements of the current State Government Policy, an extreme flood was estimated as part of the FRMS for Goulburn. With there being no extensive gauging records available for the Goulburn area, a number of other methods were used to estimate extreme flood events.

The PMF was estimated using Nathan et al (1994) and reviews of values derived in the dambreak studies for Sooley and Pejar Dams. An extreme flood was also estimated, being three times the flow for the 1% AEP event. It was assumed that this would have an AEP of 0.0001, or 1 in 10,000 chance of exceedance in a given year.

Various combinations of flows in the Mulwaree Ponds and Wollondilly River were input to the HEC-RAS model to assess flood levels and behaviour. The results were presented by SMEC for discussion at a meeting with Council and DLWC in August 2001. Following this meeting, Council directed that the extreme flood of three times the flow for the 1% AEP event was to be adopted as the extreme flood event for this study.

For the purposes of meeting Council's requirements for flood mapping, an estimate of the peak design flows for the 0.2% and 0.5 % AEP events was required. These were calculated using procedures outlined in ARR99 (IEAust 1999). The discharges adopted for the extreme floods for the Wollondilly River and Mulwaree Ponds at Goulburn are presented in **Table 3.4** .



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Level 5
118 Walker Street
North Sydney 2060

Goulburn City Council
Civic Centre
184-194 Bourke Street
Goulburn 2580

Wollondilly River & Mulwaree Ponds
Floodplain Risk Management Study & Plan

Figure 3.1: Gauging Stations

Table 3.4: Peak Design Discharges – Extreme Floods

Flood Event (% AEP)	Peak Discharge (m^3/s)
Extreme	6554
0.2	3890
0.5	2884

3.3.3 Results of Hydraulic Modelling

The revised flood discharges were input to the HEC-RAS model and it was run for each of the above design flood events. The hydraulic modelling results for each of these design floods are presented in **Appendix D**. There were some differences between the levels of the 1986 Flood Study and the results to come of this modelling. This is due to the revision of design discharges using additional data available since 1986 and updating of the model resulting from it being transferred from HEC-2 to HEC-RAS.

3.3.4 Extent of Inundation

An outcome of the 1986 Flood Study was a 1:10,000 flood reference plan. This shows the extent of inundation for the Wollondilly River and Mulwaree Ponds for the study area.

Following the update of the hydraulic model using HEC-RAS and the revised flood frequency analysis, this study has produced flood maps for the study area for the 5%, 1%, 0.5%, 0.2% and extreme flood events. These maps indicate the extent of flooding through the defined study area within the Goulburn LGA and are shown at Figures 31222-001 to 31222-005 inclusive in Volume 2 of this Report.

3.3.5 Affected Properties

There are significant numbers of both commercial and residential properties within Goulburn that are affected by major floods. **Table 3.5** summarises the numbers of developed, flood affected properties and a detailed analysis of these can be found in Section 7 dealing with flood damages. Figures 31222.001 to 31222.005 show the extent of the 5%, 1%, 0.5%, 0.2% and extreme floods in the study area.

Erratum Slip

Given the size of the Indicative flood extent maps (figures 31222-001 to 005) and Hazard Maps (figures 31222-006 to 007), they are not published in this Study and Plan but are available to view in hard copy format at Goulburn City Council.

Table 3.5: 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 3.6** lists the number of properties in Goulburn affected by the 1% AEP flood, based on a depth of water above floor level.

Table 3.6: 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	1	462
Between 3.0m and 4.0m	2	156
Between 2.0m and 3.0m	31	155
Between 1.0m and 2.0m	34	261
Above the floor level but less than 1.0m	55	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.

3.3.6 Roads

One of the flood impacts that significantly affects the Goulburn LGA study area 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 actually 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 not 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 both 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 Goulburn 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.

3.3.7 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.

3.3.8 Dambreak

As described in Section 3.1 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 9.

3.4 FLOOD RESPONSE

3.4.1 General

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.

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.

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.

With the importance of emergency management to the overall floodplain management strategy for the Goulburn LGA, it is essential that the relevant emergency plans are up-to-date and, even more importantly, consistent. The have been a number of issues identified to ensure all plans are compatible and contain the most recent information. These issues are discussed further in Section 8.

3.5 PREVIOUS FLOODPLAIN MANAGEMENT MEASURES

A number of flood mitigation options for the Goulburn area were identified and discussed in the Flood Study (1986). The works recommended included:

- Survey of flood affected areas;
- North Goulburn Levee Constuction;
- Eastgrove levee;
- House raising and voluntary purchase;
- Zoning and development controls; and
- Public education.

3.5.1 Survey of Flood Affected Areas

A survey of the floor levels and landuse in the flood affected areas was recommended to provide information with which to accurately assess potential flood damage and do a

cost/benefit analysis of flood mitigation measures. Since then, Goulburn City Council has undertaken its Local Environmental Study (1989) and assessed and rezoned land. The LEP was produced in 1990.

As part of this study, a detailed floor level survey was undertaken on those properties identified as being most at risk within the area affected by the 1% AEP event. Between March and May 2002, 116 properties were surveyed. This information was used to update floor levels on the residential flood damages database and in recommendations for management measures.

3.5.2 North Goulburn Levee Construction

This levee was conceptualised to protect the areas around Avoca/Derwent Street, generally following the course of the river channel from Victoria Street Bridge to Kenmore Street. This option was investigated as part of this study and is discussed further in Sections 8 and 9.

3.5.3 Eastgrove Levee

This levee was conceptualised to protect the lower lying areas of Eastgrove. This option was investigated as part of this study and is discussed further in Sections 8 and 9.

3.5.4 House Raising and Voluntary Purchase

This was recommended for the Eastgrove area, with eight houses being identified for voluntary purchase and twenty-three for house raising. Over time, Council has been applying this as a flood mitigation measure, and the effects are noticeable in inspections of the Eastgrove area during this study. Numerous houses now have their floor levels above the 1% AEP flood level, and residential properties that were the worst affected have been purchased and are now vacant blocks of land forming playing fields and open space.

As part of this study, this management measure ahs been further investigated and discussed in Sections 8 and 9.

3.5.5 Zoning and Development Controls

This is an effective means of containing the growth of potential flood damages and managing risk associated with development in flood prone areas. At the time of the 1986 study, Goulburn Council had already been applying development controls for several years. These controls have continued to be maintained and resulted in growth occurring that is generally flood sensitive.

As part of this study, this management measure ahs been further investigated and discussed in Sections 8 and 9.

3.5.6 Public Education

The following program for community awareness of flood issues in Goulburn was suggested:

- Flood markers throughout the town showing the depth of the 1961 flood;

- Permanent displays of flood maps and photographs;
- Distribution of a leaflet on flooding with rate notices; and
- Articles in the local press about flooding prior to the flood "season".

Of the 89 residential surveys received during the community consultation for this study, seven indicated that they had received information regarding flooding within their area, and all indicated that they felt this information was adequate to prepare them should they experience a flood. This information generally came from either the SES or Council.

While this response is encouraging, it is only 2.5% of the total number of households identified by Council's mailing lists as being affected by the 1% AEP flood event, indicating there was quite a low level of public awareness of flooding amongst the community. Many residents were not aware of the extent to which their properties could be inundated, and what action they could take to minimise the impacts on their properties

Education programs that outline the flood threat and encourage the community to take simple measures to reduce flood exposure need to be further investigated. The community needs to be more aware of the ongoing risk of flooding in the region. These matters are further discussed in Sections 8 and 9.

3.6 FLOOD MAPPING & HAZARD ASSESSMENT

3.6.1 Flood Mapping

Flood inundation maps and hazard maps have been produced using the MapInfo software. This allows the information to be used by Council in their GIS system in future. Council supplied topographic and cadastral information used in the mapping, together with a zoning map and aerial photography in digital format.

The location of the cross sections along the Wollondilly River and Mulwaree Ponds used in the hydraulic model was taken from the Goulburn Flood Reference Plan and digitised into the electronic maps supplied by Council.

Flood inundation maps showing the estimated extent of the 5%, 1%, 0.5% and 0.2% AEP and the extreme flood events has been prepared for the Goulburn LGA. The water levels were taken from the results of the HEC-RAS modelling of the Wollondilly River and Mulwaree Ponds.

The extent of inundation was determined using 3D-Mapps within MapInfo and based on 2m contour intervals. The extent of inundation for each flood was then plotted using in MapInfo. The results were compared to the previous inundation map for the 1% AEP event (WRC 1984). It should be noted that the ground level contours used have an accuracy of ±1m and while all care is taken in the preparation of the maps, the maps are not a definitive statement of the extent of flooding. The maps are indicative only and the actual extent of flooding on an individual property will require detailed survey by a qualified surveyor to determine both ground levels and flood levels.

The indicative flood extent maps are shown in Figures 31222-001 to 005 in Volume Two of this Report.

3.6.2 Hazard Mapping

Identification of the flood hazard category was determined in accordance with the NSW Floodplain Management Manual (FMM), 2001, with the assistance of recent technical papers further addressing the issue of hazard in flood prone areas.

The FMM defines flood zones into three categories, namely, "floodways", "flood storage" and "flood fringe". Floodways are areas with significant flow paths that should be kept free of obstructions, else upstream flood levels may increase. Flood storage areas hold significant volumes of water during floods and should not be filled (for development) else downstream flood discharges may increase. Flood fringe areas are inundated but pass no significant amounts of flood and hold no significant storage. These areas may be developed and filled without adversely affecting flooding, however it is considered that such developments should be conditional on measures to limit flood damages.

The FMM also categorises flood affected areas into two hazard categories, namely, "high hazard" and "low hazard". These categories are generally assessed on the basis of flow depth and flow velocity as indicated in Figure G1 and G2, Appendix G of the FMM. There are other factors that influence flood hazard including size of the flood, flood rate of rise, effective warning time, flood readiness and access or evacuation opportunities.

There are significant flood storage areas within the Wollondilly River and particularly the floodplains that contain the Mulwaree Ponds. Thus, all six flood categories may be applicable in the study area, namely:

- low hazard floodway;
- low hazard flood storage;
- low hazard flood fringe;
- high hazard floodway;
- high hazard flood storage; and
- high hazard flood fringe.

The flood hazard boundaries were initially determined using the HEC-RAS cross sections and results in conjunction with the flood inundation maps produced for the 1% AEP and extreme flood event. Typically the floodwaters within the Goulburn area are deep and slow moving, particularly in the Mulwaree Ponds, it being affected by backwater from the Wollondilly River. Therefore, hazard ratings were initially defined by depth, with all areas being greater than 1 m deep being defined as high hazard. In the remaining areas, the velocity depth product was used to assign the flood hazard boundaries. Hazard maps Hazard maps indicating the hazard categorisation, flow velocities and water level contours have been prepared for the 1% AEP and extreme flood event. These maps were produced using MapInfo and are published as Figures 31222-006 to 007 in Volume Two of this Report.

Taking all issues into account, particularly the depth of flooding, the limited warning time and generally rapid rise of water level, large areas in the floodplain are considered to be "high hazard". This hazard rating is not intended to sterilise the land for any use. Rather, it is a signal that any development that occurs in these areas should be planned

with due attention to the flood related issues and that strict implementation of flood related development controls is essential for the reduction of flood damages.

3.7 EVALUATION AND CONCLUSIONS

This review has highlighted key issues that need to be considered to determine appropriate management options. These issues are summarised below and the measures to address them are described in Section 8:

- There is a need to recognise and plan for the cyclical and random nature of flooding that affects the Goulburn LGA;
- There are a significant number of residential properties as well as many commercial and industrial properties that are flood prone in Goulburn. This situation is largely historical in nature and recent developments in the area are above the 1% AEP flood level and are designed to address flooding from local runoff within the development;
- Road access during flooding is an issue to some sectors of the community;
- A failure of either of the dams upstream of Goulburn poses a threat to areas along the Wollondilly River and emergency planning must take this issue into account;
- While flood emergency plans exist for Goulburn and its environs, there is a need to co-ordinate and upgrade these plans based on current knowledge and best practice;
- Flood awareness is generally quite low, especially since recent flooding has been of a minor nature and the experience of major flooding is disappearing with time; and
- Large areas the floodplains of the Wollondilly River and Mulwaree Ponds should be considered high hazard, mainly due to the depth of flooding, but also the relatively short warning time and the high velocities that occur during flooding.

4 PLANNING AND REGULATION REVIEW

4.1 BACKGROUND

On 27 August 1980, the Minister for Planning issued a direction under Section 117(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act 1979) requiring Councils to provide for the management of flood liable land and water catchment areas. As a result of this direction, Councils must have regard to the impacts of flooding when preparing planning instruments and policies.

The purpose of this section is to review and assess the current environmental and planning controls and policies relevant to management of flood liable land in Goulburn.

4.2 OVERVIEW OF FLOOD PLANNING MEASURES

A range of measures can be implemented for flood mitigation purposes. These measures generally involve applying various land use, planning and development controls to affected land to ensure inappropriate development or uses do not occur in high risk areas and potential property damage is limited to an acceptable level. An overview of these controls is presented below.

4.2.1 Land Use Zoning

The use of appropriate zoning on flood prone land is considered an effective long-term method of managing flood **risk**. However, the 1984 NSW Flood Prone Land Policy does not support the blanket use of zoning that unreasonably restricts development simply because land is flood prone. Land use zoning of flood prone land should be based on an objective assessment of hazard, environmental and other factors, such as:

- whether the land is in the high hazard or floodway category;
- the potential for future development having an adverse impact on flood behaviour, particularly the cumulative impact of ongoing development;
- the availability of access during flooding;
- the availability of safe evacuation routes;
- the need to exclude certain developments and uses due to additional or special risk to their users, for example, aged accommodation, hospitals and the like;
- the effectiveness of existing development controls; and
- the requirement under Sections 26 and 27 of the EP&A Act 1979 for a public authority to own or acquire land zoned as open space, environment protection or similar.

4.2.2 Flood Planning Levels

The concept of a 'Flood Planning Level' (FPL) was introduced in the 2001 NSW *Floodplain Management Manual: the management of flood liable land.* The concept of FPL supersedes

that of 'standard flood' used in the original 1986 version of the Manual and introduces flexibility whereby more than one FPL could apply to the same area. Different FPLs may be adopted for different land use zones based on the potential impact of flooding on each zone. Thus, a different FPL could apply on residential, industrial and commercial land.

Flood prone land is designated by the level of the probable maximum flood (PMF)[1]. Restricting development by using the PMF level as the FPL is neither feasible nor socially or economically desirable. Instead, a merit approach is used to determine a FPL that balances the flood risk with the economic and social benefits of using the flood prone land. A diverse range of factors must be considered in determining the FPL, including:

- long term strategic planning for land near and on the floodplain;
- existing and potential land use;
- impact on existing and future development;
- current flood levels used for planning purposes;
- changes in potential flood damage caused by the selection of a particular FPL;
- consequences of a flood above the FPL;
- ecological issues;
- flood warning, emergency response and evacuation issues;
- community flood awareness;
- creation of a false sense of security regarding flood risk;
- land values and social equity; and
- duty of care.

The FPL determines the area subject to specific flood-related planning controls and thus the selection of FPLs is an integral component of the floodplain management process. The FPL must be suitable to manage risk and provide development opportunities at the same time. If the adopted FPL is too low, development will be subject to excessive risk and the potential of damage is higher. Alternatively, if the FPL is too high, land may be subject to unwarranted controls restricting its productive use and economic value.

4.2.3 Building and Development Controls

Building and development controls provide a method of implementing detailed aspects of the Floodplain Risk Management Plan. While details of flood-related zoning are contained within a Local Environmental Plan (LEP), more specific development controls are implemented through Development Control Plans (DCPs) prepared in accordance with Section 72 of the EP&A Act 1979. Specifically, DCPs are used to set controls regarding:

- the provision of access to and evacuation from a site during flood events;
- fill and/or excavation in the floodplain;

[1] In this study, the extreme flood event adopted was that equal to a flow three times the 1% AEP peak design flow, rather than the PMF. This is discussed in Section 3 of this Report.

- flow of floodwaters across the site;
- freeboard;
- floor levels;
- structural soundness;
- building materials; and
- fencing.

4.3 REVIEW OF RELEVANT LEGISLATION, POLICIES AND INSTRUMENTS

A review of State and Commonwealth legislation and policies, and local planning instruments relevant to flood management is presented in **Appendix B**. A brief summary is presented for each item as well as comments on their relevance to flood planning in Goulburn.

4.4 SUMMARY OF ISSUES IDENTIFIED

A review of the effectiveness of Goulburn's land use planning instruments in relation to floodplain management measures was undertaken. The areas of concern identified in Goulburn's existing planning instruments are briefly summarised below:

- The 1(d) Rural (Flood Hazard) Zone is applied in a blanket manner across all land uses, and does not differentiate between flood hazard levels. In addition, application of a **rural** zone within some urban areas is inappropriate and potentially misleading;
- Clause 38(3) of the Local Environment Plan (LEP) is ambiguous – specifically, whether Council must be satisfied on **all** or only **some** of the matters listed;
- Clause 38(1A) of the LEP makes reference to a map that appears not to exist (Goulburn Local Environmental Plan 1990 – Flood Liable Land);
- Definitions in the LEP are out of date, such as flood liable land and flood standard;
- The LEP does not explicitly or transparently prohibit inappropriate land uses below the Flood Planning Level (FPL);
- Controls relating to development on land identified previously as affected in the 1:100 year flood and zoned 1(d) was not adequate. There are no controls on structural soundness, flood proofing, excavation etc, in the following relevant DCPs:
  - DCP No.1 – Residential Development Policy 1997 (residential development can occur on flood liable land – see LEP Clause 38(4)
  - DCP No.2 – Industrial Development Policy 1991
  - DCP No.4 – Development within the rural, open space and environment protection zones 1991; and
- The accuracy of Section 149 Certificates is questionable given the apparent absence of a flood map that shows flood extents and property boundaries. In addition, wording on Section 149 Certificates does not reflect best practice under the 2001 Floodplain Management Manual.

Based on the new flood model developed for this study, the levels for the 1% AEP event have changed, and in some cases increased slightly. Accordingly, there is additional land that is included within the flood planning area which would need to be appropriately identified in Council's planning instruments.

In light of the above issues, improvements to Goulburn's land use planning instruments focus on:

- ensuring consistent zoning of all land in the 1% AEP flood;
- changing the categorisation of land affected by the 1% AEP flood to reflect hazard levels;
- redrafting clauses and removing ambiguity;
- updating definitions;
- preparing a new flood map;
- providing additional development controls; and
- ensuring that Council complies with the guidelines specified in the 2001 Floodplain Management Manual.

5 COMMUNITY CONSULTATION

Community input to the Floodplain Risk Management Study and Plan has been sought throughout the process of its development. The aims of the consultation were to:

- clearly articulate the study's aims and objectives to the community;
- establish and maintain the interest and enthusiasm of the community in the study;
- ensure that the community has ownership of the study by involving them in the decision making process;
- ensure that views of all target audiences are heard and there is a two-way communication process established;
- utilise established community networks and links to disseminate information to the wider community;
- utilise the forums as a commencement of the flood awareness program;
- ensure that all material presented is in a clear and concise plain English manner; and
- establish clear lines of communication between the community and the consultants (and therefore the FWG) at the outset of the project.

The key elements of the consultation undertaken were:

a) collection of data and community input through direct surveys

b) maintaining public awareness of the Study through a newsletter and regular newspaper articles

c) utilising the membership of the Floodplain Working Group (FWG) as a conduit for community views throughout the Study

d) obtaining informal community input through public forums in Goulburn following the development of mitigation options

e) presenting the draft Floodplain Risk Management Study and Plan for comment via a period of public exhibition.

5.1 STAGE 1 CONSULTATION

The key objective of the first stage of the consultation process was to collect information from the community. In order to assist in the collection of data three survey forms were devised. These are provided in **Appendix E** (Social Survey) and **Appendix H** (Commercial and Property). The focus of the information collected is to assist in the flood loss analysis and the social impact assessment. A description of the information collected is provided below.

5.1.1 Residential Floor Level Surveys and Condition Reports

To estimate the flood damages caused by potential floods, information on property type and value was assessed for each individual dwelling. Initially, Council surveyed floor levels were not available for any of the flood prone properties, therefore an estimate of the floor level of each dwelling was also made.

All residential properties within the Goulburn LGA that are affected by the extreme flood event were surveyed. This resulted in 1277 residential surveys. The data collected for each residence was:

- type of property (house, unit, etc);
- height to floor;
- construction type;
- number of storeys;
- condition of building; and
- condition of garden.

For properties below the 1% AEP flood level, this information was collected in detail, while for properties above this level this information was averaged over each street block. Real estate agents were contacted and the local newspaper reviewed to ascertain the local values of properties. From this assessment, four value codes were established, which will be used in the establishment of damage curves.

5.1.2 Commercial/Industrial Surveys

A cross-section of commercial and industrial premises affected by the floods up to the extreme flood event were surveyed to identify the potential impacts that the range of flood events would have on the business in terms of physical damage and loss of trade. Most businesses surveyed were those potentially affected by flood events up to the 1% AEP. Many of these are located in the Braidwood Road area, however others were surveyed around the Lagoon Street, Grafton Street and Chatsbury Street areas. Details of location, business type and height to floor were recorded during the property information survey period for other commercial premises identified to be within the area affected by floods greater than the 1% AEP event.

The cross-section spanned by the surveys is representative of the types of commercial premises in the study area. A total of 46 commercial surveys were returned. A number of surveys were distributed to businesses and not returned. The data collected for each commercial survey comprised of:

- business details;
- types of buildings used by business, and details of their construction;
- height to floor;
- previous experience of flooding;
- cost of damage to stock and premises as a result of flooding;
- effect on trading as a result of flooding;
- likely future impacts in the event of an extreme flood;
- details of any future expansion of business; and
- any other impacts.

5.1.3 Social Impact Assessment

A social survey together with a newsletter was mailed to all residents within the 1% AEP flood event, using Council's database of flood-affected properties. The objective of the newsletter was to raise the community awareness of the project; provide information on the association of the current study with previous studies; provide an opportunity for the community to forward

feedback on flood history or raise any concerns; and advise the community of the Information Forum.

The objective of the social survey is to collect the following information from flood affected residents:

- resident information;
- previous experience of flooding;
- warning received of flood events;
- impacts experienced during and after previous flood events; and
- awareness of flood risks and procedures.

Council supplied the electronic lists of affected properties, to which the newsletters and surveys were sent. In all, 277 newsletters and social survey forms were sent out during the month of August 2001.

A total of 89 surveys were returned, from residents of various areas within the study area.

Residents were asked to identify any ways that flood effects could be minimised in the Goulburn Local Government Area. Various options for flood mitigation were identified, and are discussed further in Sections 8 and 9 of this report. A detailed summary of responses to the social survey is in **Appendix F**.

5.1.4 Individual Interviews

Discussions took place with Goulburn City Council, the SES, representatives from Landcare and environmental groups and DLWC regarding the behaviour of the flooding experienced in Goulburn. This allowed an understanding of the nature of the flooding to be developed. There were also a number of interviews with local residents who had experienced several floods and could provide vital information about the flood patterns experienced in the region.

5.2 STAGE 2 CONSULTATION

5.2.1 Public Meetings

The first public meeting was held on the 29 August, 2001 in Council chambers at 5.30 pm. The objectives of the meeting were to:

- Inform the community and key stakeholders on the process of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Study and Plan; and
- Address issues and concerns held by the community and stakeholders regarding floodplain management.

The second public meeting was held on the 21 February 2002. The objectives of the meeting were to gain feedback from the community and stakeholders on issues and concerns regarding the project. Proposed flood plain management options, flood modification measures, property modification and response modification measures were also presented. Written responses were

called for, and four responses were received. Minutes of each Public Meeting, together with notes regarding discussions and written responses are presented in **Appendix G**.

5.3 STAGE 3 CONSULTATION

The draft Floodplain Risk Management Study and Plan will be placed on public exhibition between *to be advised* and *to be advised.* Following the exhibition period, comments on this report will be taken into account and the Reports finalised and submitted to the Floodplain Working Group and Goulburn City Council.

6 SOCIAL IMPACT OF FLOODING

6.1 SOCIAL COSTS

The social damage caused by a flood should not be underestimated. It includes the increased levels of psychological and physiological stress imposed on flood-affected people. While loss of life is the most extreme social cost of flooding, there are also a number of lesser social costs. The term "intangible", which is associated with social costs, reflects the difficulty experienced in measuring social costs rather than their relative significance.

During the Brisbane floods of 1974, a number of residents reported feelings of "adventure" and "excitement" as they attempted to cope with the situation and evacuate their possessions. In the weeks immediately following the flood, however, these feelings tended to be replaced by feelings of depression and insecurity as people faced up to the realities, difficulties, financial costs and general inconvenience of repairing, replacing or discarding flood damaged items. Increased levels of marital stress were also reported in a number of cases (Cameron, McNamara & Partners, 1977).

A major flood causes a great deal of havoc to people's lives. Even if there is no loss of life, the lesser social costs are a very real consequence of flooding. Property owners and residents affected by flooding often report a feeling of intrusion and future dread or anxiety of an event over which they have no control. Social costs include the heartache and hurt associated with the loss of family photos, family heirlooms and other damaged items, the value of which is an emotional attachment rather than financial. These items are often described as priceless because they cannot be adequately replaced. As a result, the feeling of loss felt by those affected by flooding often exceeds the monetary value that can be attributed to flooding. In some instances the accumulated flood damage to the business community may be modest, but included in that may be sufficient loss to close a number of marginal businesses. In this case, the social cost far outweighs the financial cost.

To aid in the assessment of social costs from flooding in Goulburn, a mail survey was prepared and sent to all properties in residential areas of Goulburn subject to the 1% AEP flood. The survey questions (see **Appendix E**) gathered information concerning the history of flooding on a property; the extent of flooding and damages caused; emotional and lifestyle impacts of flooding on individuals; the extent of flood awareness among residents; and flood warning systems.

6.2 SOCIAL FINDINGS[2]

A total of 89 responses out of 277 survey forms (32% response rate) were returned. This is quite a good response rate, and demonstrates the high level of interest by some sectors of the community on this subject. Of these respondents, 32% resided in the Eastgrove area and 26% were in the area downstream of the Victoria Street Bridge (around Avoca / Bellevue Streets). The remainder of respondents were distributed across, or had properties in, the other flood prone areas of Goulburn, as shown in **Table F.1** in **Appendix F**.

[2] Percentages given in this section have been rounded to the nearest whole number.

6.2.1 Extent of Flooding

Of the 89 respondents, 45 (36%) indicated that they had previously been affected by flooding. Of these, 31% lived in the Eastgrove area, 31% were in the area downstream of the Victoria Street Bridge (around Avoca / Bellevue Streets) and 11% around Braidwood Road and Bungonia Road area. These figures are important in being able to determine the level of public awareness of flooding, and to understand the various impacts of flooding on residents' lives.

Based on the location of respondents affected by flooding, the streets most affected are shown below, with the full list appearing in **Table F.1** in **Appendix F.** The roads below accounted for 73% of all properties said to have been affected by flooding at some time:

- Avoca Street
- Emma Street
- Park Road
- Braidwood Road
- Fitzroy Street
- Victoria Street
- Bellevue Street
- Lower Sterne Street
- Bungonia Road
- Derwent Street

Of the 89 respondents to the survey, 35% (31 people) had witnessed or knew of more than five floods in the Goulburn LGA. A further 30% (27 people) had witnessed or knew of between three and five floods. 10% (9 people) of respondents had not witnessed or did not know of any floods in the LGA. Of the remaining respondents, 16% (14 people) had witnessed or knew of one or two floods, and 9% (8 people) did not respond to this question. **Table F.2** in **Appendix F** presents these figures. It can be concluded that a significant proportion of the respondents are aware or have extensive knowledge of flooding in their area. .

6.2.2 Emotion

In order to better understand the "intangible" impacts of flooding, those respondents who had witnessed or known of one or more floods (comprising 72, or 81% of, respondents) were asked a series of questions relating to their experience of flooding. The survey asked respondents to describe the emotions they felt during and after the flooding experience. **Table F.3** in **Appendix F** lists the emotions noted on the surveys. In order to assess their significance, these emotions have been categorised into four groups:

- negative emotional impact – high
- negative emotional impact – medium
- negative emotional impact – low
- neutral or positive emotional impact

Emotions conveyed that were of a high impact included fear, panic, anxiety and long term depression. Most respondents mentioned a variety of emotions, which crossed categories of high, moderate, and low negative impact and neutral/positive impact. Respondents were grouped according to the greater negative impact of the emotions they conveyed. For example, a respondent who felt both annoyed and distressed by flooding was placed into the high impact

category because of the feeling of distress, an emotion with higher negative impacts. On that basis, high impact emotions were experienced by 29% of respondents, moderate impact emotions by 6% of respondents, and low impact emotions by 32% of respondents. A third of the respondents, 33%, reported feeling neutral/positive impact emotions, claimed they were not affected by flooding or did not indicate the emotion experienced. These figures are presented in **Table F.3** in **Appendix F**.

In order to ascertain whether only those who were directly affected by flooding (45 respondents) experienced high or moderate emotions, analysis of only those directly affected by flooding was undertaken. Of those 45 respondents, 33% experienced high impact emotions; 9% experienced moderate negative impact emotions; 24% experienced low negative impact emotions; and again 33% experienced neutral or positive impact emotions with four of these not indicating the emotion. These figures are presented in **Table F.4** in **Appendix F**.

These figures reflect a slightly higher negative emotional impact of flooding among those whose own properties had been directly affected by flooded. A total of 42% of those whose properties had directly been affected experienced high to moderate negative emotional impacts; compared with 35% among the respondents who had witnessed or known of flooding.

Further, of the 21 people who expressed high impact emotions, 71% (15 people) were directly impacted by flooding on their property. Of the four who expressed moderate impact emotions, 100% (all 4 people) were directly impacted by flooding. Of the 23 people who expressed low impact emotions, 48% (11 people) were directly affected by flooding, while of the 24 people who expressed neutral or positive impact emotions, a larger proportion of 62% (15 people) were directly impacted by flooding. Obviously, the emotional impacts of flooding are escalated where a person's property is directly affected.

The impacts of floods on people experiencing these emotions were correlated with other survey results to attempt to find any particular impacts that may have caused this range of emotional impacts. Factors of lack of information and warning time are also linked to higher levels of stress during flooding.

Out of the 89 respondents, 13 people (15%) have been evacuated during flooding. Most respondents mentioned a variety of emotions due to the evacuation/s and were categorised using the same process as above. Sixty-two percent (8 people) of those who were evacuated conveyed emotions of a high negative emotional impact, which included feelings such as panic, distress and desperation. Nine respondents were evacuated from their homes for periods between "a few days" to two weeks, and the majority (though not all) of these experienced high negative emotional impacts. A further two respondents (15% of those evacuated) experienced moderate or low impact emotions, feelings of frustration or inconvenience. In addition, another two respondents (15%) stated that they were either not affected, while one respondent (8%) did not state the emotion they felt during the evacuation. These figures are presented in **Table F.5** in **Appendix F**.

Four respondents indicated that flooding threatened their lives – three of those experienced high negative emotional impacts such as panic and distress. Two of these people were evacuated, for a week in one instance, and two weeks in the other instance. The fourth person to indicate that flooding threatened their lives indicated that the emotion experienced was

inconvenience. However they noted that when living closer to the Wollondilly, flooding was "terrifying".

Of the 89 respondents, 28 indicated a length of time for which their lives were disrupted by flooding. Twelve of these respondents indicated the length of disruption to be 24 hours or greater. A variety of emotions by those disrupted due to flooding were mentioned by the respondents and categorised under the four categories described above. A total 32% of these respondents (9 people) experienced high negative impact emotions. A further 64% (18 people) experienced moderate or low negative impact emotions, and a further 4% (one person) experienced neutral or positive emotions as a result of disruptions caused by flooding.

A total of 18 of the 89 respondents (20%) indicated received no warning of flooding. As a result, five respondents (28% of those who received no warning) experienced high negative impact emotions. A slightly higher proportion of those 18 respondents (44%, or 8 people) experienced moderate or low negative impact emotions, where the most common emotion was frustration or inconvenience. A further four respondents (22%) experienced either neutral or positive emotions during the flood experience. One person (6%) did not specify the emotions they felt.

6.2.3 Lifestyle Impacts

There are several different lifestyle impacts flooding can have on the community. These include damage to their property, disruption due to access difficulties or evacuation.

The main forms of physical flood damage for residences were to fencing, gardens, machinery/equipment, furnishings, and building structure/floor/walls. Of the 26 respondents who stated that their property had been damaged by flooding, eight (31%) experienced high negative emotional impacts, two (8%) experienced moderate negative emotional impacts and eight (31%) experienced low negative emotional impacts. Only five (19%) experienced neutral or positive emotional impacts. Three (12%) did not indicate their emotional responses. Estimates of property damage were given by only three respondents, and these varied dramatically, from $50 to +$16,000. Damage to gardens was the most common flood impact reported by respondents (25 instances), with damage or loss of essential services being the second most commonly reported impact (10 instances).

Flooding in Goulburn has caused substantial disruptions to lifestyle through evacuation being required. Of those residents whose properties had been affected by flooding, 31% (8 residents) were forced to evacuate their premises. The emotional impacts of evacuation on people have been discussed above.

Apart from the impacts of evacuation, some of the greatest disruptions of flooding to people's lifestyle were access to friends, and to shopping and leisure facilities. Respondents were given a list of potential disruptions, and asked to select those that were experienced by them during flooding. Many people selected more than one disruption. Of the 84 respondents, 21% (19 people) reported disrupted access to shopping, 22% (20 people) reported disrupted access to friends, and 19% (17 people) said access to leisure facilities was disrupted. Access to work was disrupted for 17% (15 people) and 16% of respondents (14 people) said that access to school was disrupted.

Respondents were asked to indicate, given a list of potential impacts, how the disruptions mentioned above had affected them. A total of 28 respondents answered this question, with most indicating a combination of impacts. Longer travel times were the most common impact on people, affecting 54% of those who answered (15 people). Loss of convenience in shopping was mentioned by 43% of respondents (12 people). Taking time off work was mentioned by 4% of respondents (1 person), and loss of convenience with respect to work mentioned by 25% (7 people). Children missing school was not indicted to be an impact, but loss of convenience with respect to school was identified by 29% of respondents (8 people). Of the respondents, 58% (52 people) did not indicate if they were affected by the disruptions.

Other impacts on people included being unable to access livestock, loss of livestock, unable to pursue farming operations and loss of irretrievable personal property.

6.2.4 Length of Impact

As part of the survey, respondents were asked to indicate how long these disruptions to lifestyle lasted. Of the 28 respondents whose lifestyles were disrupted, 21% (6 people) indicated that the disruptions lasted between 1 and 3 days. The next most common response was that disruptions lasted for less than one day (14% of respondents, or 4 people). Disruptions continued for a week for 7% of respondents (2 people). For another respondent (4%), disruptions lasted as long as a fortnight. Six people indicated disruptions occurred, but did not quantify the duration.

Of those who had been forced to evacuate from their homes, the length of disruption was from a few days to two weeks, as discussed in section 6.2.1.

6.2.5 Community Awareness and Education

A significant way of minimising the impacts of flooding is to modify the response of the community to a flood threat. One of the most effective ways is to educate the community about flooding impacts within their area and to provide information on evacuation procedures, on how to minimise property damage, and on the recovery of an area once the flood waters subside.

A number of questions were included on the survey to gauge the level of awareness within the community. The following responses were obtained from the community.

i Amount of warning people were given about expected flood

Many respondents (at least 18 people, or 20%) indicated that they received no warning of impending floods. Of those who indicated they received warning, (55 % of the respondents to the survey) approximately 41% (20 people) 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 (6 people). Five respondents or 10% received one day's warning, while only 6% (3 people) received an hour or less notice. In addition, 22 respondents (24%) did not answer this question.

ii How people were advised of flood

Of those who received a flood warning and indicated the source of that warning (47 respondents or 53%), 17 people (36%), were notified by radio. The SES was also a major notifier, with seven people (15%) being warned by the SES. 28% (13 people) were warned by some combination of neighbours, friends, and/or the Council. Some people were dependent only on their own observation for flood warning (10 people or 21%).

iii Information received regarding advice on preparing for a flood

Out of the total of 89 people who responded to the survey, only seven respondents (8%) reported receiving information by mail about what to do in a flood. Of the 26 people who had received information, 2 (29%) said it had come from the Council, while three (43%) received information from the SES. Others stated the information had come from other government departments, or they did not remember the source. All seven respondents felt the information they received was adequate to make them aware of what to do in the event of a flood.

iv Preparation made in advent of a flood

Respondents were asked to indicate the preparations they would make in the advent of a flood. Of the 58 people who responded, preparations made included:

- move out;
- move valuables/belongings above water level;
- move livestock to higher ground;
- disconnect power/gas;
- follow directions from authorities;
- watch/listen to the radio; and
- assist others.

Three people indicated that they would make no preparations or would stay at home.

v Summary

A combination of the preparations mentioned above indicate that some members of the community would know exactly what to do to protect their lives, their family and property against a flood. However, there are others who would not. Given the generally low level of warning received (only 12% of respondents (11 people) indicated they received a day or more warning of impending floods), it is likely that many residents would need assistance to safeguard their property after a flood warning had been given. Without adequate assistance, risks to life increase as people attempt to secure their property in potentially hostile weather and environmental conditions. Elderly, farmers and those with machinery are likely to be placed in this position.

Survey results also highlight the need for a more effective warning system, to aid those who would make preparations in the event of a flood. The majority of respondents stated that they received warning of an approaching flood from the radio, themselves or their neighbours and friends. There is a need to increase awareness of the warning systems, where these are in operation. There is also potential for the local television network to increase assistance in warning people. Also, since so few respondents indicated that they had received information

in the mail about what to do in a flood, it would be beneficial to launch a community education program. This could take the form of a mail-out, static display, or some other median, with the purpose of increasing community awareness.

6.2.6 Living in a Flood Prone Area

Residents were asked why they chose to live in an area affected by floods. Twenty-six people answered this question, with many of them having a combination of reasons. All indicated they were unaware of the flooding risk. A further 12% (3 respondents) indicated it was affordable housing, 8% indicated the flood effects were minor or location and block what they were after and 4% expressed either no risk or the property was always their home.

Forty-seven percent (42 people) indicated that they were aware that their properties were flood prone when purchasing the property, while 38% indicated they did not know (34 people). Of those respondents who were aware, most had been informed by Council, their solicitor, real estate agents, or neighbours at the time of buying the property or a combination of these sources. A large proportion 64% indicated they had local knowledge of the flood problem. Five percent went on to indicate that they considered their property was above the flood level.

6.3 CONCLUSION

The social survey, mailed to residents in Goulburn LGA, received a 32% response rate. The 89 respondents were residents from across the flood prone areas within the Goulburn LGA. Key results of the survey were:

- 36% of respondents had previously been affected by flooding on their property. Most were located in either in Eastgrove area or around the area downstream of the Victoria Street Bridge;
- 65% of respondents had witnessed or knew of more than three floods in the Goulburn LGA;
- Of the 72 respondents who had previously witnessed or knew of flooding, emotions experienced were:
  - 29% high negative emotional impact;
  - 4% moderate negative emotional impact;
  - 32% low negative emotional impact;
  - 33% neutral or positive impact.
- Of the 45 respondents who had been affected by flooding on their property, emotions experienced were:
  - 33% high negative emotional impact;
  - 9% moderate negative emotional impact;
  - 24% low negative emotional impact;
  - 33% neutral or positive impact.
- Factors of evacuation, lack of warning of approaching floods and the length of time for which people were affected by floods, contributed to greater occurrence of high negative impact emotions such as panic, distress and anxiety;

- Other common impacts of flooding were physical damage to residences (up to $16,000 in damage estimates reported), disruption of access to shops, friends, schools, work and to leisure facilities;
- Respondents were disrupted by flooding mostly for a few days, though for some the disruptions lasted a fortnight or longer;
- A few respondents indicated they knew what preparations to make for a flood; however many would appear to be unaware of what is needed to be done, or do not see the need to be prepared; and
- Many chose to live in the area on the basis that flood effects were minor and housing was affordable. Many indicated that they were unaware of any flooding problem associated with their property.

These results show that, though the majority of respondents have witnessed or know of floods in Goulburn, just over a third have actually experienced floods on their property. Among the latter group, the emotional and physical impacts of flooding have been high, involving disruptions to lifestyle, in some cases evacuation and threat to life, and damage to residences. A need for greater flood awareness was highlighted by the number of respondents who had not received any information on how to prepare for a large flood, or did not indicate they would make appropriate preparations.

Based on the findings of the social survey a number of flood mitigation measures will be assessed to ascertain whether they adequately address the above impacts.

7 THE ECONOMIC IMPACTS OF FLOODING

7.1 INTRODUCTION

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.

7.2 FINANCIAL DAMAGES

The direct costs of flooding can be subdivided into the cost of damage to the actual structure of an inundated building, the cost of damage to its contents, and the cost of the immediate post flood clean up operations. These costs are referred to as "structural", "contents" and "clean up" costs.

The type of structural damage sustained by a building depends upon both the materials and manner of its construction and the depth of inundation and velocity of the floodwaters. Inundation by deep, fast-flowing floodwaters may actually wash a building away, whereas shallow, slow moving water may cause relatively minor structural damage.

A large proportion of the buildings exposed to potential flooding in Goulburn are used for residential purposes. The materials and manner of their construction are variable, most are of brick or fibro while others are of timber cladding. There are also a number of commercial and industrial properties, particularly around the Braidwood Road area, subject to inundation and damage. These are also of mixed construction, often with concrete floors at or just above ground level.

The damage to the contents of residential dwellings and out buildings includes the cost of cleaning, repairing or replacing flood damaged furnishings (carpets, furniture, etc), appliances, services (electricity, telephone, water supply and sewerage) and clothing. Flood damage to cars and other equipment stored on the property is also included in the contents category. Contents damage to commercial property includes damage to raw materials, plant and equipment, stock, and "incidentals". The last category includes damage to office furnishings, employees' possessions, and services.

After a flood has subsided, there is a concentrated clean-up period. It is common for community minded people and organisations to rally as volunteers to help in the clean-up of flooded houses. Walls require washing down, both inside and out, in an attempt to reduce silt

staining, silt is removed from the houses and irreparably damaged items are taken away for disposal. Similarly, volunteers and employees help in the clean-up operations at commercial establishments affected by the flooding.

The cost of immediate post flood clean-up operations is essentially the value of the time of those engaged in the clean-up process plus the cost of removing and dumping flood damaged materials, together with loss of business for commercial establishments.

7.3 INDIRECT DAMAGE

A flood can severely disrupt the goods and services provided by commercial establishments in the community (this includes industrial and rural ventures). It may take many weeks for a community to regain their pre-flood levels of productivity. The indirect flood damages to the community includes the loss of production, revenue and wages, which occurs during the flood and the post-flood recuperative phase. Indirect damages also arise in a number of other ways. For example, the disruption and diversion of traffic, both during and immediately after a flood, represents another indirect loss.

Indirect residential damages may include clean up costs, loss of wage or salary, cost of removal and accommodation and inconvenience and loss of amenity. Inconvenience and loss of amenity includes such factors as possible loss of schooling, the loss of personal mementoes, cancellation of social events and the like, many of which are intangible losses which are very difficult to quantify.

Indirect commercial damage may include costs of removal and storage, loss of business confidence and loss of trading profit. Smith's study of Lismore (1980) found that indirect costs were 18.5% of direct damage suffered by the commercial sector and 35% in the industrial sector. It is normal to include clean up costs as a direct damage. If it is incorporated into the equation as a percentage of indirect costs, then the indirect costs can be up to 25% of the total direct costs (Smith 1980).

7.4 ACTUAL AND POTENTIAL DAMAGES

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.

7.4.1 Commercial

For the purposes of calculating the commercial damages for the current study, a number of local property owners and business operators were interviewed, to ascertain the actual level and the potential level of damage experienced in recent floods. As the last major flood experienced in the Goulburn area that affected a large number of properties was in 1961, many of the commercial/industrial operators now in Goulburn do not have experience with flooding. Thus the actual damage estimates supplied were insufficient for an assessment of future flood damages. Some business operators were able to supply information on potential future damages.

Therefore damage estimates in this study were made based on potential flood damages, using values provided by business operators in Goulburn in the commercial surveys and supplemented by an extensive database of damages gathered by SMEC in previous floodplain management studies. (Gunnedah Floodplain Management Study (SMEC 1999); Upper Nepean River Floodplain Management Study & Plan (SMEC 2001)).

Initial estimates were derived based on there being adequate warning to raise/move items that were indicated as being raiseable in the commercial survey. For the purposes of damage assessment in Goulburn, flood damages for industrial properties were combined with flood damages for commercial properties.

7.4.2 Infrastructure / Public sector

A major component of infrastructure damage is concerned with transport – damages to roads, bridges and culverts and locally to rail and air connections where applicable. Other losses are to services such as water, sewage treatment plants, gas, electricity and telephones. The variability in terms of location, the period of inundation, problems of sedimentation and erosion are such that no standard technique is possible. Australian and international literature suggests that infrastructure damage is normally within the range of 7% to 20% of that to the private sector. (DI Smith et al 1986).

In this study, data on previous flood damage to roads was not available so the above estimate was adopted for damage to roads. Seven percent of the potential damages to the private sector was applied up to the 2% AEP, ten percent for the 1% AEP, fifteen percent for the 0.5% and 0.2% AEP and twenty percent for the extreme flood.

7.4.3 Residential

For the residential properties, it was necessary to derive estimates of potential flood damage for a range of flood magnitudes. In addition, it was necessary to take account of community "flood awareness" and their experiences in coping with floods, that is, the higher the awareness and experience, the lower the ratio of potential damages to actual damages will be. Preparedness of a community is a function of both the turnover of the population and the time since the last flood. The higher the awareness and experience, the lower the ratio of potential damages to actual damages will be. A reduction factor is applied to reflect community flood awareness and flood warning procedures.

Results from the social survey indicated that there is generally low level of flood awareness in the community (due to time since the last major flood in 1961 and the continuing population turnover) and there is limited application or knowledge of flood warning and emergency procedures. In reflection of these factors, a small reduction factor (0.9) was applied to the Study area.

The data obtained from actual flood damages was extended to include potential damages incurred in larger floods. The extension was based on information obtained from interviews and from floods experienced in other centres, such as Upper Nepean (SMEC 2001) and Gunnedah (SMEC 1999).

7.5 FLOOD DAMAGE ESTIMATES DERIVED IN THE PRESENT STUDY

This study estimates the flood damage likely to occur in Goulburn for the following two major damage categories:

- the **direct financial costs** of damage to property; and
- the **indirect financial costs** associated with the disruption of social, community, industrial and commercial relationships during the post-flood period. Indirect commercial damage may include, costs of removal and storage, loss of business confidence and loss of trading profit.

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. The equations used to calculate the potential damages that incorporate these factors are discussed further in **Appendix H**.

The residential indirect damages were estimated at 30% of the direct damages, however a reduction of 10% was allowed for the flood warning system being in place. These factors were based on a review of previous studies i.e. Upper Nepean (SMEC 2001), Gunnedah (SMEC 1999), and Tamworth (PPK 1993) and an assessment of the conditions within Goulburn.

As discussed above, many of the residents of the Goulburn area have not experienced heavy flooding. The last major flood (requiring evacuation) occurred in 1961, and only 14.6% of survey respondents indicated they had been evacuated. In addition, approximately 39% of respondents did not indicate that they would make appropriate preparations in the event of a large flood. Many in the community believe that only a few areas are flood prone, unaware that their residence lies within the 1% AEP flood area. This is not indicative of a prepared community, and it is likely that many of those who responded positively would not be truly aware of the scope of the response required in a major flood.

These issues result in a 10% reduction in potential damages being representative of the actual damages in the Goulburn area.

For commercial and infrastructure calculations, an allowance for clean up costs has been included in the indirect component. The direct damages were estimated based on curves relating flood height to level of damage sustained, then factored up by 25% for indirect damages. It is possible that the factors used in the estimation of indirect damages underestimates the true value of these damages. The current estimates are based on previous studies and experience, as the true value will only be determined when an actual flood occurs.

7.6 ESTIMATION OF FLOOD DAMAGE

A variety of factors affect the flood damage caused to a particular piece of property. In this study, the following three factors have been used to predict direct, potential flood damages:

- the use to which the land is put (hereinafter referred to as land use);
- the "size" of the buildings and other improvements associated with the land use; and
- the depth of flooding.

Land in the flood-prone areas of Goulburn is used for a variety of purposes, such as residential, commercial, industrial and recreation. Flood damage varies with land use.

The amount of damage that occurs on a particular piece of land tends to increase with the "size" or "scale" of the operations undertaken there, other factors remaining constant. Measures of property size can include annual assessed value ($) as the measure of size for residential and recreational property and floor area (m^2) for all other types of property.

For this study, damages for commercial properties were based on information obtained from interviews with individual owners/operators, supplemented by an extensive database of actual and potential damages from previous studies undertaken (Upper Nepean, SMEC 2001; Gunnedah, SMEC 1999). This information was analysed and estimates of damage for various components of each business was made e.g. stock, fittings, fixed or moveable machinery, etc and a flood level at which this damage would be sustained was assigned. All commercial properties were divided according to a business category, and by summarising the above data, an estimate of average damage made for each category based on a flood level.

For this study, the damage estimates applicable to residential properties were based on published data relating to flood damages and survey of properties in Goulburn. A damage curve was assigned to each residential property, which estimates the structural, contents and external costs. These curves were taken from previous studies and adjusted to suit property values in Goulburn.

A total of 1277 properties were surveyed and the data collected included:

- type of property (house, unit, etc);
- height to floor;
- construction type;
- condition of building;
- condition of garden; and
- a value code (5 were used).

Local real estate agents were contacted and local newspaper reviewed to ascertain the local property values that could be applied to factor each value code.

7.7 AVERAGE ANNUAL POTENTIAL DAMAGES

Average Annual Potential Damage (AAD) is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period and assumes that development is constant over the analysis period.[3] It has been calculated using the total financial potential damages (direct and indirect costs) for a range of flood events and the probability of the event's occurrence. Effectively, AAD is the area under the curve when these two variables are graphed.

Flood damages for existing conditions in Goulburn to residential properties are given in

Table *7.1*, damages to commercial/industrial properties are given in
Table 7.2 and damages to infrastructure are given in **Table 7.3**. A summary of the AAD for each sector is given in **Table 7.4**. Flood damages for the variety of flood events are illustrated as graphs in **Appendix H.**

Based on these calculations, the **total** AAD for the Goulburn LGA affected by the Wollondilly River and Mulwaree Ponds is estimated to be $398,300 (in round terms).

Table 7.1: Potential Flood Damages, Existing – Residential

Flood Event (AEP)	Damage	Number of Houses Affected
20%	$9,635	1
10%	$40,080	3
5%	$481,890	33
2%	$1,573,420	74
1%	$4,426,440	150
0.5%	$7,709,390	238
0.2%	$12,016,210	357
Extreme	$43,611,770	1165
Average Annual Damage	**$189,140**	

Table 7.2: Potential Flood Damages, Existing – Commercial/Industrial

Flood Event (AEP)	Damage	Number of Properties Affected
20%	$2,555	2
10%	$14,087	2
5%	$123,800	2
2%	$1,446,592	6
1%	$4,324,064	9
0.5%	$10,216,718	11
0.2%	$12,980,568	14
Extreme	$40,976,295	45
Average Annual Damage	**$179,095**	

[3] Floodplain Management Manual, NSW Government, January 2001 - Appendix H

Table 7.3: Potential Flood Damages, Existing – Infrastructure

Flood Event (AEP)	Damage
20%	$2,142
10%	$5,161
5%	$40,740
2%	$206,840
1%	$740,519
0.5%	$2,519,179
0.2%	$3,639,558
Extreme	$16,822,576
Average Annual Damage	**$46,790**

Note: In all the above, calculation of AAD the extreme flood (3 x 1% AEP flow) was assumed to have a 0.01% AEP (equivalent to an ARI of 10,000 years).

Table 7.4: Average Annual Potential Damages

Sector	AAD
Residential	$189,140
Commercial/Industrial	$179,095
Infrastructure	$46,790
TOTAL	**$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.

7.8 IMPACTS OF FLOODPLAIN MANAGEMENT MEASURES

The full range of floodplain management measures are identified and assessed in Section 8. Those identified as appropriate for detailed investigation were considered further and their impacts, including any reduction in flood damages, are discussed in Section 9.

7.9 REFERENCES

DI Smith, The Assessment of Urban Flood Damage in Australia: Methods, Problems and Recommendations, CRES, ANU, Australian Water Resources Council, Proceedings of the Floodplain Management Conference, Canberra, Australia, 7-10 May 1980

DI Smith et al, An Approach to Assessing the Effectiveness of Urban Floodplain Management in Australia, Hydrology and Water Resources Symposium 1986, Griffith University, Brisbane 25-27 November, 1986

8 FLOODPLAIN MANAGEMENT MEASURES

8.1 GENERAL

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 new and effective method of minimising the affect of floods. Examples of the range of measures is shown in **Table 8.1** below:

Table 8.1: Floodplain Management Measures

Flood Modification Measures	Property Modification Measures	Response Modification Measures
Flood Control Dams	Zoning	Community Awareness
Retarding Basins	Building and Development Controls	Community Preparedness
Levees	Voluntary Purchase	Flood Prediction and Warning
Bypass Floodways	House Raising	Flood Plans
Channel Improvements/ environmental enhancement	Flood Proofing Buildings	Evacuation Arrangements
Flood Gates	Flood Access	Recovery Plans

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 and managed. 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.

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 Plan needs to consider all three types of management measures and adopt an integrated and effective mix that is appropriate to the specific circumstances of the flood prone community. The options

suggested to form part of the Floodplain Risk Management Plan are summarised in **Table 8.4** following the discussion.

The Floodplain Management Options discussed were developed by SMEC in close co-operation with Council's Floodplain Working Group. The Goulburn Community also contributed ideas for Floodplain Management Options through the information questionnaire. The options suggested by the community are listed in **Table 8.2** below and these were considered in the development of the overall floodplain management approach adopted in the resultant Floodplain Risk Management Plan.

Table 8.2: Summary of Community Identified Potential Management Measures

Mitigation Option	Number of Mentions
Levee construction	2
Stream clearing / removing debris on the Wollondilly River and/or Mulwaree Ponds / removing willows	6
Drainage issues (includes enlargement, maintenance, cleaning)	1
Cut a channel through Eastgrove	1
Development controls / prevent natural flood area being reduced	1
Revegetate River banks and Floodplain	2
Detention basins	1
"Bee lining" Mulwaree Ponds	1
Provide more openings in the By-Pass	1

8.2 FLOOD MODIFICATION MEASURES

The purpose of flood modification measures is to modify the behaviour of a flood by reducing flood levels or velocities or by excluding floodwaters from areas at risk. Flood modification measures, by their structural nature, may have environmental and ecological impacts (positive or negative) and so any proposal for such works must be subject to detailed assessment in accordance with the existing planning and assessment legislation.

8.2.1 Flood Mitigation Dams

Flood mitigation dams reduce downstream flood discharges. As the flood wave passes through the dam, the dam is progressively filled to the point of overflow, trapping a portion of the floodwaters. The full dam then provides temporary storage for floodwaters subsequently passing through it.

The mitigating effects of a large dam on a major flood is often surprisingly small for the following reasons:

- the volume of water in a major flood may be much greater than the storage capacity of even a large dam;
- the dam may be nearly full at the start of a flood; and
- floods may result from rainfall in parts of the catchment that are not commanded by dams.

Consequently the benefits of flood mitigation dams are generally limited to mitigating the effects of a flood generated in only one portion of the catchment. For flood mitigation dams to be effective, it is essential that adequate airspace be retained to store water when a flood occurs. While compromises are possible, this generally limits and possibly precludes their use for other purposes, such as town water supply or irrigation. Besides the high cost of construction, there are environmental and social implications to be considered in the construction of a dam.

There are two water supply dams upstream of Goulburn in the Wollondilly River catchment – Pejar and Sooley Dams. Neither dam commands a significant catchment and they have only a limited impact on flood flows, particularly major to extreme flows. These dams are not suitable for raising to act as flood storages and any flood storage would have to be a new site, however suitable sites are limited. There is even less scope for a flood storage dam on the flat, wide Mulwaree Ponds.

The capital and maintenance costs for mitigation dams is considerable, and the economic benefits of a mitigation dam would appear minimal unless it could be multi-purpose, e.g. hydro-power and/or water supply.

This Management Option appears to offer some floodplain management benefits, however the benefit to cost ratio would be low. This option was **not recommended** for further detailed investigation.

8.2.2 Retarding Basins

A retarding basin is a small dam that provides temporary storage for floodwaters. It behaves in the same way as a flood mitigation dam, but on a much smaller scale. They are most effective in urban areas for small streams or floodways that respond quickly to rapidly rising flooding.

The catchments of the Wollondilly River and Mulwaree Ponds are rural and the effectiveness of basins would be minimal. However, while retarding basins are not a viable flood modification measure when addressing the river-sourced flooding in Goulburn, they are effected in addressing local flooding issues are management of an increase in runoff arising from development within local catchment.

Council already incorporates retarding basins in the developing areas, with three being located within the Goulburn LGA at present, and this approach should be continued in local catchments. Any basin will, however need to be sited outside the possible backwater influence of the rivers.

It is **not recommended** that this approach be investigated further for inclusion in the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.2.3 Levees

Levees are frequently the most economically attractive measure to protect existing development in flood prone areas. The height or crest level of a levee is determined by a variety of factors including:

- the economics of the situation (including the nature of development requiring protection);
- the physical limitations of the site; and
- the level to which floods can rise relative to the ground levels in the area (important in safety considerations).

A levee may rarely be called upon to achieve its design requirements. If it fails at this time because of poor design, improper construction or poor maintenance, the money spent on its construction has largely been wasted and the flood damages that had been "saved" were, in all probability, significantly increased. Even if design, construction and maintenance is exemplary, all levees will ultimately be overtopped by an 'overwhelming' flood.

There is a range of factors to be considered in the design and construction of a levee system, including:

- proper maintenance of the levee crest level, grass cover and spillways;
- development control measures for protected development behind the levee;
- emergency response plans for levee overtopping and evacuation;
- analysis of flow conditions that may develop when overtopping occurs and the flood continues to rise. In some situations high hazard conditions can develop in protected areas; and
- on-going community education to ensure that the population is aware of the risk of overtopping, is informed about emergency response plans and does not suffer a false sense of security simply because a levee has been constructed.

Some of the foregoing precautions do not apply when the probable maximum flood is adopted as the design event for levees. In such cases, important factors to consider include the maintenance of the levee and the provision of adequate freeboard against wave action and subsidence.

There are two localities within the floodplains of the Wollondilly River and Mulwaree Ponds that may benefit from levees – Eastgrove and downstream of the Victoria Street bridge. Subject to suitable design and conditions on protected structures, even limited height structures may provide flood protection for these areas.

There has been a suggestion from the community to construct works (a levee) to control backwater flows from the Wollondilly River into the floodplain of Mulwaree Ponds. This would require a large earthen structure with spillway to accommodate Mulwaree floods, together with drainage works to allow normal flows. It would be a significant structure across the floodplain that could be used as a recreational lake if the drainage capacity was limited, however this would require some specialised hydrologic investigations to ensure that any lake remains viable and does not become a swamp/bog.

It was **recommended** that this option be investigated in detail prior to final consideration for inclusion in the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.2.4 By-pass Floodways

By-pass floodways redirect a portion of the floodwaters away from areas at risk, and so reduce flood levels along the channel downstream of the diversion. However, by-pass floodways may exacerbate downstream flood problems.

Within the floodplains of the Wollondilly River and Mulwaree Ponds, there is little or no opportunity to mitigate flooding by use of a by-pass floodway. Any by-pass floodway would involve high environmental costs in the loss of many trees and high construction costs.

It is **not recommended** that this approach be investigated further.

8.2.5 Channel Improvements

The capacity of a drainage channel to discharge floodwater can be increased by widening, deepening or re-aligning the channel, and by clearing the channel banks and bed of obstructions to flow. The effectiveness of channel improvements depends upon the characteristics of the channel and the topography of the catchment.
In the floodplains of the Wollondilly River and Mulwaree Ponds, channel modifications have occurred along the course of the Mulwaree Ponds as the catchment has developed. Generally the creek morphology has changed by the clearing of overbank vegetation, introduction of infrastructure (road and rail) across the creek alignments and encroachment from development.

Although the Wollondilly River maintains some form and continuity, the Mulwaree Ponds shows signs of significant degradation of the river channel. Both channels exhibit, however, extensive willow growth and weed infestation.

Conventional channel improvements are not contemplated for the floodplains of the Wollondilly River and Mulwaree Ponds, as these would be visually unsightly, environmentally deleterious and, in all probability, socially unacceptable, even if there were significant flooding benefits. It is considered more acceptable to use this opportunity to enhance the floodplain environment through a detailed vegetation management plan. This plan would be designed to minimise hydraulic impacts while enhancing the floodplain environment. Goulburn Field Naturalists provided comments and suggestions on this matter and, if adopted, would be further contacted to ensure a suitable plan is drafted.

It is **recommended** that floodplain enhancement be investigated for inclusion in the Floodplain Risk Management Plan; with strategies developed for reinstatement of riverine habitat, re-establishment of the creek channel and erosion protection works.

8.3 PROPERTY MODIFICATION MEASURES

8.3.1 General

Property Modification Measures refer to modifications to existing development and/or land use and development controls on property and infrastructure. These measures are aimed at shepherding inappropriate development away from high risk areas, and ensuring that potential damage to developments at risk is limited to acceptable levels by means of requirements for minimum floor levels, flood proofing, etc. Appropriate land use control measures are a vital part of a Floodplain Risk Management Plan and are essential if the rate of growth of future flood damage is to be limited.

8.3.2 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.

The following are areas in which measures can be implemented which meet these objectives.

i Zoning

The NSW Flood Prone Land Policy does not support the use of zoning to restrict unjustifiably development simply because land is flood prone. However, the judicious division of flood prone land into appropriate land-use zones is an effective and long-term means of limiting flood damage to future development. Accordingly, flood-related zonings should be incorporated in a local environmental plan or development control plan in conjunction with the Floodplain Risk Management Plan.

Zones over flood prone land should be based on an objective assessment of hazard, environmental and other factors, for example:

- the objectives of the Floodplain Risk Management Plan (FRMP);
- whether the land is in the high hazard or floodway category;
- potential for future development to have an adverse impact on flood behaviour at existing developments, particularly the cumulative effects of on-going development;

- whether or not adequate access and evacuation is available during floods;
- whether certain activities should be excluded because of additional or special risk to their users, e.g. accommodation for aged people, hospitals and the like;
- the impact of floods on services such as power, potable water, sewerage and drainage or activities such as fuel storage or galvanising workshops; and
- the provision of public open space or environmental reserves.

It is **recommended** that amendment to the Goulburn LEP 1990 be considered as a significant part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

ii Building and Development Controls

Building and development controls provide a means of implementing detailed aspects of Council's Floodplain Risk Management Plan with respect to future flood hazard. Development Control Plans prepared under Section 72 of the Environmental Planning and Assessment Act, 1979 may appropriately implement the following building and development controls:

- access to and evacuation from a site during flood events;
- any fill or excavation in the floodplain;
- flow of floodwaters across the site;
- freeboard, as part of the Flood Planning Level and floor level controls;
- structural soundness when flooded;
- fencing;
- building materials;
- the cumulative impact of development, not only the impact of the development on other users of the floodplain but also the impact of development on the flood regime; and
- flood awareness.

It is **recommended** that building and development controls as part of a DCP be developed as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.3.3 Voluntary Purchase and House Raising

i Voluntary Purchase

The NSW Flood Prone Land Policy provides that in certain high hazard areas of the floodplain, it may be impractical or uneconomic to mitigate flood hazard to existing properties at risk, or flood modification measures significantly increase hazard to a property unable to be protected.

In such circumstances it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the danger and cost of future floods. This is achieved by the purchase of the properties and their removal or demolition as part of a

Floodplain Risk Management Plan. Under such circumstances, property should be purchased at an equitable price and only where voluntarily offered. Such areas should ultimately be rezoned to a flood compatible use.

ii House Raising

House raising has long been a traditional response to flood risk in New South Wales, as demonstrated by the number of raised houses in frequently flooded urban areas such as Lismore and Fairfield.

Avoidance of flood damage by house raising achieves the following three important objectives:

- a reduction in personal loss;
- a reduction in risk to life and limb and in the costs of servicing isolated people who remain in their homes to protect possessions; and
- a reduction in stress and post-flood trauma.

Not all houses are suitable for raising. Houses of single or double brick construction or slab-on-ground construction are generally either impossible or too expensive to raise, however the decision on this latter issue is very site specific. Houses best suited to raising are timber-framed and clad with non-masonry materials.

While raising a house may achieve the objectives described previously, care must be exercised in implementing this measure by considering the implications of a slightly higher than design flood. The new construction may be isolated during floods, necessitating an increased demand on emergency services should they be required. Thus it is essential that both the benefits and disbenefits of house raising are considered in the floodplain management planning process and any subsequent community education campaign.

iii Considerations for Wollondilly River and Mulwaree Ponds

The table below summarises preliminary findings for properties affected by over floor flooding in the floodplains of the Wollondilly River and Mulwaree Ponds for the 1% AEP and Extreme events. The number of houses identified is based on hydraulic modelling for existing conditions and floor levels derived from the contour base supplied by Council and site inspections.

It was found that 1034 houses would experience a depth of flooding greater than 2 m in an extreme event and 68 houses would experience a depth of flooding greater than 1 m in a 1% AEP event. These are shown in **Table 8.3** below.

Table 8.3: Properties Affected by Flooding

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

It should be noted that these figures are derived from detailed floor level surveys undertaken for properties affected by the 1% AEP flood and through estimates made during site inspections for those properties above the 1% AEP flood level.

It is **recommended** that Voluntary Purchase and House Raising be investigated in detail for final consideration for inclusion in the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.3.4 Flood Proofing of Buildings

Flood proofing refers to the design and construction of buildings with appropriate water resistant materials such that flood damage to the building itself (structural damage) and possibly its contents is minimised should the building be inundated.

At best, flood proofing is an adjunct to other management measures. Whilst flood proofing can minimise structural and possibly content damages to flood-affected buildings, the occupiers of flood-affected buildings still suffer the social and economic disruption of flooding.

To prevent or minimise structural damage from flooding, developments should be designed to withstand inundation, debris and buoyancy forces. Particular methods of construction and certain types of materials are better able to withstand inundation. For example, plasterboard and chipboard, both materials commonly used for the internal wall linings and cupboard fittings of a house, can be badly damaged on inundation and may have to be replaced. In contrast, double brick construction can withstand inundation and may only require a hose and scrub down when the flood subsides. In commercial buildings the adopted floor level is also affected by economic and commercial risk-taking considerations.

A flood proofing code or an enhancement of the planning matrix may be a viable option for inclusion in the DCP for Wollondilly River and Mulwaree Ponds.

It is **recommended** that Flood Proofing be investigated in detail for final consideration for inclusion in the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.3.5 Flood Access

Flood access is concerned with the access to all developed parts of the catchment during a flood event. In a developing catchment, it can be partly dealt with as a building or development control, with consideration also given to isolation of residences during a flood, the availability of alternative routes, and the issue of access routes for evacuation and/or emergency.

In floods up to the 1% AEP flood event, within the floodplains of the Wollondilly River and Mulwaree Ponds, the majority of properties have access to higher ground in the event of evacuation being necessary. The major access problems are in the vicinity of Bungonia and Braidwood Roads where, should evacuation become necessary, the roads may already be affected in other locations before the decision is made to evacuate.

In floods above the 1% AEP event up to the 0.2% AEP event, properties in Gibson Steet, Lower Sterne Street, Kerr Place Audubon Crescent, Neville Street, Ruby and Opal Street progressively all have isolated pockets as floodwaters rise. The areas north of the Wollondilly River and east of the railway embankment are also separated from the centre of Goulburn as bridges are cut.

As floodwaters continue to increase in an extreme flood event, the floodwaters of the Mulwaree Ponds and the Wollondilly River cut across Goulburn 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.

It is **recommended** that this option be investigated in detail as part of the consideration of the Flood Emergency Plan.

8.4 RESPONSE MODIFICATION MEASURES

8.4.1 General

Response Modification Measures encompass various means of modifying the response of the community 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.

Response measures, such as flood warning and evacuation procedures, can be of substantial benefit in their own right. Flood warning and evacuation plans can be very cost effective. In fact, they may be, in some cases, the only economically justified management measures.

It is **recommended** that Flood Response measures be considered as major part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

8.5 ASSESSMENT AND SUMMARY

8.5.1 General

The above options were presented to the FWG and to a Public Meeting on 21 February, 2002 for consideration, together with an initial recommendation as to which were considered feasible for further investigation. These options summarised in **Table 8.4** below.

The FWG then undertook a multi-criteria assessment of the options in **Table 8.4**, considering the social, environmental and economic impacts to the Goulburn LGA of each. The assessment is used as a guide to rank the floodplain risk management options in order of importance to the community. The criteria for the assessment is presented in Section 8.5.2, together with the summary of the responses received and the outcomes of the assessment given in 8.5.3.

Those options that received a medium or high rating were subject to detailed investigations, from which final recommendations were made. These investigations and the outcomes are presented in Section 9.

Table 8.4: Potential Floodplain Management Measures

Floodplain Management Measures	Comment	Recommended for Further Investigation
Flood Modification Measures		
flood control dams	Not viable under current conditions.	No
retarding basins	Not viable.	No
levee system	levee for Eastgrove may be viable – other areas may have significant hydraulic impacts - to be investigated.	Yes
bypass floodways	Not viable.	No
channel improvements / environmental enhancement	Major changes to river channels not viable however environmental enhancement is major option.	Yes
Property Modification Measures		
zoning	Needed to address existing and future flood problems.	Yes
building and development controls	Needed to address existing and future flood problems.	Yes
voluntary purchase and house raising	May be a viable option	Yes
flood proofing buildings	May be a viable option.	Yes
flood access	Not generally required. Flood emergency procedures needed to address access in some areas.	No
Response Modification Measures - Will require close liaison with SES		
community awareness	Surveys indicate need.	Yes
community preparedness	Surveys indicate need.	Yes
flood warning and emergency plans	Essential part of overall Floodplain Risk Management Plan. SES to develop Local Flood Plan in parallel with FRMP.	Yes
evacuation procedures	Essential part of overall Floodplain Risk Management Plan. SES to develop Local Flood Plan in parallel with FRMP.	Yes
recovery procedures	Essential part of overall Floodplain Risk Management Plan. SES to develop Local Flood Plan in parallel with FRMP.	Yes

8.5.2 Outcome of Assessment

i 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 8.5**. 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.

Table 8.5: 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?

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.

All members of the FWG were invited to assess the options. Responses received are presented in **Appendix I**. Scores were compiled and the average shown in **Table 8.6**.

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) may be beneficial to the community.

ii Outcomes of Assessment

Based on the findings of the Flood Damages and Mitigation Options Report and the scores in the Options Assessment, the following Floodplain Management Options have been selected for detailed investigations:

From **Table 8.6** the ranking of options is:

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

The detailed investigations and final recommendations are presented in Section 9.

Table 8.6: Assessment of management options

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.
Mulwaree River Levee (Lake)	43			34		45	41	40.7	Very poor economically and environmentally.
Flood Control Dam	33			43	28	52	41	39.4	No feasible sites available

9 ASSESSMENT OF MANAGEMENT OPTIONS

9.1 GENERAL

Based on the results of the assessment by the FWG, further investigations were undertaken to determine which options were appropriate for final recommendation in the FRMP for Goulburn. These investigations are detailed below.

9.2 FLOOD MODIFICATION MEASURES

9.2.1 Floodplain Environmental Enhancement

Site inspections by SMEC and community consultation have 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. The hydraulic effect of dense vegetation can be modelled through the Manning's 'n' value, a measure of hydraulic roughness used in the HEC-RAS model. During the site inspections, data was collected and photographs taken to allow estimates to be made of 'n' values that reflected the willow growth within the various reaches of the river channels and floodplains. This information was supplemented by aerial photography for the Goulburn LGA subsequenty supplied by Council.

The areas noted as being most overgrown with willows and therefore with the most significant increases in the 'n' values were:

Mulwaree Ponds
- In the vicinity of the Landsdowne Bridge, both upstream and downstream; and
- Downstream of the Rail Bridge.

Wollondilly River
- Upstream of the Marsden Bridge; and
- From downstream of the Victoria Bridge by a couple hundred metres, to the confluence with the Mulwaree Ponds.

The worst affected reach noted was that from a couple hundred metres downstream of the Victoria Bridge, to several hundred metres downstream of the Taralga Bridge and Tully Park Golf Course (beside the treatment pond).

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.

Removal of the willows would have the effect of reducing flood levels, however it should be noted that this would be combined with increased flow velocities in the rivers, leading to erosion and siltation problems downstream. Therefore, the resolution of this issue requires appropriate strategies to mitigate against both potential flooding and erosion problems.

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 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.

It is **recommended** that the Native Vegetation Enhancement Strategy be adopted as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

9.2.2 Eastgrove Levee

Two separate alignments were considered for the Eastgrove levee, shown on **Figure J.1** in **Appendix J**. These two alignments were modelled in HEC-RAS by inserting a levee at the relevant cross sections. An additional cross section was interpolated to allow the levee to be modelled at the northern end of Eleanor Street. The levee was set to provide protection for the 1% AEP flood event.

The hydraulic model results for each were very similar, and indicated that there would be a potential increase in water levels upstream of 10 mm and a potential increase in velocities of 0.04 m/s within the vicinity of the levee. These are minor hydraulic impacts.

A preliminary estimate of the costs and the size of this levee were made, based on a side slope of 2:1 on the river side, 4:1 on the dry side and a 3 m wide crest width. The approximate length of the alignment was 1.15 km. With a 2.5 m high levee (allowing for 0.5 m freeboard), this gives a footprint of 18 m. The preliminary cost estimate was $1.34 million, which included site clearance, importing fill, construction and finishing and landscaping.

These dimensions, hydraulic results and costs were presented to the FWG on 10th April, 2002 for their consideration. It was decided that this option was not to be adopted due to social, environmental and economic impacts.

Construction of a levee in the Eastgrove area is **not recommended**.

9.2.3 Victoria Street Levee

Two separate alignments were considered for the Victoria Street/Roberts Park levee, shown on **Figure J.2** in **Appendix J**. Both levees were set to provide protection for the 1% AEP flood event. The first was run along behind the Police Youth Club, giving the shorter of the two alignments, approximately 0.6 km long. The second alignment was 1.1 km long and encircled the Roberts Park area, allowing this area to remain available for flood storage.

These two alignments were modelled in HEC-RAS by inserting a levee at the relevant cross sections. A number of additional cross sections were interpolated between cross sections 10 and 11 to allow the levees to be correctly modelled.

➢ *Alignment One*

The hydraulic model results for the first alignment, behind the Police Youth Club, indicated that there would be a potential increase in water levels upstream, beyond the Victoria Street Bridge of 220 mm (cross section 14), decreasing to 140 mm at Albert Street (cross section 17). This was accompanied by a potential decrease in velocity upstream of .13 m/s and an increase in velocity of up to 0.4 m/s within the vicinity of the levee.

A preliminary estimate of the costs and the size of this levee were made, based on a side slope of 2:1 on the river side, 4:1 on the dry side and a 3 m wide crest width. An average height of 2.5 m was used in the calculations, (allowing for 0.5 m freeboard), giving a footprint of 18 m. The preliminary cost estimate was $712,000, which included site clearance, importing fill, construction and finishing and landscaping.

These dimensions, hydraulic results and costs were presented to the FWG on 10th April, 2002 for their consideration. It was decided that this option was not to be adopted due to the adverse impact on flood levels upstream.

➢ *Alignment Two*

The hydraulic model results for the second alignment, around Roberts Park indicated that the increase in water levels upstream would be less than the above alignment, but still significant with a 200 mm potential increase upstream of the Victoria Street Bridge of 220 mm (cross section 14), decreasing to 130 mm at Albert Street (cross section 17). At the downstream end of the levee however, the potential increase in water levels was 220 mm, where water was again constricted by the presence of the levee. This was accompanied by a potential decrease in velocity upstream of 0.12 m/s and an increase in velocity of up to 0.55 m/s within the vicinity of the levee.

A preliminary estimate of the costs and the size of this levee were made, based on a side slope of 2:1 on the river side, 4:1 on the dry side and a 3 m wide crest width. An average height of 2.5 m was used in calculations for the sections following the first alignment, and 1.0 m for

sections around the Park. This gave a footprint of 18 m and 9 m respectively. The preliminary cost estimate was $908,000, which included site clearance, importing fill, construction and finishing and landscaping.

These dimensions, hydraulic results and costs were presented to the FWG on 10th April, 2002 for their consideration. It was decided that this option was not to be adopted due to the adverse impact on flood levels upstream.

Construction of a levee in the Victoria Street/Roberts Park area is **not recommended.**

9.3 PROPERTY MODIFICATION MEASURES

9.3.1 Land Use Management

This section provides recommendations and options to manage flood prone land in Goulburn. The recommendations are designed to bring Goulburn in to line with current best practice and are based on the land use management guidelines specified in the 2001 Floodplain Management Manual.

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 outlined in Section 8 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. The maps show the level of the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and extreme events. Flood hazard maps for the 1% AEP and extreme events also differentiate between high and low hazard areas.

It is **recommended** that new flood maps prepared as part of this study be adopted.

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.

It is **recommended** that the 1% AEP flood level + 0.5 m be adopted as the Flood Planning Level in Goulburn.

iii LEP amendments

Amendments to the LEP focus on rezoning flood affected land, providing for appropriate land uses and redrafting clauses.

Land use zone changes

- **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.

  Two other options were considered for rezoning, but these were not recommended. These were:

  Retain existing zoning – Council could elect to retain the current 1(d) – Rural (Flood Hazard) zone for land inundated in the 1% AEP event. While this option would obviate the potentially complex process of rezoning, it would not be in line with best practice. Firstly, continuing with existing zoning would not include all land subject to higher flood levels, both old land previously identified and new land identified by this flood study. This is inequitable as different properties subject to the same flood risk could be zoned, and thus treated, differently. Secondly, the 1(d) – Rural (Flood Hazard) zone is a misleading label for land within urban areas.

  Rezone flood affected land to Zone 2 – Living Area Zone – In this option, the 1(d) – Rural (Flood Hazard) zone would be eliminated from urban areas, with flood affected urban land being rezoned to the existing Living Area Zone. This would improve the clarity and simplicity of Goulburn's land use zoning and could be more acceptable than zoning some land Residential (Flood Planning). Under this option, flood affectation would be shown only on the flood map. On the other hand, however, zoning flood affected land the same as non-affected land may create the impression that a flood risk does not exist.

- **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.

It is **recommended** that the above zoning changes be adopted as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

Flood categories

The LEP and DCP should define the various flood hazard categories, as outlined below:

- 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.

It is **recommended** that these hazard categories should be adopted as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan for use in the Goulburn LEP and Flood DCP.

Permissible Uses

The following permissible uses have been defined for land uses within flood prone areas within Goulburn:

Table 9.1: 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%.

It is **recommended** that the table defining permissible land uses be adopted as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan and incorporated into the Goulburn LEP.

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."*

It is **recommended** that these LEP amendments be adopted as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan and incorporated into the Goulburn LEP.

iv Flood Development Control Plan

It is **recommended** that Council adopt a Flood DCP which includes the above content as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management 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 proposed 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. 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 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 (refer **Appendix K**).

  - **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.

v Section 149 Certificates

It is **recommended** that the following information 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.

It is **recommended** that the following information 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.

vi Definitions

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.

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.

It is **recommended** that these definitions be included in the LEP and Flood DCP.

It is **recommended** that Council adopt a Flood DCP which includes the above content as part of the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan.

9.3.2 Voluntary Purchase, House Raising and Flood Proofing

i 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 8.1) .

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.

ii 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.

iii Economic Impact

As detailed in Section 7, a detailed flood damages analysis was made for the residential, commercial and industrial areas of Goulburn that may be flood prone. The analysis established that the Average Annual Damage (AAD) in Goulburn is $415,025 of which the residential sector contributes $189,140.

The recommended floodplain management measures, voluntary purchase, house raising and flood proofing, all of which relate solely to the residential sector, were applied to the property database used to calculate the existing AAD. This was done by:

- eliminating all damages for properties proposed for voluntary purchase; and
- eliminating internal damages and structural damages for house raising and flood proofing.

As shown in Table 9.2 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 9.2: 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.

iv Benefit/Cost Ratio

As evident from **Table 9.2**, 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:

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

9.4 RESPONSE MODIFICATION MEASURES

9.4.1 General

Response Modification Measures encompass various means of modifying the response of the community 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.

Response measures, such as flood warning and evacuation procedures, can be of substantial benefit in their own right. Flood warning and evacuation plans can be very cost effective. In fact, they may be, in some cases, the only economically justified management measures.

9.4.2 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.

Flood Warning (Australian Emergency Manuals Series, Volume 3, Guide 5, Emergency Management Practice Guidelines) describes a Total Flood Warning System, comprising the following stages:

- Prediction of flood severity and time of onset of particular levels of flooding;
- Interpretation of the prediction to determine flood impacts on the community
- Construction of warning messages describing what is happening, the expected impact and what action should be taken;
- The dissemination of such messages;
- Response to the warnings by the agencies involved and the community; and
- Review of the warning system after flood events.

These components, as they apply to the Goulburn LGA, are discussed below and recommended actions within the Floodplain Risk Management Plan are highlighted.

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.**

Costs

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

Table 9.3: 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.

The **recommendations** for the prediction process are:	
Stream Gauges	1. Additional automatic rain gauges built in the catchments of both Wollondilly River and Mulwaree Ponds. 2. Additional stream gauges be constructed in the catchments of both Wollondilly River and Mulwaree Ponds. 3. The rain and stream gauges linked into the Bureau of Meteorology system to allow real-time flood predictions for the City.

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 Risk 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 report.

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 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 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 Section 9.4.3 below.

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 (Section 9.4.3).

9.4.3 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 be implemented, having regard to the following 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).

9.4.4 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.

It is **recommended** that the range of Emergency Plans be amended or upgraded in addition to the recommendations in Section 9.4.2 as below:

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.

9.4.5 Economic Benefit of Flood Prediction and Warning

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 9.4** 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 9.4: Potential AAD with Recommended Flood Warning and Prediction System

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

Benefit/Cost Ratio

From **Table 9.4**, 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 9.3**, the costs of implementing the total scheme are $80,000, plus there will be 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:

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

9.5 COMBINED ECONOMIC BENEFIT

Using the estimates presented for the economic analysis of property modification measures and response modification measures in 9.3.2 and 9.4.5 respectively, a combined benefit/cost has been derived for the property modification and response modification measures and is presented below:

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

10 CONCLUSIONS

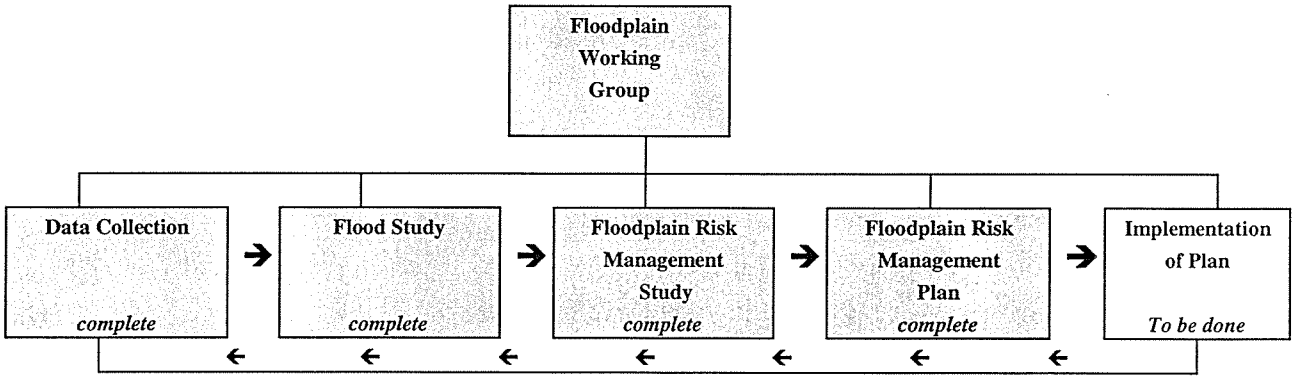
10.1 GENERAL

The formulation and implementation of a Floodplain Risk Management Plan is the cornerstone of the NSW Government's Flood Prone Land Policy. Such plans eliminate the need for ad hoc decision-making, a process that has contributed to many of the present day floodplain problems.

The Floodplain Risk Management Plan is directly linked to Council's strategic planning process for its area of responsibility. During the preparation of this Study, the merits of different degrees and types of development in the various flood prone areas have been given detailed consideration. It is only during the formulation process that proper and full consideration can be given to the full range of land use and management options and their interaction with flood risk.

Broad community involvement in the Floodplain Risk Management Planning process, from the very beginning, will result in community acceptance of and commitment to the resulting plan. This has been undertaken as part of the preparation of this Study.

The steps involved in formulating and implementing a Floodplain Risk Management Plan are shown below.



This Report, the Floodplain Risk Management Study, identifies and compares various management options, including a multi-criteria assessment of their social, economic and ecological impacts, together with opportunities to maintain and enhance river and floodplain environments.

The Floodplain Risk Management Study draws together the results of the previous flood study, an update of the hydraulic model and flood frequency analysis, and the data collection exercises. The flood study provided information on flood behaviour and previously recommended floodplain management measures. The results of the hydraulic model provided information on flood hazard and a means of assessing the impact of options emerging from the floodplain management studies on flooding behaviour and flood hazard. The data collection exercise provides the necessary information to assess the social, economic and ecological costs

and benefits of proposed strategies.

Management options investigated in the study may seek to modify a flood (levees, dams, etc.), modify land use and development controls (zoning, building regulations), or be aimed at achieving a more effective community response to the onset and aftermath of floods (flood plans and community awareness). In each of such options, opportunities were sought for the enhancement of the ecological well-being of the floodplain. In this regard, options considered included floodplain usage changes like house raising and voluntary purchase of hazardous flood prone property as well as environmentally positive design of any works.

Often, no single floodplain management option will suffice by itself. The determination of the optimum mix of measures, as undertaken in this Study, involved extensive community consultation and the careful balancing of social, economic and environmental issues, as well as flooding issues. In assessing the impact of proposed developments on flooding behaviour elsewhere, **it is incorrect** to assess developments on an isolated and ad hoc basis. Their effects must be assessed on a **cumulative basis** within the context of the Floodplain Risk Management Plan. This includes both the effect of development on flood behaviour and the number of people who may have to evacuate.

10.2 FLOODPLAIN MANAGEMENT MEASURES

10.2.1 General

A wide range of floodplain management measures were developed for the Goulburn LGA and presented in Section 8. These measures are summarised in **Table 10.1**.

Table 10.1: Floodplain Management Measures

Flood Modification Measures	Property Modification Measures	Response Modification Measures
Flood Mitigation Dams	Land-use Zoning	Flood Prediction and Warning
Retarding Basins	Building and Development Controls	Emergency Planning
Levees	Voluntary Purchase	Community Awareness
Bypass Floodways	House Raising	Community Preparedness
Channel Improvements/ environmental enhancement	Flood Proofing of Buildings	Flood Plans
	Flood Access	

These options were presented to the FWG and the Community in a public meeting on 21 February, 2002. Feedback was received and the multi-criteria assessment undertaken. The outcomes of this process indicated which options were considered appropriate for detailed investigation.

Section 9 presents the detailed investigations undertaken for each of these options and the final recommendations made for inclusion in the Wollondilly River and Mulwaree Ponds Floodplain

Risk Management Plan. During this period, consultation continued with the relevant stakeholders, including Council, SES, Landcare groups, Goulburn Field Naturalists, etc and the FWG.

10.2.2 Final Recommendations

The final recommendations for floodplain management measures are summarised in **Table 10.2** below.

10.3 FLOODPLAIN RISK MANAGEMENT PLAN

The recommendations and findings of the Floodplain Risk Management Study have been incorporated into a draft Floodplain Risk Management Plan, presented in Volume Three of this Report.

Table 10.2: Summary of Recommended Floodplain Management Measures

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 within Planning Documents	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 development above flood planning levels in flood affected	Yes	Sections 8.3.3 and 9.3.2

Management Option	Objective	Recommended for inclusion in the FRMP	FRMS Reference
	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