GRAFTON AND LOWER CLARENCE FLOODPLAIN RISK MANAGEMENT PLAN



Clarence River in flood, March 2001



Brushgrove Hotel, March 2001



Lawrence, March 2001



Palmers Island Village, March 2001

Volume 1 – Main Report

June 2007

Bewsher Consulting Pty Ltd

GRAFTON AND LOWER CLARENCE FLOODPLAIN RISK MANAGEMENT PLAN

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June 2007

Report of Clarence Valley Council's
Clarence Valley Floodplain Management Committee, prepared by

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PREFACE

The Grafton and Lower Clarence River Floodplain Risk Management Plan was prepared by Bewsher Consulting Pty Ltd for the Clarence Valley Floodplain Management Committee and Clarence Valley Council. Assistance has also been provided by WBM Oceanics Australia on flood modelling and Don Fox Planning on planning issues.

Funding and technical assistance was provided for the study through the Department of Natural Resources (formerly Department of Infrastructure, Planning & Natural Resources) under the State Government's Floodplain Management Program. Funding was also provided by the Commonwealth Department of Transport and Regional Services, through its Natural Disaster Risk Management Program.

This Plan is based on a review of previous floodplain management studies and other flood investigations carried out in the study area, including the Lower Clarence Flood Study Review (WBM, 2004). The Plan recommends a range of measures to manage the flood risk at Grafton and throughout the Lower Clarence Valley.

A draft Plan was placed on public exhibition from October to December 2006. A public meeting was also held on 27th November 2006 to discuss the draft recommendations. Feedback received from the community following the exhibition and public meeting is summarised in Appendix C.

In January 2007, the State Government issued new Flood Planning Guidelines which have some implications in regard to recommended planning controls. Further discussion on this issue is included in Section 4.5.9.

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SUMMARY

Reasons for the Plan

A floodplain management study and plan was previously prepared for the Lower Clarence Valley (Maclean Shire Council, 1999). A floodplain management study was also prepared for South Grafton (Paterson Consultants, 2000) and numerous flood investigations have been undertaken for other specific areas. The purpose of the current report is to review and amalgamate the findings from these previous studies into a single plan covering the majority of the Lower Clarence Valley floodplain. This is particularly pertinent given:

i) the amalgamation of the four former Council areas into a single Clarence Valley Council, and the desirability to adopt uniform policies and approaches to floodplain management throughout the Valley;

ii) results from a recently completed Lower Clarence River Flood Study Review (WBM, 2004), providing improved flood information throughout the Lower Valley; and

iii) recent updates of the Floodplain Development Manual (NSW Government, 2001, 2005) which places increased emphasis on managing all floods up to the probable maximum flood (PMF), and the importance of emergency management planning.

Responsibilities

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake floodplain management studies and plans, such as the current project, and for the implementation of works identified in these studies.

Clarence Valley Council's floodplain management committee oversaw the preparation of the Plan. The committee includes councillors and Council staff, officers from the Department of Natural Resources, the State Emergency Service and community representatives.

Study Area

The study area essentially covers Grafton and the Lower Clarence River floodplain downstream of Junction Hill, except those areas that are covered by separate floodplain management studies that are being undertaken by others.

Report Structure

The Floodplain Management Plan has been prepared as two Volumes. **Volume 1** (this document) presents a summary of the key findings of the review of previous investigations and presents the recommended floodplain management plan. **Volume 2** presents a compilation of working papers that have been prepared during the course of the study. The working papers allowed the floodplain management committee to monitor the project, and to provide direction where required. Full copies of the working papers are also included on a CD attached to the end of this report.

Flood Behaviour

Flood behaviour is extensively documented in the 2004 Lower Clarence River Flood Study Review (WBM, 2004). Drawing 40 from that report shows that the majority of the floodplain would be inundated by over 3m in a 100 year flood, and represents a high flood hazard.

Information on the number of properties susceptible to flooding is limited. Whilst some data on floor levels is available in previous reports, much of this data is old, incomplete, or properties are difficult to locate. It is not possible to prepare a comprehensive database of flood affected properties in the Lower Clarence Valley floodplain with the data that is currently available.

There has also been a perception that the levees at Grafton and South Grafton provide complete protection against the 100 year flood. Based on the latest Flood Study Review, this is not the case. Both levees would be overtopped in more frequent events. The Maclean levee is also overtopped in floods more frequent than the 100 year event. Flood conditions will be particularly hazardous when these levees are overtopped. This can be further compounded by the risk of catastrophic levee failure.

The Recommended Measures

The recommended Floodplain Management Plan is outlined in **Table 6.1**.

Most of the structural flood mitigation works that have been identified within the Valley have already been constructed, such as the levees at Grafton, South Grafton and Maclean. The subsequent floodplain management studies and plans have predominantly recommended non-structural, valley-wide measures as the most appropriate outstanding floodplain management measures for the Valley.

Valley-wide floodplain management measures, including flood warning, emergency management planning, community awareness, voluntary purchase and voluntary house raising schemes, and flood-related planning considerations are included as recommended measures in this Plan.

Specific issues and measures that are also relevant to Grafton, South Grafton, Maclean, Brushgrove, other towns and villages, rural areas and caravan parks are also presented in this Plan.

The potential exists for overtopping of the existing levees to cause significant risk to life. At present, the capability to safely evacuate people, particularly from Grafton, has not been established. The preparation of such an evacuation capability assessment is recommended as a high priority measure. Further, until such time as an ability to safely evacuate residents has been demonstrated, Council should avoid any intensification of existing development within these areas.

Timing and Funding

The total estimated cost of the Grafton and Lower Clarence Floodplain Risk Management Plan is $6,700,000. This estimate is dominated by the allowance provided for the valley-wide house raising scheme, which has assumed as many as 300 properties might be eligible throughout the Valley. This cost will need to be reviewed once the proposed property survey and property database is established. The costs also do not allow for levee augmentation measures that may be recommended following subsequent investigations.

Council can expect to receive the majority of financial assistance through the Department of Natural Resources. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is usually provided on a 1:1:1 basis (Commonwealth:State:Council).

The timing of the proposed works will depend on Council's overall budgetary commitments and the availability of funds from other sources.

TABLE 6.1
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)	Funding Sources*	Priority
Valley-Wide Measures				
6.1.1	**Property Survey and Database**			
	a) Property Survey	$50,000	1,2	Medium
	b) Assemble GIS database	$20,000	1,2	Medium
	c) Evaluate VP and VHR Schemes	$10,000	1,2	Medium
	d) Emergency Management planning	$20,000	1,2,3	Medium
6.1.2	**Further Flood Modelling**			
	a) Levee overtopping investigations at Grafton	$40,000	1,2	High
	b) Update floodplain topography & delineate floodways	$20,000	1,2	Medium
6.1.3	**Emergency Management**			
	a) Additional rain gauges above Copmanhurst	$40,000	1,2,4	Low
	b) Review Grafton Rating Curve in flood predictions	$5,000	4	High
	c) Incorporate tidal anomalies in flood predictions	$10,000	4	Medium
	d) SES training for potential levee overtopping scenarios	$10,000	3	High
	e) Standard warning templates for all major urban areas	$5,000	3	High
	f) Develop integrated flood warning web-site	$30,000	1,2,3,4	Medium
	g) Consider merging four local flood plans into one	$10,000	3	High
	h) Update flood plans & intelligence with new flood data	$5,000	3	High
	i) Update evacuation plans for levee overtopping events	$5,000	3	High
6.1.4	**Community Awareness**			
	a) Update FloodSafe brochures with new flood data	$10,000	3	Medium
	b) Develop web site providing flood advice	$10,000	1,2,3	Medium
	c) Strategic signage regarding risks of levee overtopping	$20,000	1,2	Medium
	d) Periodic distribution of flood certificates	On-going	1	Medium
	e) Consider installing meter-box flood labels	$40,000	1,2,3	Low
	f) Institute annual flood awareness weeks	On-going	1,2,3	Low
	g) Evaluate effectiveness of flood awareness strategies	$10,000	1,2,3	Medium
6.1.5	**Voluntary Purchase**			
	a) Complete Palmers Island VP Scheme	$600,000	1,2	Medium
	b) Review need for additional VP Scheme	$10,000	1,2	Medium
6.1.6	**Voluntary House Raising**			
	a) Compile list of eligible properties	$5,000	1,2	Medium
	b) Develop guidelines and administrative procedures	$20,000	1,2	Medium
	c) Prepare brochure	$10,000	1,2	Medium
	d) Progressive implementation of Scheme	$4,500,000	1,2	Medium
6.1.7	**Planning Considerations**			
	a) Endorse Planning approach outlined in Plan	Nil	1	High
	b) Endorse inclusions in Council's LEP	Nil	1	High
	c) Endorse adoption of Flood management areas	Nil	1	High
	d) Endorse development controls & model DCP chapter	Nil	1	High
	e) Apply to Departments for 'exceptional circumstances'	Nil	1	High
	f) Finalise flood management maps	$20,000	1,2	Medium
	g) Include flooding advice on S149 Certificates	On-going	1	High
	h) Review current policies and remove misleading info	$10,000	1	High
	i) Review Clarence Valley Settlement Strategy	$10,000	1	High

TABLE 6.1
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)	Funding Sources*	Priority
Measures for Specific Areas				
6.2.1	**Grafton**			
	a) Regular maintenance of existing levee system	On-going	1	High
	b) Complete outstanding items from 2004 levee audit	$100,000	1,2	High
	c) Up-to-date survey of complete levee system	$10,000	1,2	High
	d) Review potential levee deficiencies	$10,000	1,2	High
	e) Prepare flood evacuation capability assessment	$40,000	1,2,3	High
	f) Improved emergency management operations	$10,000	3	Medium
	g) Investigate flood free access to Junction Hill	$20,000	1,2	Medium
	h) Improved community awareness of overtopping risk	$10,000	1,2	Medium
	i) Install box culverts through levee near North Street	$300,000	1,2	Low
6.2.2	**South Grafton**			
	a) Regular maintenance of existing levee system	On-going	1	High
	b) Complete outstanding items from 2004 levee audit	$100,000	1,2	High
	c) Up-to-date survey of complete levee system	$10,000	1,2	High
	d) Review potential levee deficiencies	$10,000	1,2	High
	e) Improved emergency management operations	$10,000	3	Medium
	f) Improved community awareness of overtopping risk	$10,000	1,2	Medium
6.2.3	**Maclean**			
	a) Survey complete levee system & identify deficiencies	$15,000	1,2	High
	b) Review internal drainage strategy	$20,000	1,2	Low
	c) Apply appropriate development controls	On-going	1	High
	d) Improved emergency management operations	$10,000	3	Medium
	e) Improved community awareness of overtopping risk	$10,000	1,2	Medium
6.2.4	**Brushgrove**			
	a) Voluntary house raising of 8 houses	$400,000	1,2	Medium
	b) Improved emergency management planning	$10,000	3	Medium
	c) Apply appropriate development controls	On-going	1	High
	d) Feasibility study of improved flood access to bridge	$20,000	1,2	Medium
	e) Investigate septic overflows & health concerns	$20,000	1,2	Medium
6.2.5	**Other towns, villages & rural areas**			
	a) Review evacuation plans – Chatsworth, Cowper, Harwood, Palmers Island, rural areas	$10,000	3	High
	b) Development controls on future development	On-going	1	High
6.2.6	**Caravan Parks**			
	a) Risk assessment for flood prone caravan parks	$30,000	1,2,3	Low

TOTAL: $6,740,000

* Potential funding sources are as follows:

1 Clarence Valley Council
2 Department of Natural Resources
3 State Emergency Service
4 Bureau of Meteorology

1 INTRODUCTION

1.1 BACKGROUND

Bewsher Consulting was commissioned by Clarence Valley Council[1] to prepare and review floodplain management plans for Grafton and the Lower Clarence Valley. Assistance has also been provided by WBM Oceanics Australia on flood modelling and Don Fox Planning on planning issues.

The Clarence Valley Floodplain Management Committee has overseen the preparation and review of this Plan. The Committee comprises councillors and council staff from Clarence Valley Council, representatives from the Department of Natural Resources (DNR), the State Emergency Service (SES) and other community members.

A floodplain management study and plan was previously prepared for the Lower Clarence Valley (Maclean Shire Council, 1999). A floodplain management study was also prepared for South Grafton (Paterson Consultants, 2000) and numerous flood investigations have been undertaken for other specific areas. The purpose of the current report is to review and amalgamate the findings from these previous studies into a single plan covering Grafton and the majority of the Lower Clarence Valley floodplain.

Other reasons for preparing an updated plan include:

i) the amalgamation of the four former Council areas into a single Clarence Valley Council, and the desirability to adopt uniform policies and approaches to floodplain management throughout the Valley;

ii) results from a recently completed Lower Clarence River Flood Study (WBM, 2004), providing improved flood information throughout the Lower Valley; and

iii) recent updates of the Floodplain Development Manual (NSW Government, 2001, 2005) which places increased emphasis on managing all floods up to the probable maximum flood (PMF), and the importance of emergency management planning.

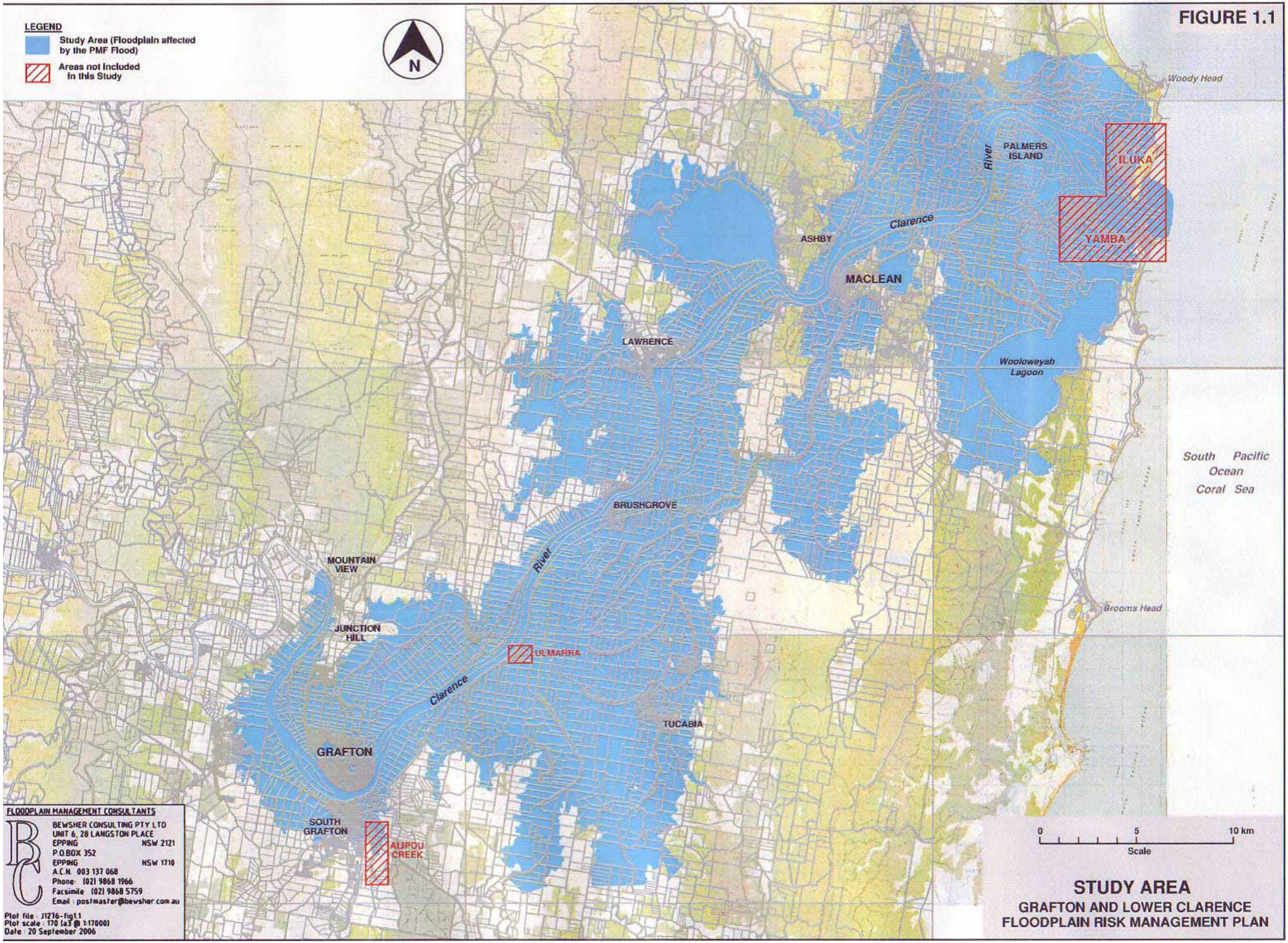
1.2 THE STUDY AREA

The study area essentially covers the Lower Clarence River floodplain downstream of Junction Hill, except those areas that are covered by separate floodplain management studies that are being undertaken by others concurrently. A map of the study area is included on **Figure 1.1**.

Specifically, the study area includes:

- Flood-prone areas of Grafton and South Grafton formerly administered by Grafton City Council, excluding Alipou Creek and Musk Valley Creek, which are the subject of separate studies.
- Flood-prone areas of the Lower Clarence River formerly administered by Maclean Shire Council, from Brushgrove to Palmers Island, including Maclean, and excluding Iluka and Yamba, which are the subject of separate studies.
- Flood-prone areas along the Clarence and Coldstream Rivers, in areas formerly administered by Copmanhurst and Pristine Waters Shires, largely situated between Grafton and Brushgrove, but excluding Ulmarra, which is the subject of a separate study.

[1] Clarence Valley Council was proclaimed on 25 February 2004, with the amalgamation of Grafton City, Maclean, Copmanhurst and Pristine Waters Councils. Pristine Waters Shire had been formed on 1 July 2000 by the amalgamation of Nymboida and Ulmarra Shires.


FIGURE 1.1
LEGEND
Study Area (Floodplain affected by the PMF Flood)
Areas not included in this Study
N
Woody Head
PALMERS ISLAND
River
ILUKA
YAMBA
Clarence
ASHBY
MACLEAN
LAWRENCE
Wooloweyah Lagoon
South Pacific Ocean
Coral Sea
BRUSHGROVE
MOUNTAIN VIEW
River
Brooms Head
JUNCTION HILL
ULMARRA
Clarence
TUCABIA
GRAFTON
SOUTH GRAFTON
ALIPOU CREEK
0
5
10 km
Scale
STUDY AREA
GRAFTON AND LOWER CLARENCE
FLOODPLAIN RISK MANAGEMENT PLAN
FLOODPLAIN MANAGEMENT CONSULTANTS
BEWSHER CONSULTING PTY LTD
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Plot file : J1276-fig1.1
Plot scale : 170 (a3 @ 1:17000)
Date : 20 September 2006

1.3 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake floodplain management studies and plans, such as the current project, and for the implementation of works identified in these studies.

A Flood Prone Land Policy and a *Floodplain Development Manual* (NSW Government, 2005) forms the basis of floodplain management in New South Wales.

The objectives of the Policy include:

> reducing the impact of flooding and flood liability on existing developed areas by flood mitigation works and measures, including ongoing emergency management measures, the raising of houses where appropriate, and development controls; and
>
> reducing the potential for flood losses in new development areas by the application of ecologically sensitive planning and development controls.

The Policy provides some legal protection for Councils and other public authorities and their staff against claims for damages resulting from their issuing advice or granting approvals on floodplains, providing they have acted substantially in accordance with the principles contained in the *Floodplain Development Manual*.

The implementation of the Flood Prone Lands Policy generally culminates in the preparation and implementation of a Floodplain Management Plan, which is the objective of the current study.

The steps in the floodplain management process are summarised on **Figure 1.2**.

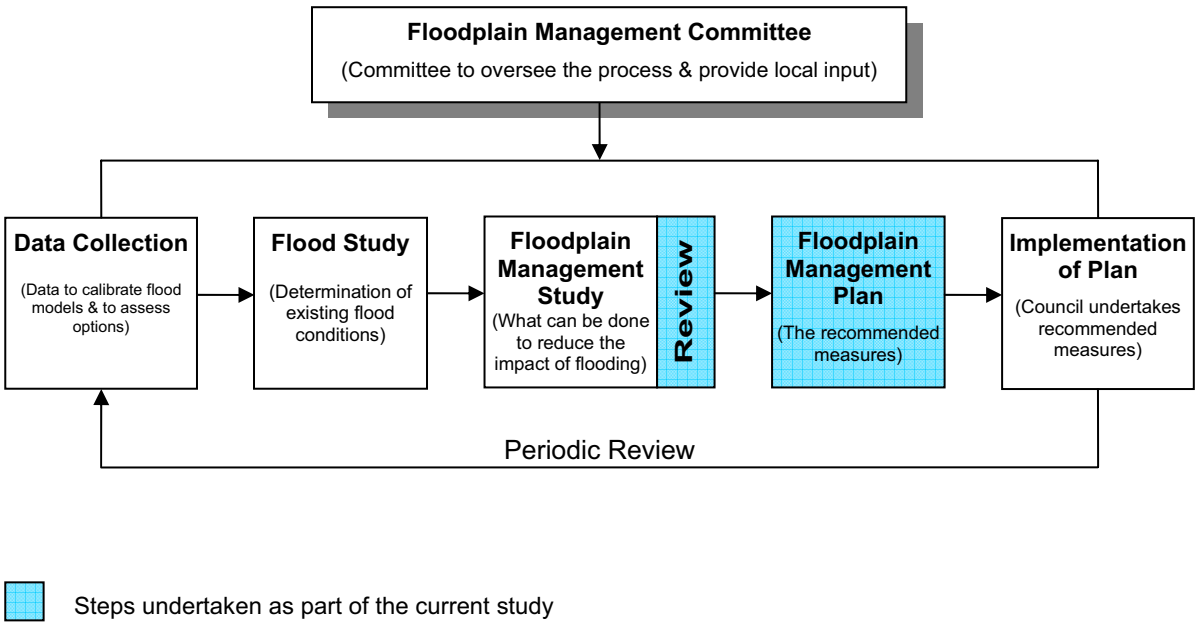


FIGURE 1.2
The Floodplain Management Process

1.4 STRUCTURE OF REPORT

The Floodplain Management Plan has been prepared as two Volumes.

Volume 1 (this document) presents a summary of the key findings of the review of previous investigations and presents the recommended floodplain management plan.

Volume 2 presents a compilation of working papers that have been prepared during the course of the study. The working papers allowed the floodplain management committee to monitor the project, and to provide direction where required.

Working paper titles are listed in **Table 1.1**. Full copies of the working papers are also included on a CD attached to the end of this report.

TABLE 1.1
List of Working Papers

Working Paper	Title
WP 1	Flood Behaviour
WP 2	Voluntary Purchase and Voluntary House Raising
WP 3 & 7	Flood Warning, Emergency Planning and Community Awareness
WP 4	Development Control, LEP and DCP
WP 5 & 6	Levee System and Internal Drainage – Grafton and South Grafton
WP 8	A Review of Brushgrove's Floodplain Management Options
WP 9	A Review of Maclean's Floodplain Management Options
WP10	A Review of Floodplain Management Strategies for Other Towns and Villages, including Rural Areas

This (Volume 1) report is structured as follows:

Chapter 1 – Background to the study

Chapter 2 – A summary of previous studies and investigations

Chapter 3 – Information available on flood behaviour throughout the Lower Valley

Chapter 4 – Valley-wide floodplain management measures, including flood warning, emergency management planning, voluntary purchase and voluntary house raising schemes, and flood-related planning considerations

Chapter 5 – Measures for specific areas, including Grafton, South Grafton, Brushgrove, Maclean, other towns and villages, rural villages and caravan parks

Chapter 6 – The recommended Floodplain Management Plan for Grafton and the Lower Clarence Valley

2 PREVIOUS STUDIES AND INVESTIGATIONS

The floodplain management plan is based on numerous studies and investigations that have previously been undertaken in the Lower Clarence Valley.

A list of the relevant reports and investigations that have been collected and reviewed as part of this project is provided in **Table 2.1**. A brief comment on the relevance of each report has also been provided.

TABLE 2.1
List of Previous Investigations Reviewed

No.	Date	Title	Author	Comment
1	Sep 1980	Frequency of flooding at Grafton (Preliminary Report)	PWD	The report presents a flood frequency analysis of river flows at Grafton. A summary of historical levee works is provided. It is also noted that the Grafton City Levee would be overtopped at a level of 8.25m (Std)
2	Dec 1980	NSW Coastal Rivers Flood Plain Management Studies: Main Report, The Clarence Valley	Soros-Longworth & McKenzie, and Cameron McNamara	A broad floodplain management study covering the entire Clarence Valley. Flood levels were based on flood frequency analysis at Grafton and extended downstream using correlation curves. A history of previous works in the Valley is provided. Some specific and valley-wide floodplain management measures are proposed.
3	Oct 1981	Hydraulic Effects of Proposed Mitigation Works in South Grafton	PWD	The report examines the hydraulic effects of nine levee proposals at South Grafton. Flooding impacts of the different proposals are assessed using a 'CELLS' computer model.
4	Aug 1983	South Grafton Flood Plain Management Interim Advice to Council	PWD	Provides advice to Clarence River County Council on flood behaviour at South Grafton, including development controls and delineation of flood prone areas.
5	~ 1983	Historical Indications of the Frequency of Flooding at Grafton	Environmental Management	Analyses the reliability of historical flood heights at Grafton and recommends some adjustments to past heights. Also recommends flood frequency analysis based on normal distribution.
6	Jul 1984	Social and Economic Effects of an Augmented Levee System at South Grafton (Draft)	Environmental Management	Evaluates some of the economic and social effects of raising the South Grafton Levee system. Some general floor level data is provided for Grafton and South Grafton. The report concludes that the social and economic effects should be beneficial, though notes that there may also be some adverse impacts elsewhere.
7	Aug 1984	North Grafton Drainage Study	PWD	The report investigates ponding in North Grafton, on the eastern side of Alumy Creek. Notes that the worst ponding event occurred in 1974 when flood gates were closed due to river flooding. Remedial measures recommended include landuse planning, adjustments to internal drainage, additional culverts to the river and installation of pumps.
8	Nov 1984	Clarence River Maximum Probable Flood Estimate at Grafton	Willing & Partners (for PWD)	Estimates are provided for the PMF at Grafton using different techniques. Peak flows for the PMF varied from 43,750 m^3/s to 72,450 m^3/s.

TABLE 2.1
List of Previous Investigations Reviewed

No.	Date	Title	Author	Comment
9	Dec 1985	South Grafton Levee Augmentation Study	Cameron McNamara	Reviews options for upgrading the South Grafton Levee. Three schemes are investigated in detail. Scheme 8d is recommended, including Waterview levee at 100yr-0.1m, Rural levee at 100yr, Urban levee at 100yr +0.5m and Heber St levee at 100yr +0.25m.
10	Feb 1986	South Grafton Levee Augmentation EIS	Cameron McNamara	Environmental Impact Assessment for the proposed upgrading of the South Grafton Levee system. The location of proposed works is identified and long sections showing the existing and proposed levee heights are provided.
11	Dec 1988	Lower Clarence River Flood Study	WBM Oceanics (for PWD)	The report provides information on flood behaviour on the Clarence River downstream of Grafton. Flood levels were assessed using the ESTRY computer model. Various combinations of ocean tide and river flooding were trialled, although no definitive recommendation is provided on which scenario should be adopted.
12	Jun 1989	Preliminary Drainage Study, Eastern Drainage Basin, North Grafton	Paterson Consultants	Investigation of ponding problems in Grafton and a review of local drainage improvements in this area. The ability of pumps to reduce flooding problems was also considered.
13	Jul 1989	Maclean Drainage Pumps Investigation	Paterson Consultants	The report was commissioned following failure of the Maclean levee pumps to remove impounded water behind the Maclean levee during the 1988 flood. Some new pumping facilities are recommended in addition to drainage improvements and stormwater diversion.
14	1989	Flooding on the Clarence River: The Experience of the Emergency Organizations, April 1988	Neil R. Britton, James Cook University	Describes the sequence of flooding on the Clarence River during the April 1988 flood, and emergency management operations conducted during the flood.
15	Aug 1990	Heber Street Review (Draft)	Paterson Consultants	Three options are presented for the Heber Street levee in an effort to reduce construction costs. No definitive recommendations are provided, and the original design appears to have been subsequently pursued.
16	Sep 1992	Grafton Flooding Caused By Levee Overtopping Vol 1: Flood Behaviour and Contingency Planning	Water Studies Pty Ltd	Study undertaken to assist the Grafton Emergency Management Committee in the development of a contingency plan to deal with levee overtopping at Grafton. Different river discharges ranging from 20,000 m^3/s to 55,000 m^3/s are tested in a computer model and overtopping behaviour assessed for each case. The sequence of overtopping is discussed. It is also noted that substantial levee erosion and breaching can be expected during an overtopping event.
17	Sep 1992	Grafton Flooding Caused By Levee Overtopping Vol 2: Technical Studies	Water Studies Pty Ltd	Volume 2 provides the technical basis and additional details to support the findings that are presented in the Volume 1 report.

TABLE 2.1
List of Previous Investigations Reviewed

No.	Date	Title	Author	Comment
18	Aug 1993	Lower Clarence River Floodplain Management Study	Paterson Consultants	Evaluates floodplain management measures for the Lower Clarence Valley throughout the former Maclean Shire Council LGA. Provides recommendations for urban areas of Maclean, Yamba, Iluka, Brushgrove, Lawrence, Tyndale, Ilarwill, Ashby, Harwood, Chatsworth Island, Palmers Island and Woombah. Some floor level details are provided in an appendix.
19	Jan 1995	Palmers Island Riverbank Management Plan	Maclean Shire Council	Describes Maclean Shire Council's plan for addressing the threat of riverbank erosion adjacent to Palmers Island village, including development controls and voluntary purchase of some existing properties.
20	Apr 1995	Riverbank Rock Protection at South Grafton, Clarence River: Engineer Diving Inspection and Appraisal	Patterson Britton & Partners	Investigation of the stability of the rock-protected bank at South Grafton, in view of the recent augmentation of the South Grafton Levee and expected increases in river velocities. The report concludes there is no immediate threat to the bank at South Grafton.
21	May 1995	North Grafton Levee Wall	Neil McKenzie and Associates	The report investigates the stability, permeability, strength and conditions of sections of the North Grafton Levee wall between Dobie and Fry Streets, and between Fry and Bacon Streets. It concludes that generally the walls are in a reasonable state of repair.
22	Oct 1995	Lower Clarence River Floodplain Management Plan	Connell Wagner and Resource Design & Management Pty Ltd	Follows on from the 1993 Lower Clarence River Floodplain Management Study. Preferred options mainly include non-structural measures, including flood warning, evacuation strategies, public information program and development controls.
23	Aug 1996	Investigation of Controlled Overtopping of North Grafton Levees During Extreme Flood Events (Draft)	Water Studies Pty Ltd	An extension of the 1992 overtopping study to see whether controlled overtopping of levees would provide more time for emergency services to respond. The report concludes that an effective evacuation strategy is the best option.
24	Dec 1996	Grafton Ponding Kent Street Area, Draft Report	Paterson Consultants	An investigation in response to a resident's suggestion that mobile pumps be used to reduce ponding when flood gates at Grafton are closed due to river flooding.
25	Nov 1997	Lawrence Area Floodplain Management Study	WBM Oceanics	A specific study of flooding at Lawrence, including as assessment of the impacts of Munro Island on flood behaviour. A detailed 2-dimensional computer model was used for the assessment.
26	Sep 1999	Lower Clarence River Floodplain Management Plan	Maclean Shire Council	An update of the 1995 Lower Clarence River Floodplain Management Plan. Includes similar recommendations as the previous plan, with further implementation strategies provided. Largely includes non-structural measures and includes a general house raising scheme.
27	May 2000	South Grafton Floodplain Management - Flood Study (Exhibition Report)	Paterson Consultants	Investigates flood behaviour at South Grafton following the upgrade of the South Grafton levees. Ponding levels behind the levee system are assessed, and an analysis of extreme events that overtop the levee also provided.

TABLE 2.1
List of Previous Investigations Reviewed

No.	Date	Title	Author	Comment
28	May 2000	South Grafton Floodplain Management Study (Exhibition Report)	Paterson Consultants	Investigates floodplain management measures for South Grafton following the upgrade of the South Grafton levees. Assesses the likely flood hazard for ponding and overtopping events, and reviews available floodplain management measures, including minimum floor level controls, other development controls, evacuation planning and public awareness initiatives.
29	Jun 2001	Assessment of Brushgrove Floodplain Management Options	Webb, McKeown & Associates	Assesses the merits of various floodplain management measures for Brushgrove, including the feasibility of constructing a levee to protect low-lying properties. Different levee heights are assessed, and information from public meetings provided. All levee options have a low benefit-cost ratio, and a house raising scheme is noted to be the most affordable and practical solution.
30	Oct 2001	Grafton City Local Flood Plan	SES	This plan addresses preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the former Grafton City Council area.
31	Oct 2001	Pristine Waters Local Flood Plan	SES	This plan addresses preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the former Pristine Waters council area.
32	Oct 2001	Copmanhurst Local Flood Plan	SES	This plan addresses preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the former Copmanhurst council area.
33	Jun 2002	Maclean Shire Local Flood Plan	SES	This plan addresses preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the former Maclean Shire Council area.
34	2002	Community Response to Flood Warnings: The Case of an Evacuation from Grafton, March 2001 (AJEM, Vol 17, 19-29)	Neil Pfister (SES)	A paper exploring why flood warnings issued during the Grafton floods in March 2001 were ignored by 90% of the community. Concludes that most residents had little appreciation of the flood threat or the evacuation strategy. Critically reviews emergency management operations and recommends areas for improvement.
35	2002	Flood Warnings: Recent Lessons Learned and Developments Underway	Neil Pfister and Allen Rutledge (SES)	A paper that reviews the dissemination of flood warning advice to the community following the March 2001 flood. Discusses areas for improvement.
36	Mar 2003	Levee Stability and Structural Integrity Investigation at Grafton City Services Bowling and Sporting Club	SMEC	Report on a stability assessment and design of remedial works for the Grafton Levee scheme between the Grafton Bowling Club and the Crown Hotel. Original design drawings are included in an appendix.

TABLE 2.1
List of Previous Investigations Reviewed

No.	Date	Title	Author	Comment
37	May 2003	Maclean Riverbank Stability and Levee Structural Integrity Investigation	Coffey	Report assesses the stability of the riverbank and the structural integrity of the concrete section of the levee at Maclean. 19 cross sections of the levee are provided, and original design drawings are reproduced. The report notes some areas of riverbank instability and some potential problems to the concrete levee. Also considers the impact of raising the levee by 300mm and notes that remedial measures would be required to the existing concrete sections.
38	2003	Budget Estimate of Construction Costs for Proposed Raising of Levee at Maclean	Coffey	Provides a cost estimate to raise the levee at Maclean by 300mm. Total estimated cost is $1.04M plus GST.
39	Mar 2004	Lower Clarence River Flood Study Review (2 volumes)	WBM Oceanics	A new flood study for the Lower Clarence Valley using a different computer model and revised flood frequency analysis at Grafton. The study area now extends upstream to Mountain View (10km upstream of Grafton). More extensive use of flood mapping is provided, including flood extents, flood contours, flood velocities and velocity x depth contours. All flood information is provided digitally in GIS format. Hard copy maps are also provided in the Volume 2 report.
40	Mar 2004	Flood Levee Audit – Grafton	Dept of Commerce, Dams & Civil	Provides an audit of the Grafton and South Grafton levees, based on flood information available in the 2004 Lower Clarence River Flood Study Review. Longitudinal levee crest profiles are compared with flood profiles derived by WBM, and potential overtopping points indicated. Some geotechnical investigations and stability analysis is undertaken at selected locations. Works to upgrade the levees are discussed.
41	Feb 2006	Grafton and Maclean Flood Levee Overtopping: Hydraulic Assessments (Draft)	WBM Oceanics	More detailed model investigations on the potential overtopping of levees at Grafton, South Grafton and Maclean. Uses the same computer model developed for the 2004 Flood Study Review but includes a finer scale 2D grid at these three locations to provide improved resolution. Some topographic details were also upgraded. Also looks at the effect of flood duration on overtopping flood behaviour, and provides time series plots of flood extents after the commencement of levee overtopping.

3 FLOOD BEHAVIOUR

This Section reviews the available data on flood behaviour in the Clarence Valley. Previous Flood Study reports have been reviewed and the basis of the existing flood level estimates and flood mapping throughout the Valley discussed. The delineation of the floodplain into two different flood management areas is also proposed for the purpose of applying different development and planning controls.

3.1 PREVIOUS FLOOD STUDIES

A number of flood studies have been completed in the Clarence Valley over the years. These have ranged from flood frequency analysis of historic flood heights at specific locations (eg Grafton, Ulmarra, Maclean) to more extensive valley-wide studies that include a hydraulic model of the Clarence River and its main tributaries. The benefit of the latter studies is that the hydraulic models are able to provide information on flood levels and flood velocities throughout the floodplain.

The most relevant studies undertaken to date include:

i) Clarence Valley Floodplain Management Study (SL&M, 1980);

ii) Lower Clarence River Flood Study (PWD, 1988)

iii) Lower Clarence River Flood Study Review (WBM, 2004); and

iv) Grafton and Maclean Flood Levee Overtopping Hydraulic Assessment (WBM, Draft, 2006).

The 2004 Flood Study Review includes the use of a sophisticated two-dimensional computer model to simulate flooding in the Lower Clarence River. The river and floodplain was divided into approximately 200,000 cells with a grid resolution of 60m. This is a much finer resolution than the previous model adopted for the 1988 study, where nodes were spaced several kilometres or more apart. A review of the flood frequency analysis of flood flows at Grafton was also undertaken, based on revised rating curves to represent different river and floodplain conditions and the progressive construction of levees on both sides of the river.

Further refinement of the computer model was undertaken in 2006 to provide improved definition of flood behaviour for floods that overtop the levees at Grafton, South Grafton and Maclean. A finer scale 10m grid was embedded within the 60m grid model and the topography of these areas updated.

The appropriate study to describe flood behaviour throughout the Lower Clarence Valley is the 2004 Flood Study Review, supplemented at Grafton, South Grafton and Maclean with the more refined modelling undertaken for the 2006 levee overtopping study.

3.2 DESIGN FLOOD LEVELS

The Flood Study Review provided an extensive set of A3 size drawings showing the extent of flood inundation, flood levels, flood depths, flood velocities and velocity x depth products for each of the 5 year, 20 year, 100 year, 500 year and extreme (PMF) floods. The flood information was also provided as mapping layers for incorporation in Council's GIS computer system to permit more precise interrogation of the data.

Design flood levels at key locations are reproduced in **Table 3.1**. Flood levels can also be read directly from the flood contour maps provided in Volume 2 of the Flood Study Review (at 0.5m intervals) or from the digital GIS data provided to Council (at 0.1m intervals).

TABLE 3.1
Peak Design Flood Levels (m AHD) at Selected Locations
(Source Table 5-1, WBM, 2004)

Location	5y ARI	20y ARI	100y ARI	500y ARI	Extreme (1.53x100y)
Grafton (Prince St Gauge)	6.10	7.95	8.36	8.42	9.76
*Grafton (inside levee)	Not flooded	Not flooded	4.90 to 6.03	6.80	9.00
South Grafton (Alipou Ck at Hwy)	2.56	7.43	7.77	7.82	9.26
*South Grafton (inside levee)	Not flooded	Not flooded	6.16	8.38	10.20
Junction Hill West (Clarence R)	7.05	9.36	9.92	10.02	11.49
Junction Hill East (Alumy Ck)	4.24	6.12	6.47	6.78	8.82
Ulmarra (Ferry Terminal)	4.83	6.07	6.37	6.68	8.49
Ulmarra (Coldstream Basin)	2.62	5.11	6.15	6.57	8.49
Swan Creek	2.69	6.23	6.58	6.90	8.75
Great Marlow	4.24	6.12	6.46	6.77	8.69
Southgate	4.25	6.10	6.44	6.75	8.61
The Avenue	2.70	5.11	6.14	6.54	8.45
The Forks	2.70	5.11	6.13	6.54	8.45
Tucabia	2.78	5.11	6.13	6.54	8.44
Calliope	2.48	5.10	6.11	6.50	8.39
Cowper	4.01	5.17	5.92	6.31	8.20
Brushgrove	4.16	5.15	5.87	6.25	8.16
Bultitudes	2.66	4.78	5.59	5.96	7.79
Ensbey	3.63	4.68	5.41	5.78	7.64
Lawrence	3.56	4.61	5.34	5.71	7.57
Tyndale	2.65	4.16	4.88	5.21	6.92
Gregor / Shark Ck Bridge	2.86	4.01	4.66	4.98	6.62
Ilarwill	2.66	3.60	4.23	4.52	6.06
Ashby	2.43	3.21	3.72	3.95	5.19
Maclean Golf Course	2.69	3.99	4.67	5.01	6.76
Maclean (in river)	2.41	3.34	3.71	3.94	5.17
Maclean (inside levee)	Not flooded	Not flooded	3.73	3.96	5.17
Warragah Island	2.33	3.02	3.47	3.68	4.81
Harwood	2.05	2.78	3.23	3.45	4.64
Chatsworth	2.16	2.77	3.19	3.39	4.53
Palmers Island	1.77	2.44	2.86	3.09	4.32
Woombah	1.77	2.28	2.67	2.89	4.14
Iluka	1.13	1.86	2.38	2.44	3.65
Yamba	0.40	1.80	2.34	2.39	3.39
Ocean	0.80	2.09	2.60	2.60	2.61

* Flood Levels for Grafton and South Grafton should be obtained from the Levee Overtopping Study currently in preparation (WBM 2006).

Further consideration of design flood levels at Yamba and Iluka may be warranted as part of proposed floodplain management studies for these towns, as flood levels in this vicinity are dominated by assumed ocean conditions and the timing differences between river flooding and ocean storm tides.

3.3 EXTENT OF FLOOD INUNDATION

The general definition of "flood liable land" has in the past been taken to represent the area of land that would be inundated in the 100 year flood. The most recent Floodplain Development Manual (NSW Govt, 2005) emphasises the need to manage flood risk on all land potentially affected by flooding. The Manual now defines "flood liable land" and "floodplain" as all areas susceptible to flooding up to the PMF flood.

The Lower Clarence River Flood Study Review (WBM 2004) provided mapping of flood levels and flood depths throughout the Clarence Valley floodplain for a range of floods. The boundary shown on these maps effectively represents the limit of flood inundation as determined by the computer model.

The extent of flooding for the 100 year and PMF floods is reproduced on **Figure 3.1.** This indicates that there is relatively little difference in flood extents between the 100 year flood and the PMF flood. This is despite flood levels for the PMF flood being up to 2m higher than the 100 year flood over much of the floodplain. Hence the extension of the definition of "flood liable land" to include the PMF flood makes little practical difference in this catchment.

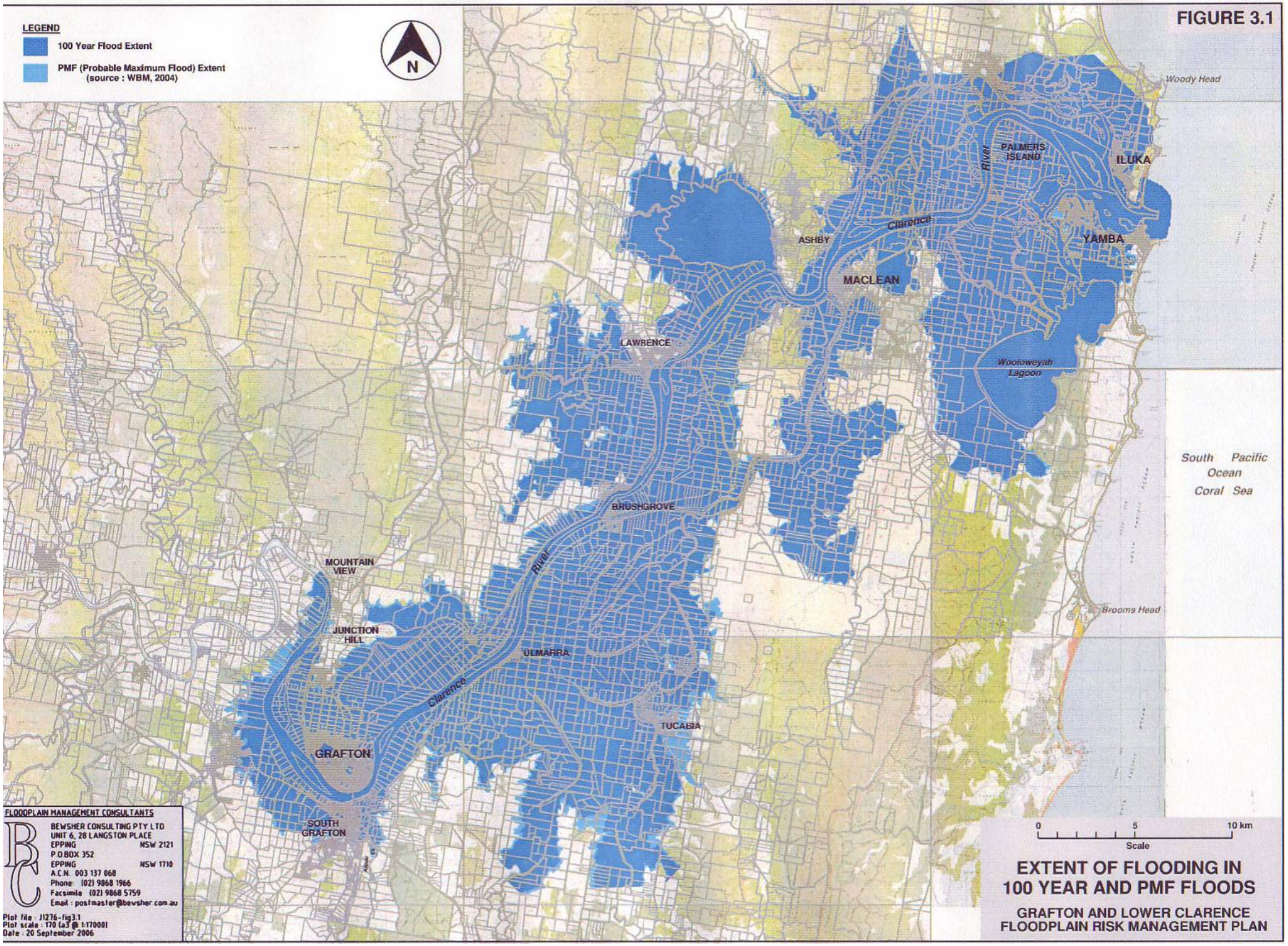
The area of flooding represents those cells in the flood model that are subject to flooding for a particular flood. As each cell is based on a 60m grid spacing, the limit of flooding appears pixellated when the maps are zoomed in to the property level. Improved resolution of the limit of flooding can be obtained by subtracting the flood surface grid from the ground surface grid to produce a smooth line that represents the intersection of both surfaces. As the ground terrain relies largely on a flood mitigation survey obtained in the early 1960s, further improvements would be possible if more detailed ground survey was available. It is noted that the RTA recently acquired Airborne Laser Scanning (ALS) survey of part of the Lower Clarence River floodplain. Should the RTA provide consent to use this data, or wider ALS coverage is obtained by Clarence Valley Council in the future, this would permit better definition of the floodplain topography, and hence improved resolution of the limit of flooding. It is likely that any difference in results would only be visible when the digital mapping is zoomed in to the property level. At the valley-wide level (such as shown on Figure 3.1), no difference in flood extents is likely to be noticeable.

3.4 REVIEW OF PREVIOUS FLOOD HAZARD DELINEATION

It is common to delineate the floodplain into different hydraulic categories, flood hazard areas or other form of flood risk categorisation. In this way, different development controls can be applied to different parts of the floodplain. A review of the available mapping in the Clarence Valley indicates that little in this regard has been undertaken.

The Clarence Valley Floodplain Management Study (SLM, 1980) is one of the few reports to attempt to identify floodway locations within the floodplain. These were shown as broad arrows on a flood extent map. However, no basis for their determination was provided and their locations appear to be somewhat subjective.

FIGURE 3.1



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Plot file : J1276-fig3.1
Plot scale : 170 (a3 @ 1:170001
Date : 20 September 2006

EXTENT OF FLOODING IN 100 YEAR AND PMF FLOODS

GRAFTON AND LOWER CLARENCE FLOODPLAIN RISK MANAGEMENT PLAN

The Lower Clarence River Floodplain Management Plan (Maclean Shire Council, 1999) defined the Lower Clarence River floodplain, or extent of flood liable land, as that area that would be inundated in the 'designated' flood (100 year event). No other categorisation of the floodplain was provided, except for a table showing the flood hazard category for eight localities as either high, medium or low.

The South Grafton Floodplain Management Study (Paterson Consultants, 2000) provides several plans showing flood hazard categorisation (as either high or low) for various sized floods. Most of the flood affected area has been classified as high hazard.

The flood mapping prepared as part of the Lower Clarence Flood Study Review (WBM, 2004) provides the most detailed information on flood behaviour across the floodplain, in terms of maps showing flood depths, flood velocities, and the hydraulic product of depth x velocity (often taken as a measure of hazard). There is a wealth of mapping that has been provided as hard copy plans and digital maps, but no recommendation on which maps or criteria should be used to delineate the floodplain into different flood management areas.

The Floodplain Development Manual provides an indication of hazard based on depth and velocity, which is reproduced as **Figure 3.2**. High hazard conditions occur when there are high velocities or high flood depths, or a combination of both. For example, when the depth of flooding exceeds 1.0m (even with low flood velocities), it is regarded that high hazard conditions prevail. In the case of the Lower Clarence River study area, high flood velocities are mainly confined to the river and tributaries, with low velocities typically experienced across the floodplain. In contrast, flood depths across the floodplain are high, and it is the depth of flooding that largely influences the hazard rating on the floodplain.

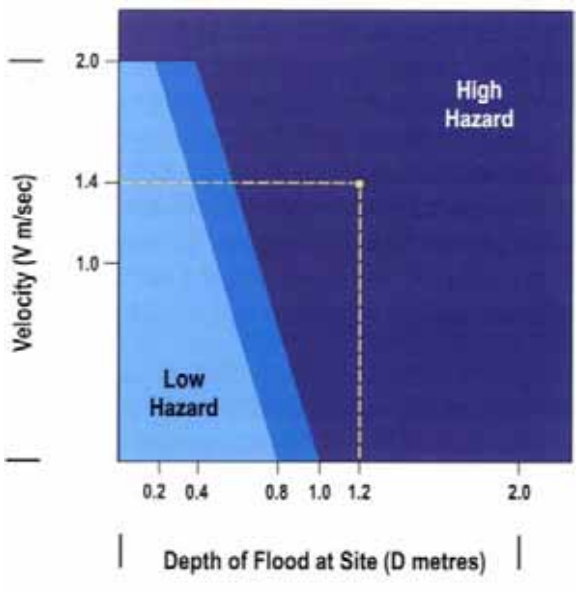


FIGURE 3.2
Hazard Categorisation
(Source: Floodplain Management Manual, 2005)

The Flood Study Review shows the depth of flooding in a 100 year flood across the floodplain (Drawing 40, Volume 2). This indicates that almost the entire area that is inundated in the 100 year flood would be inundated by over 1.0m, and would therefore represent high hazard conditions in accordance with the categorisation provided in the Floodplain Development Manual. It also indicates that the majority of the area would also be inundated by over 3m in a 100 year flood, and highlights the hazard that exists based on excessive flood depths alone.

3.5 PROPOSED FLOOD MANAGEMENT AREAS

Floodplain management is all about managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of hazard or flood risk. Controls on future development should not only consider the type of development proposed, but also the flood risk of the area where the development is to be located.

To some degree the high hazard rating of the Lower Clarence River floodplain is mitigated by the flood warning time available for people to evacuate their homes (The Bureau of Meteorology attempts to provide 24 hours warning of flooding in the Valley and 12 hours warning of events that could potentially overtop the major levee systems at Grafton, South Grafton and Maclean). Nevertheless, for those people who fail to evacuate in time, or are reluctant to leave their homes, the high flood depths result in a significant risk.

Despite the majority of the floodplain being classified as high hazard, there will be other "floodway" areas where high flood velocities also occur, such as close to the main rivers, tributaries or major breakout locations. These will be particularly dangerous areas, from which most new development should be avoided, and where the removal of existing dwellings through voluntary purchase schemes should be carefully considered.

For the purpose of applying planning and development controls, the Lower Clarence River floodplain has been delineated into two different flood management areas, as follows:

i) **General Floodplain** – that part of the floodplain (up to the PMF) other than floodways.

ii) **Floodways** – Those areas where a significant discharge of water occurs and is based on normal waterway areas and those parts of the floodplain where the product of velocity x depth exceeds 1.0.

A preliminary identification of floodways has been determined by identifying all rivers, creeks and other waterway areas defined in Council's property cadastre and adding to this those areas on the floodplain where the product of velocity x depth exceeds 1.0 for the 100 year flood (using data from the 2004 Flood Study Review). The floodways should be regarded as preliminary only, as more comprehensive floodplain survey is required to accurately map these areas.

A map showing the locations of the general floodplain and preliminary floodway locations is shown on **Figure 3.3**.

3.6 PROPERTY AFFECTED BY FLOODING

The assembly of a property database is often a useful tool in the preparation of floodplain management studies. Such databases are often used to:

i) determine which properties are affected by various floods;

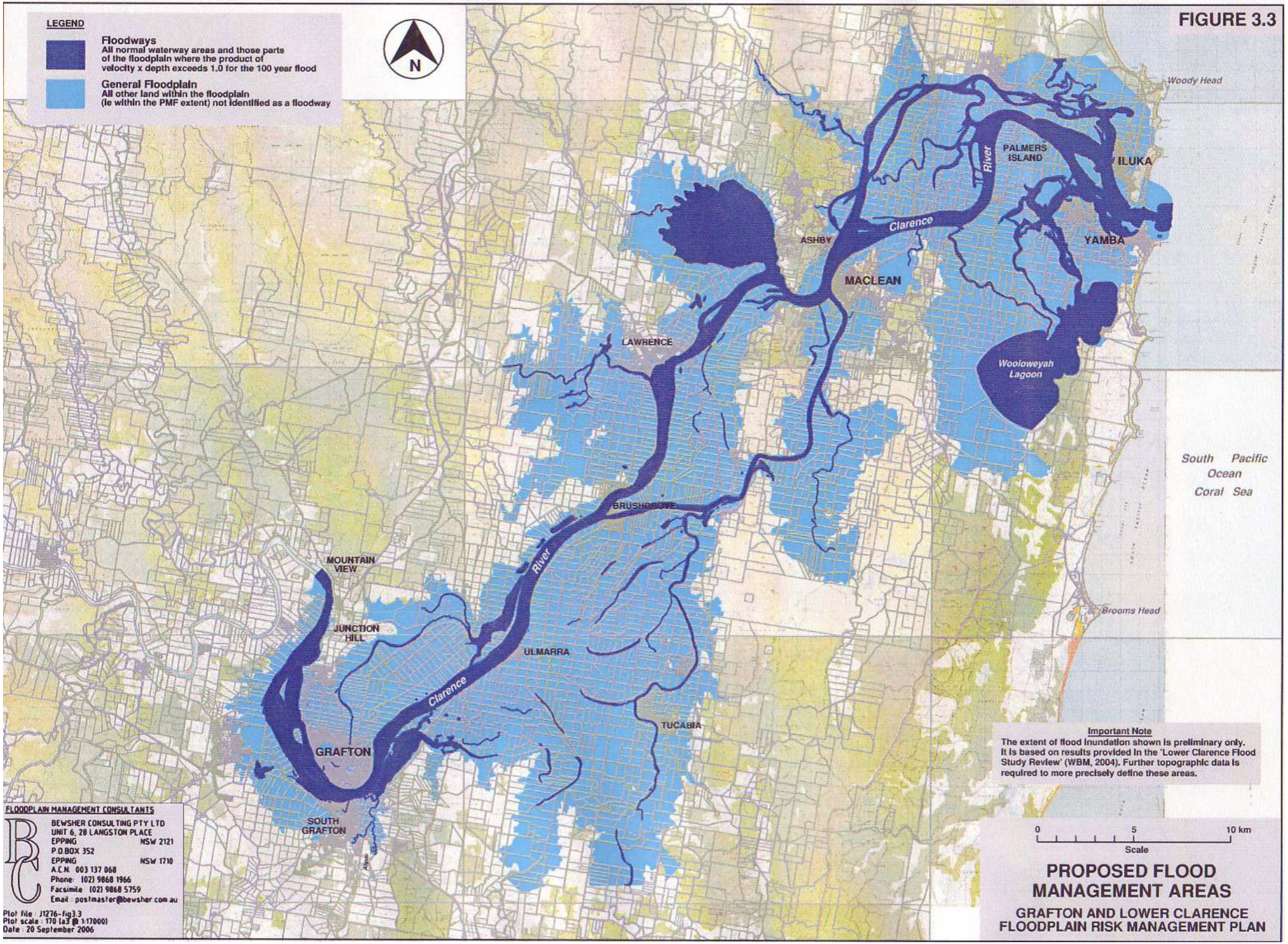
ii) locate potential problem areas within the catchment;

iii) quantify flood damages and evaluate economic benefits of flood mitigation works;

iv) identify properties for flood notification or other flood awareness activities; and

v) assist the SES plan for evacuation activities.

Whilst some limited property floor level data is available in previous reports, much of this data is old, incomplete, or properties are difficult to locate. It is not possible to prepare a comprehensive database of flood affected properties in the Lower Clarence Valley floodplain with the data that is currently available.


FIGURE 3.3
LEGEND
Floodways
All normal waterway areas and those parts of the floodplain where the product of velocity x depth exceeds 1.0 for the 100 year flood
General Floodplain
All other land within the floodplain (ie within the PMF extent) not identified as a floodway
N
Woody Head
PALMERS ISLAND
ILUKA
Clarence River
ASHBY
YAMBA
MACLEAN
LAWRENCE
Wooloweyah Lagoon
South Pacific Ocean
Coral Sea
BRUSHGROVE
MOUNTAIN VIEW
JUNCTION HILL
ULMARRA
Clarence River
TUCABIA
Brooms Head
GRAFTON
SOUTH GRAFTON
Important Note
The extent of flood inundation shown is preliminary only. It is based on results provided in the 'Lower Clarence Flood Study Review' (WBM, 2004). Further topographic data is required to more precisely define these areas.
0
5
10 km
Scale
PROPOSED FLOOD MANAGEMENT AREAS
GRAFTON AND LOWER CLARENCE FLOODPLAIN RISK MANAGEMENT PLAN
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Plot file : J1276-fig3.3
Plot scale : 170 (a3 @ 1:17000)
Date : 20 September 2006

4 VALLEY-WIDE FLOODPLAIN MANAGEMENT MEASURES

Most of the structural flood mitigation works that have been identified within the Valley have already been constructed, such as levees at Grafton, South Grafton and Maclean. The subsequent floodplain management studies and plans have predominantly recommended non-structural, valley-wide activities as the most appropriate outstanding floodplain management measure for the Valley.

Valley-wide floodplain management measures, including flood warning, emergency management planning, community awareness, voluntary purchase and voluntary house raising schemes, and flood-related planning considerations are discussed in this section.

4.1 FLOOD WARNING AND EMERGENCY MANAGEMENT PLANNING

4.1.1 The Total Flood Warning System

Emergency Management Australia (EMA, 1999, p.2) defines the purpose of flood warning in the following way:

> *"…to enable and persuade people and organisations to take action to increase safety and reduce the costs of flooding. Generating appropriate responses, from the people and organisations at risk and from the agencies with responsibilities during flood times, is the goal of any flood warning system."*

An effective flood warning system can be defined as having six components, which are depicted in **Figure 4.1**. *Prediction* refers to height-time predictions issued at river gauges. *Interpretation* refers to the identification of the impacts of the predicted flood levels on communities at risk (e.g., roads closed, properties inundated). *Message construction* refers to the process of devising messages describing what is happening, expected impacts and what actions should be taken. *Communication* refers to the process of disseminating warning messages in a timely fashion to organisations and people likely to be affected. *Protective behaviour* represents the goal of the flood warning system, whereby the agencies and threatened community respond appropriately. *Feedback* refers to the process by which the system is reviewed in order to enhance its performance.

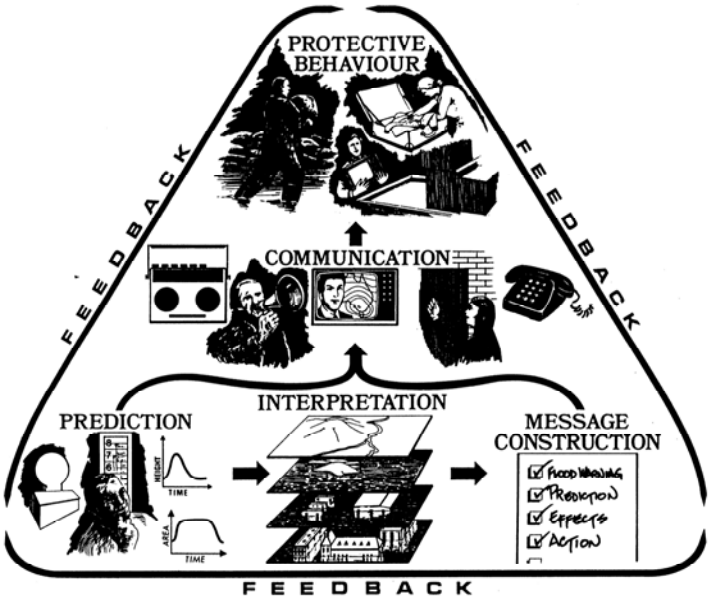


FIGURE 4.1
The Total Flood Warning System

For a flood warning system to work effectively, these components must all be present and be integrated. Organisations responsible for various components of the flood warning system in NSW are listed in **Table 4.1**.

TABLE 4.1
Current Organisational Responsibilities for Flood Warning and Response
Source: EMA, 1999, p.17

Prediction	Interpretation	Communication	Response
BoM; provided to SES State and Division HQ.	SES Division and Local HQ.	BoM disseminates preliminary flood warnings to the public through electronic media. All other warnings disseminated by SES through Division Offices in Flood Bulletins to public in threatened areas. BoM and SES disseminate direct to government departments and agencies.	SES local units; with help from police, local government and other organisations as listed in Flood Plans.

4.1.2 Evaluation of the March 2001 Flood

The flood which occurred in March 2001 reached a level of 7.7m AHD at the Prince Street gauge at Grafton, which makes it the third or fourth highest flood in a record that extends back to 1839.

During the flood, the Bureau of Meteorology issued a flood warning predicting that the Clarence River would rise to 8.1m or more at Grafton, with a real danger of the city's levees being overtopped. This would have resulted in significant flooding of most of the urban area of Grafton, and a decision to evacuate some 12,000 residents was made. Only about 13% of residents actually evacuated the city, and it was only good luck that rainfall subsided and the flood did not reach the height that had earlier been predicted.

Detailed discussions concerning the 2001 flood and potential improvements to the Clarence Valley Flood Warning system were conducted with Gordon McKay, manager of the Bureau of Meteorology's NSW Flood Warning Centre, and Chas Keys, recently retired Deputy Director of the State Emergency Service. In addition, Pfister (2002) evaluated response measures to the March 2001 flood in a paper prepared for the Australian Journal of Emergency Management. Key findings arising from the 2001 flood are summarised in **Table 4.2**.

Pfister (2002) concluded that the flood warning system failed to adequately evacuate residents. He also noted that to a certain extent "the battle was lost before it was fought", because since the construction of the levees, people had developed a low consciousness of the flood threat and were not prepared to leave.

Pfister also notes that the evacuation was characterised in evacuation warnings as 'voluntary' and made the following insightful observation about this (p.28):

> '*An evacuation warning that is not presented as a compulsory order will not compel evacuation. A voluntary evacuation warning implies uncertainty on the part of the emergency management agency and so promotes inaction on the part of residents. Furthermore, it pushes the onus for decision making onto those that are not in the best position to make that decision. Emergency managers are in the best position to appreciate the threat presented by a flood, and they must shoulder the responsibility to make a decision and act wholeheartedly on that decision*.'

TABLE 4.2
Evaluation of Flood Warning System for Grafton, March 2001 Flood
(Sources: Personal communications with BoM, SES; Pfister, 2002; Robinson & McKay, 2003; Keys, 2003)

	Evaluation of 2001 flood	Improvements to date	Potential improvements
Prediction	▸ A peak level of 8.1m (later revised downwards to 8.0m) predicted at the Prince St gauge. Actual level reached 7.75m.		▸ A few more rain gauges in lower catchment, including above Copmanhurst. ▸ Check Grafton rating and check any correlations with Grafton gauge. ▸ Better modelling how oceanic conditions influence water levels.
Interpretation	▸ A degree of scepticism about prediction, and fear of overreaction, resulting in an evacuation warning characterised as voluntary.		▸ Need to develop mindsets attuned to flood intelligence, including readiness for extreme flooding.
Message Construction	▸ Messages not persuasive about need to evacuate.	▸ SES pre-written messages (e.g., now emphasise consequences of loss of services).	▸ Need consonance in messages emanating from different official sources.
Communication	▸ Door-knocking too little, too late, too haphazard.	▸ BoM river levels on Internet since late 2001. ▸ BoM telephone weather services. ▸ SES door-knocking policy.	▸ Develop integrated flood warning web-site ▸ Need to break normality. ▸ Need to plan delivery of warnings for different levels of expected flooding.
Protective Behaviour	▸ Few people (13% of survey sample) evacuated, despite warning of levee-overtopping event.	▸ FloodSafe guides developed. ▸ 1st anniversary commemoration held.	▸ Need ongoing community education (see **Section 4**).

A key need for the SES, according to Chas Keys, is to develop mindsets that are attuned to flood intelligence. SES volunteers are not immune from succumbing to the wider community's myths about flooding, including the notion that levees around a town have completely dealt with the flood problem. Complacency is the likely result of this denial, such that the SES may be poorly prepared for extreme (e.g., levee-overtopping) flooding. Extreme flooding is qualitatively distinct from other flooding – the evacuation of 12,000 people from Grafton is a vastly different task from the typical small-scale flood operations that use boats to evacuate or re-supply isolated rural residents. Clearly, ongoing education and training of SES personnel is required, partly to deal with staff turnover, but especially in order to debunk myths, to shape mindsets, to develop a culture of planning, and to practise responses to the floods that are of such an extreme magnitude that not even the oldest local resident is familiar with them. Exercises can be used "to create mental bridges over the sometimes lengthy periods between real events" (Keys, 2003).

Warning messages need to be persuasive, understandable, and with a tone that is vivid, positive, suggests action and invites sociability (EMA, 1999, p.37). Messages should describe the flood, say what is currently happening, what is expected to happen, when it will

occur and indicate how people should act (EMA, 1999, p.39). For evacuation warnings, messages ought to explain why evacuation is vital (e.g., unsafe to remain), when residents should go, where they should go, by what means they should go, and what they should take. It is understood that the initial warning advising of the need to evacuate Grafton did not meet this standard, referring more to the difficulty of re-supply than the danger of a levee-overtopping flood.

Recognising the difficulty of constructing appropriate messages during real-time events, the SES has drafted ten template warning messages for Grafton, which cover various predicted flood magnitudes. Pre-written warning messages represent a significant advance. If not already in existence, some operational guidelines may need to be developed to help determine which evacuation message template should be broadcast under which circumstances. Development of standard messages for levee overtopping at Maclean and Ulmarra would also provide a significant improvement.

4.1.3 Flood Warning Predictions

The Bureau of Meteorology provides a quantitative flood warning prediction service to Glenreagh, Grafton, Ulmarra and Maclean. The SES has informally approached the Bureau to extend this service to Brushgrove.

The Clarence Valley Flood Warning system uses real-time data from 26 automatic rain gauges and 25 automatic river gauges. These gauges are owned and maintained by the following agencies:

The NSW Department of Commerce (Manly Hydraulics Laboratory) for gauges in the tidal areas;

The NSW Department of Natural Resources (DNR) for gauges upstream of the tidal areas;

The Bureau of Meteorology (BoM), who maintain over half of the rain gauges as well as some manually read river gauges, including Glenreagh and Copmanhurst; and

The Clarence Valley Council, which maintains a number of manually read river gauges along the river.

The Bureau aims to provide 24 hours warning time for levee-overtopping events at Grafton and Maclean. However, this can only be achieved using predicted rainfall, and only 12 hours notice is available when modelling recorded rainfall. This is distinct from the warning time of the “peak” of a flood, for which 18 to 24 hours notice is generally available.

Flood predictions may be marginally improved by a denser network of rain gauges in the area above Copmanhurst, though the area is remote and often not connected to the telephone network. In view of the progressive constriction of the floodplain as a result of levees, including the South Grafton levee scheme completed in 1996 (WBM, 2004, p.4-4), the Bureau’s rating curve for the Grafton gauge should be revised according to the new Flood Study. Also, any predictions for other sites (such as Ulmarra, Brushgrove and Maclean) that rely on correlations with the Grafton gauge should be revised to reflect this changed rating.

Flooding in the Lower Valley is subject to influence from the ocean. Ocean storm tide consists of three components: normal astronomic tide, storm surge and wave set-up. An improved flood prediction system should incorporate all three components of ocean storm tides. This will have greatest impact on the coastal communities at Yamba and Iluka, and may also have a secondary influence on flood behaviour up to about Maclean, especially for more frequent events such as the 5 year flood.

4.1.4 Local Flood Plans and Flood Intelligence Cards

"Emergency management needs to be a planned resource, not a last resort" (Steve Opper, SES)

Currently, flood emergency management procedures for the study area are detailed in four local flood plans, corresponding to the former council areas: Copmanhurst, Pristing Waters, Grafton City and Maclean. The first three plans are dated October 2001, while the Maclean plan is dated June 2002.

Each plan contains a glossary, an introduction which describes the responsibilities of key organisations and generic material on flood preparedness, response and recovery. A series of annexes are attached to each plan, detailing the flood threat, the effects of flooding on the community and evacuation arrangements, including maps.

It is recommended that consideration be given to merging these four plans into a single Clarence Valley Local Flood Plan, with multiple annexes. There is a good deal of common material between the plans. Current inconsistencies between the plans could be resolved. Maintenance of a single plan would also be an easier task.

In any case, following the completion of a flood study, the *NSW State Flood Plan* (p.35) requires that SES Division and Local Flood Plans be reviewed. This particularly relates to the data included in Annex A. Graphs showing the distribution of Clarence River floods by month should show all 12 months, even if no floods have been recorded in a particular month. The flood history at the Prince Street gauge should be checked against records in the new Flood Study (WBM, 2004, Tables 4-3 and 4-4). Flood plans (and flood intelligence cards) should record gauge zeros and datum types, as well as indicating the relationship with Australian Height Datum (AHD) where known. The Prince Street gauge is –0.06m AHD according to the Bureau of Meteorology. Even accounting for the use of different datums, there appear to be some minor discrepancies in recorded flood levels (e.g., WBM records the peak in 1996 as 6.98m AHD whereas the local flood plans record the level as 7.07m).

In updating the flood plans, particular attention needs to be paid to details about the magnitude of design floods and the level and frequency at which levees are expected to overtop, since much of this information has been revised. Some of the details in these plans in need of review have been extracted in **Table 4.3**. It is noted that design flood levels and levee overtopping heights listed in the *NSW State Flood Plan* are also in need of revision.

In the same way, flood intelligence cards need to be updated with the latest flood information. Thorough vetting is required to ensure consistency with flood plans.

4.1.5 Evacuation Plans

The four local flood plans (and flood intelligence cards and FloodSafe brochures) contain substantial information about the levels at which transport routes are closed, property and dwellings affected, and levees overtopped. This information is valuable for planning evacuation, especially in the event of levee-overtopping events.

Given the magnitude of the task of evacuating Grafton, which can be further compounded by the rate of rise of floodwater once the levees overtop and the potential for levee breaching and scouring, a more detailed evacuation capability assessment is warranted. It is essential to determine whether or not there are sufficient resources to evacuate the city within the available warning and response time. This could be undertaken in conjunction with additional levee overtopping investigations incorporating various levee failure scenarios.

Evacuation plans will also form a critical floodplain management measure for many of the smaller villages and rural areas within the Valley. The assembly of a comprehensive

database of property within the floodplain would provide valuable data for evacuation planning for these smaller areas. The database would ideally be a GIS based system so that the number and distribution of flood affected properties can be determined for a particular magnitude of flood. The system could also be used in real-time by including the ability to input flood height predictions provided by the Bureau and to then determine which properties are likely to be affected by the predicted flood. Critical levels such as levee heights and road low points could also be incorporated within the system.

A similar flood intelligence system was recently prepared by Bewsher Consulting for the Georges River (see Gissing et al., 2004).

TABLE 4.3
Flood Plans in Need of Review

Flood Plan	Page	Current information
Grafton	A-4	1890 flood = about 100 year event
Grafton	A-5	March 2001 flood = about 3% AEP event
Grafton	A-5	Levee protection to about 1% AEP event
Grafton	A-6	Levees would overtop in flood about the size of 1890 event
Grafton	A-6, F-1	Levees would overtop at gauge height of 7.9m
Grafton	A-6	PMF = 12.0m (±0.8m) on Prince Street gauge
Maclean	A-5	100 year flood = 3.8m on Maclean gauge
Maclean	A-6, F-1	Maclean levee protects to 3.3m on Maclean gauge, which corresponds to 2–3% AEP [contradiction w.r.t. AEP]
NSW State	C-2	Grafton 20% AEP = 5.4m
NSW State	C-2	Grafton 1% AEP = 8.2m
NSW State	C-2	Grafton PMF = 12.0m (±0.8m)
NSW State	C-2	Grafton levees overtopped at 8.23m
NSW State	C-2	Ulmarra 20% AEP = 4.9m
NSW State	C-2	Ulmarra 1% AEP = 6.4m
NSW State	C-2	Ulmarra levee overtopped at 5.8–6.0m
NSW State	C-2	Maclean 20% AEP = 2.5m
NSW State	C-2	Maclean 1% AEP = 3.8m
NSW State	C-2	Maclean levee overtopped at 3.3m

4.2 COMMUNITY AWARENESS

Actual flood damages can be reduced, and safety increased, where communities are 'flood-ready'. Warning messages will be best able to generate appropriate community behaviour when they are preceded by soundly-based public education programs (EMA, 1999, p.11).

> *"People who understand the environmental threats they face and have considered how they will manage them when they arise will cope better than people who lack such comprehension… Many people who live and work in flood liable areas have little idea of what flooding could mean to them – especially in the case of large floods of severities well beyond their experience or if a long period has elapsed since flooding last occurred. It falls to the combat agency, with assistance from councils and other agencies, to raise the level of flood consciousness and to ensure that people are made ready for flooding. In other words, flood-ready communities must be purposefully created. Once created, their flood-readiness must be purposefully maintained and enhanced."* (Keys, 2002, p.52)

Although the experience of the 2001 flood heightened the community's awareness of flooding, this level of interest will inevitably decline with time. Furthermore, it is not easy to convince the residents of towns 'protected' by levees that these levees will sooner or later be overtopped in a large flood.

For these reasons, efforts to create and maintain the community's capacity to respond to floods are of vital importance. Many techniques are available (EMA, 1999, pp.11-12):

- Provide flood information (brochures etc) by periodic door knocking campaigns;
- Provide flood action guides, brochures and flood plans to schools and libraries;
- Encourage or require (as condition of license) caravan park managers to display relevant safety information, to develop response plans which help residents and visitors to save belongings and evacuate safely;
- Construct flood markers to indicate levels reached by historic floods;
- Submit articles to local newspapers;
- Arrange interviews of response agency personnel on radio;
- Use council rates notices to carry reminder messages about floods;
- Prepare 'awareness advertisements' for radio;
- Prepare static displays in public buildings about flooding, including maps;
- Meet people living or working in flood-prone areas, to explain flood warning system;
- Periodically test the flood warning system.

4.2.1 Brochures

Following the 2001 flood, the SES and Clarence River County Council prepared seven FloodSafe brochures for sites in the Clarence River Valley: 1) Grafton; 2) South Grafton; 3) Carrs Island, Bakers Swamp and Southgate areas; 4) Ulmarra and surrounding areas; 5) Brushgrove and Lawrence areas; 6) Maclean and on Woodford, Harwood, Chatsworth and Warregah Islands; and 7) Yamba and Iluka and on Palmers and Goodwood Islands. These brochures have some information in common, but also address issues and convey information relevant to particular areas. All brochures provide answers to these questions:

- How will we know when a flood is coming?
- What can we do to be ready for flooding?
- What should we do if we have to evacuate?
- Where can I get more information?

Each brochure explains the risk of flooding, and records important consequences for various levels on the local gauge. The Grafton and South Grafton brochures pay particular attention to the threat of levee-overtopping floods, noting that the levees will be overtopped in rare events, outlining some of the unpleasant consequences of such floods (failure of power, water supply and telephones; toilets may surcharge; snakes, spiders and vermin will invade houses), and explaining how a large-scale evacuation will be managed.

Overall, these brochures are of a very good quality, and would do much to build on people's experience of flooding. The Grafton and South Grafton brochures are clearly designed to challenge the community's reticence to evacuate that was so apparent during the 2001 flood emergency (Pfister, 2002). Flood intelligence included in the brochures seems to have been carefully compiled. For example, it is stated that levees at Grafton and South Grafton will overtop when a level of 8.0m at the Prince Street gauge is reached, which seems about right based on recent flood and levee profiles (WBM, 2004, Appendix B).

However, the new Flood Study (WBM, 2004) suggests that levee-overtopping events are much more likely to occur than the "1% chance" stated in the brochures. Low spots along sections of the Westlawn levee and South Grafton Urban levee require filling by up to 0.5m to provide protection against the 20 year flood (Dams & Civil Unit, 2004). Consequently, future revisions of the Grafton and South Grafton FloodSafe brochures should convey the relative *frequency*, rather than *infrequency*, of these most serious floods. In addition, it would be worth noting that a flood of the volume of the 1890 event would today reach a level of about 8.4m AHD (based on historic rating curves in WBM, 2004, Figure 4-1).

Another need is the incorporation of levee-overtopping scenarios into the Ulmarra and Maclean FloodSafe brochures. Apart from noting the levels at which the levees are overtopped (inconsistencies with levels recorded elsewhere suggest that these levels need to be vetted carefully)[2], presently these brochures give no explicit comment to say that the levees could be overtopped, and offer little advice on what to do and where to go in such events.

4.2.2 Internet Site

The Clarence River County Council (CRCC) maintained a web-site (www.crcc.nsw.gov.au) that contained a good deal of useful flood information, including the FloodSafe guides, summaries of the February and March 2001 floods, and material about the Council's flood mitigation works. This information now needs to be linked to the homepage of the new Clarence Valley Council. In addition, there is an opportunity to enhance the content of the site and to streamline 'navigation'. The current front-page of the CRCC is structured according to the services offered by the Council: "Council Details", "Civic and Corporate Services", "Engineering Services" and "Clarence Floodplain Project". A more engaging and sympathetic approach would be to ask the questions that the community is seeking answers to. Two good web-site models are those designed for Lismore (www.lismore.nsw.gov.au) (search for "flood") and for Kempsey (www.mhl.nsw.gov.au/www/kempindex.htmlx).

A list of topics covered on the Lismore web-site demonstrates the comprehensive nature of its flood coverage. As well as providing an explanation of flooding, a history of flooding, and photos of flooding, the site lists flood and floor levels for properties in the city, and lists information to assist in evacuation:

1. Emergency Information
2. Flood Safe Week
3. Flood Information
4. What to do in a flood
5. Flood Photo Gallery
6. Why Lismore Floods
7. Lismore Flood Heights and Floor Levels
8. History of our Floods
9. CBD Floor Plan 1
10. CBD Floor Plan 2
11. CBD Floor Plan 3
12. Flood Evacuation Plan - Last Roads Out
13. Historical Floods of Lismore (85 Kb.)
14. Road Closure Information

[2] The Maclean FloodSafe brochure records the levee crest as 3.5m, whereas the NSW State Flood Plan (Annex C) and the Maclean Flood Intelligence Card record the levee crest as 3.3m.

The Kempsey web-site (which is hosted by the Manly Hydraulics Laboratory) includes the Kempsey Local Flood Plan, which outlines the nature of floods, effects of floods, and evacuation procedures during flood events. The site also provides near real time rainfall and river level data from throughout the Macleay River catchment.

It is recommended that a revised, comprehensive flood web-site be developed for the Clarence Valley, which would be of benefit in informing the community both in and out of flood time. This site could be promulgated through Council rate notices and future FloodSafe brochures.

4.2.3 Flood Markers

Another method of raising flood awareness is the construction of one or more flood markers in the Clarence River floodplain. Placement of signs in relation to travel routes is critical to their effectiveness in delivering messages, so the most appropriate locations may be next to main bridges. An example of a sign along the Woronora River is shown in **Figure 4.2**. This sign has proved to be very effective element in raising community awareness (Molino & Huybrechs, 2004b). However, in the Clarence River Valley, few would doubt that the Clarence River floods. Perhaps a more strategic message for Grafton and Maclean would be "Levees don't stop all floods – Are you ready?"



FIGURE 4.2
Flood Marker, Woronora River

Following the 2001 flood, Clarence River County Council instigated a "Clarence River Flood Awareness Program" which included the erection of flood signs on telegraph poles in towns and villages subject to flooding. These signs indicated the level of the 100 year flood, the 2001 flood, and the minimum height of levees where applicable. The signs act as a good reminder to the community of the potential for flooding in the Clarence Valley. Further strategic signage may also be warranted in some places to further enunciate on the potential risks associated with levee banks overtopping and/or failing during floods.

4.2.4 Certificates

A very effective means of raising community awareness about flooding is the regular issuing of 'flood certificates' to all occupiers of the floodplain. These certificates would record ground and floor levels (where available) as well as the expected flood levels in a range of design floods. This would allow an assessment of the depths of flooding over the property and building floor. Where property levels are unknown, residents could be encouraged to obtain these levels using a registered surveyor.

Much of the flood level data necessary to complete these flood certificates is available in the new Flood Study (WBM, 2004), although it is relatively coarse (derived from a 60m grid). Some building floor data is available from past floodplain management studies. A database would need to be incorporated into Council's GIS computer-based system and mechanisms established to maintain the data. It would be relatively simple to print out a flood certificate for one or more properties once this link was established.

A sample flood certificate is included as **Figure 4.3**. The certificate could be attached to Section 149 certificates and also posted out with Council's rates notices every 1–2 years.

Clarence Valley Council

Flood Certificate

Certificate Issued for Property at: 25 Stephen Street, Southgate
Lot 25, DP 25252

Owners Name: Mr F. & Mrs L. Flood

1. Classification of Flood Risk

Council records indicate that the above property is located within a Medium Flood Risk area.

Land that is potentially subject to inundation is classified as low, medium or high flood risk. Council has prepared a development control plan known as "Managing our Flood Risks" that provides details of flood related development controls that may be applicable.

2. Known Floor and Ground Levels

The lowest floor level of the main building on this property is : 6.2m AHD
Source of information : Council Survey November 2004
The lowest ground level on this property is : Not known
Source of information :

If the floor level and/or ground level are currently unknown and you would like to know what the levels are; this can be surveyed by a registered surveyor. Alternatively, Council can arrange this for a fee of $90.

3. Estimated Flood Levels

Flood levels in the vicinity of the above property have been extracted from the Lower Clarence River Flood Study Review (WBM Oceanics, March 2004).

Size of Flood*	Flood Level	Depth over Lowest Floor Level	Depth over Lowest Ground Level
Probable Maximum Flood	8.5m AHD	2.3m	not known
500 Year Flood	6.7m AHD	0.5m	not known
100 Year Flood	6.4m AHD	0.2m	not known
20 Year Flood	6.0m AHD	Not flooded	not known
5 Year Flood	4.3m AHD	Not flooded	not known

**The Probable Maximum Flood (or PMF) is extremely rare.*
A 100 year flood is a large flood. It has a 1 in 100 (ie 1%) chance of occurring in any year.
A 50 year flood has a 1 in 50 (ie 2%) chance of occurring in any year.
A 20 year flood has a 1 in 20 (ie 5%) chance of occurring in any year.
A 5 year flood is more frequent. It has a 1 in 5 (i.e. 20%) chance of occurring in any year.

Issued by Clarence Valley Council

FIGURE 4.3
Sample Flood Certificate

4.2.5 Meter Box Labels

Another means of communicating property-specific flood and floor-level information to residents is by attaching labels inside electrical meter boxes. This has the advantage over brochures in that they are not easily mislaid, they remain with the house when residents move on, and they will be noticed from time to time (Molino & Huybrechs, 2004b).

4.2.6 Commemorative and Flood Awareness Weeks

The commemoration of severe floods, in round-number anniversary years, has been an important means of raising flood awareness. The SES has led or participated in several such ventures, including in 1999 the 50th anniversary of the devastating Kempsey flood of 1949. In 2002, the SES was involved in flood awareness weeks to capitalise on the first anniversary of the 2001 floods, including at Grafton and Maclean (Pfister & Rutledge, 2002). These commemorative events have featured a range of activities (Keys, 2002):

- Public meetings to discuss floods, flood plans and flood management strategies;
- Radio interviews;
- Newspaper articles;
- The production of flood videos;
- The display of flood photographs and other flood memorabilia;
- Guided tours to inspect and explain local flood mitigation systems;
- Street parades featuring flood response agency personnel; and
- School projects with flood themes.

Another way of building a culture of flood readiness would be to designate an annual flood awareness week, preferably at the time of a significant flood anniversary or near the beginning of the flood season. Lismore seems to have set aside the first week in February as 'Flood Safe week'. Activities need not be conducted across all flood-prone communities in the shire every year. The Council and SES could devise a rotation system, with a focus on the Grafton area one year, the Maclean area the next, and so forth.

4.2.7 Evaluation Strategy

Prior to implementing a community education strategy, it would be prudent to design an evaluation strategy, in order to inform future activities. This would ideally include securing baseline information on the level of community awareness (e.g., how many people are aware that their property may be at risk from flooding?). An evaluation of the Woronora River Preparedness Strategy (Molino & Huybrechs, 2004b) indicated that permanent signage was the most widely received flood education measure, but meter box labels were the most retained. More residents recalled receiving the personally-delivered household kit than the posted brochure.

4.3 VOLUNTARY PURCHASE

4.3.1 Overview

Under a voluntary purchase (VP) scheme, Council offers to purchase existing properties that have been identified as severely flood affected if and when they become available for purchase, subject to the availability of funds at the time. Voluntary purchase is, as the name suggests, *voluntary* – not compulsory acquisition, and affected property owners can expect to receive market values. Land purchased under a VP scheme should ultimately be rezoned to open space or some other flood-compatible use.

The main problem with voluntary purchase schemes is the high cost in acquiring properties. The schemes often extend over a long time-frame since there is usually only sufficient Government funds to purchase a few properties every year. Despite unfavourable benefit-cost ratios, VP schemes may still gain funding if the properties are subject to extreme flood hazard, and where other measures are impractical or uneconomic. The 2005 Floodplain Development Manual (p.J-4) recognises that 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.*

4.3.2 Previous Schemes

A review of various flood reports has revealed two voluntary purchase schemes – at South Grafton and Palmers Island.

South Grafton

In November 1979, the State Government allocated $1 million over 15 years for the resumption of properties not included in the then levee proposals for South Grafton. Included in this scheme were 80 houses, St Josephs Primary School, 19 blocks of land and 5 other properties (SL&M, 1980, p.10-24).

Figure 4.4 shows the area of South Grafton believed to be included in the 1979 VP scheme (derived from PWD, 1983). In all, only 7-8 houses and the school were actually purchased under the scheme in the early 1980s (Bob Pavitt, Grafton Council, pers. comm., Nov 2004). A greater level of protection against flooding following levee improvements led to the cessation of the VP scheme. Since some of the properties to be purchased were vacant, it is not possible to identify the locations of demolished houses by inspection of the recent aerial photography.

The potential for voluntary purchase of houses at South Grafton was again considered as part of the South Grafton Floodplain Management Study (Paterson Consultants, 2000). The study concluded that VP was not appropriate because the flood conditions that had prompted the VP scheme had been significantly modified by the South Grafton levee scheme (p.49). Also, it was thought that the community would not be in favour of a VP scheme and that a scheme would cause a depletion of rental properties available to lower income groups (p.47). The copy of the report provided to Bewsher Consulting included a hand-written comment noting that the main reason VP was inappropriate was that only one residential property was located in the high hazard category in the 100 year ponding event, and that voluntary house raising was a preferred option.

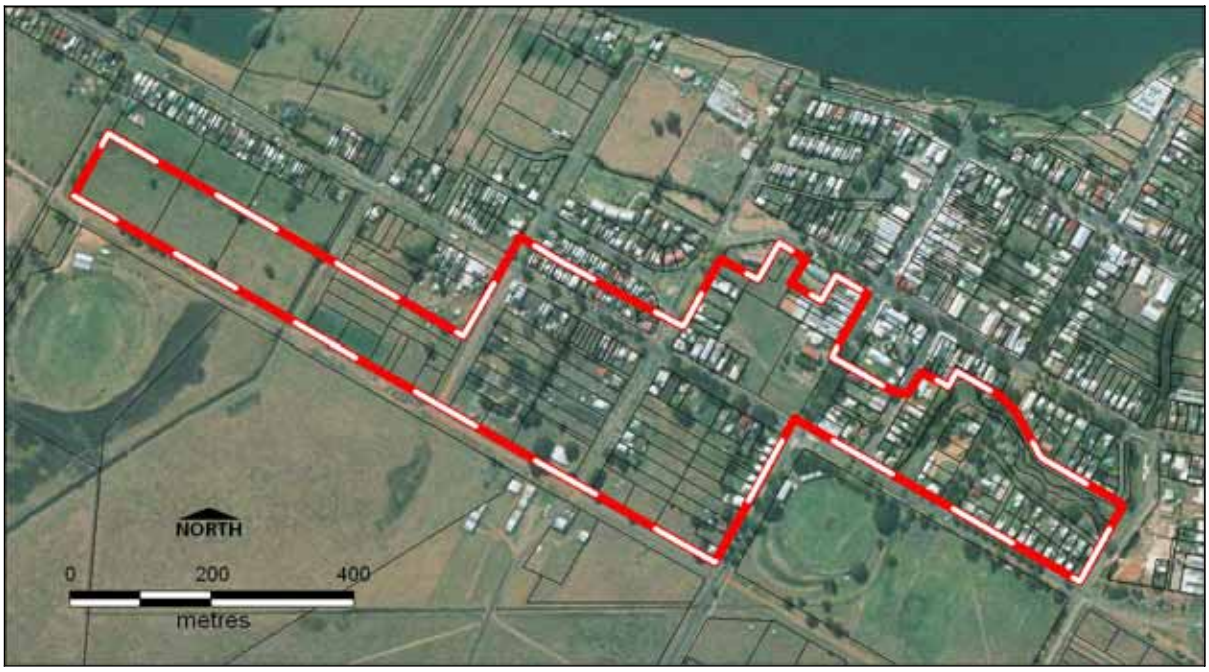


FIGURE 4.4
Floodway Acquisition Areas, South Grafton
Based on PWD, 1983, Exhibit 1

Palmers Island

Property situated on the western side of Palmers Island has been troubled by river-bank erosion since at least the mid-1960s. Rock protection proved to be ineffective in addressing the problem, at substantial expense (SL&M, 1980, p.10-6f). Consequently, in 1995 Maclean Council prepared a Palmers Island Riverbank Plan that targeted dwellings within an "Immediate Impact Zone" for voluntary purchase (Maclean Shire Council, 1995). Initially, 12 houses along River Road were offered VP, 9 of which had been purchased by June 1996. Another 14 houses were offered VP over subsequent years. By July 2005, 24 out of 26 houses along the riverbank had been acquired or relocated. DIPNR declined to fund purchase of two caravan parks located in the Immediate Impact Zone (Peter Lane, Floodplain Services, pers. comm., Jul 2005).

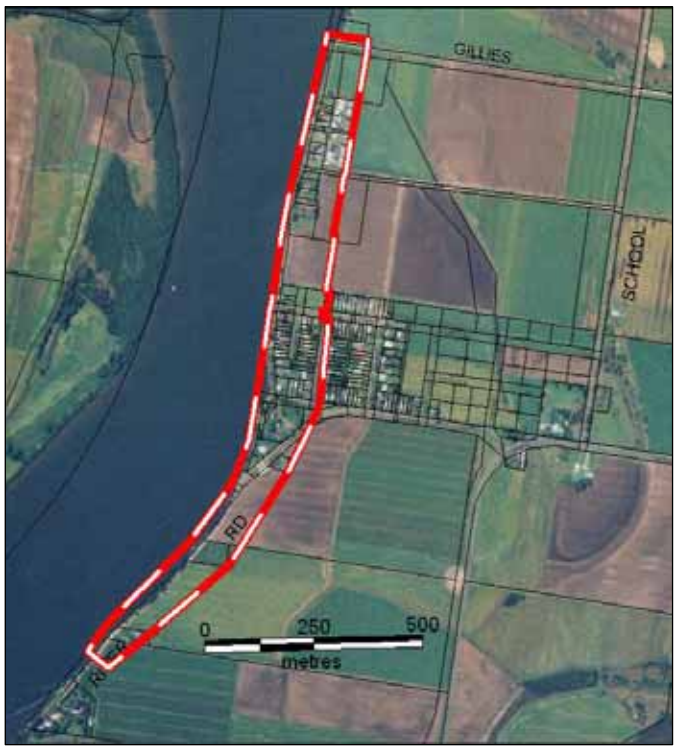


FIGURE 4.5
Immediate Impact Zone, Palmers Island
Source: Maclean Shire Council; Date of Photography 1998

4.3.3 Other Recommendations

The previous South Grafton VP Scheme and the on-going Palmers Island VP Scheme appear to be the only VP Schemes that have been specifically identified for the Clarence Valley.

The Clarence Valley Floodplain Management Study (SL&M, 1980) discussed in general terms the possibility of a redevelopment and relocation program for smaller urban areas within the floodplain (pp.10-11 to 10-13). This included the provision of incentives for people to relocate to flood free areas, and for the local authority to purchase buildings approaching the end of their structural life so that the land could be converted to open space. Included among the overall recommendations for the Valley were the "gradual clearing of existing development in floodway areas" and also the "gradual relocation of farm dwellings away from areas of high velocity flow or other hazards, combined with flood proofing of these isolated buildings" (p.12-1). No properties or areas were specifically identified, and apart from the South Grafton and Palmers Island Schemes, no other property purchases or relocation programs have since been pursued in other areas.

The application of voluntary purchase as a floodplain management measure was revisited in the 1993 Lower Clarence River Floodplain Management Study. The Study concluded that, in general, voluntary purchase schemes were impractical and not warranted on the basis of damage potential, flood flow hazard and the availability of alternatives such as levees or house raising (Paterson Consultants, 1993, pp.11,14).

An informed assessment of the merits of voluntary purchase schemes would require an up-to-date database of flood-prone properties, especially listing flood and floor levels, so that the benefits of removing flood-prone houses can be compared to the costs of purchasing properties and demolishing houses. Some floor level data is available in previously published reports. However, none of these data sources are entirely satisfactory: the property listings for South Grafton (Paterson Consultants, 2000, App. B) and the Lower Clarence River (Paterson Consultants, 1993, App. C) do not provide flood levels, and the "lot numbers" for Brushgrove (WM&A, 2001, Table E6) cannot be reconciled to real lot numbers or street numbers. Of course, none of these reports contain data from the latest Flood Study (WBM, 2004). No floor level data at all is available for (North) Grafton or for properties situated between Grafton and Brushgrove.

Until such time that an adequate property database can be prepared and assessed, it would appear that:

- It is unlikely that a broad voluntary purchase scheme will be cost-effective. This is especially the case where properties are afforded some protection from levees (e.g., Grafton, South Grafton, Maclean) and for rural properties where the house is situated on a small portion of a large (expensive) block.
- Consequently, VP schemes could only be justified where houses are located in high risk floodways, or where the flood hazard represents a danger to life.
- Preliminary mapping of floodways was undertaken as part of this study. Further refinement of floodway locations has been recommended using improved topographic data and further model investigations. This would provide the basis, in conjunction with the proposed property survey, to evaluate which properties (if any) warrant inclusion in a voluntary purchase scheme.
- On larger, rural properties there may be some scope to relocate severely flood affected dwellings to an area of less risk within the same property. This could be provided under incentives suggested under voluntary house raising schemes.

4.4 VOLUNTARY HOUSE RAISING

4.4.1 Overview

House raising has been an effective floodplain management measure in a number of jurisdictions in NSW, including Fairfield and Lismore. **Table 4.4** records some advantages and disadvantages of voluntary house raising (VHR). House raising is expected to reduce tangible and intangible flood losses. However, it may not be appropriate in all cases (e.g., for elderly residents) and the implications of house raising for emergency management require careful thought.

TABLE 4.4
Advantages and Disadvantages of House Raising
Based on Penning-Rowsell & Smith, 1987; NSW Government, 2005

Advantages	Disadvantages
▸ Reduced tangible flood damage. ▸ Reduced risk to personal safety and intangible costs such as anxiety, stress and post-flood trauma. ▸ Provision of under-house space for a garage, laundry or storage. ▸ Enhanced resale value of property.	▸ The development of areas beneath a raised house may offset reduction in damage potential. ▸ People living in raised houses may be less likely to evacuate, increasing the threat to life in the rare event that a flood reaches the floor level; risk to emergency services if rescue required. ▸ House isolated at times of flood; some intangible costs remain; risk to emergency services if rescue required due to medical emergency. ▸ Building may prove to be incapable of withstanding force of floodwater and debris loading, resulting in structural collapse. [Note that the Floodplain Development Manual regards VHR as a suitable management measure only for *low hazard* areas of the floodplain]. ▸ Steps to gain access to the house may not be suitable for older people or those with disabilities. ▸ Aesthetic and town planning constraints may apply: e.g., isolated raising of individual properties in a street may be less desirable than schemes that include a group of properties in a street.

An important influence on the ability to raise houses, and on the nature of house raising, is building material. It is easiest to raise houses of either timber or fibro construction. In 2005 dollar terms, the cost of raising this sort of house has been estimated at about $36K (Penning-Rowsell & Smith, 1987) or $42K (Maclean Shire Council, 1999; Paterson Consultants, 2000). The experience of Fairfield Council in Prospect Creek has shown that a figure of $50K is more applicable.

At first glance, it may appear costly and impractical to raise brick veneer, full brick, or double-storey houses. However, Fairfield Council has piloted a number of innovative approaches towards dealing with these 'difficult' houses. Two approaches were trialled for full-brick houses. At one house, the roof was converted to a living area, then the ground floor was gutted. The renovation cost only $60K, though there was a degree of inconvenience to the occupants. At another property, Council purchased and demolished the house then sold the vacant land on the open market with building conditions on the title that complied with Council's Flood Policy. The typical net cost for this option was about $80K. For double-storey houses, if the flood planning level is less than a metre above floor

level, Fairfield Council has undertaken a form of flood-proofing by replacing carpets and gyprock with more flood-compatible materials and by raising power-points and other services like air conditioning units. This option costs in the order of $10K-$20K/house.

Where voluntary house raising in a specific area is identified in an adopted floodplain risk management plan as a means of protecting a significant number of houses at serious risk of flooding, it becomes a formal management measure and, as such, is eligible for Government financial assistance (NSW Government, 2005, p.J-4). Where economically justified, a subsidy based on the full cost of house raising may be provided. This is generally the case for timber or fibro houses with floor levels located below the 20 year flood level. In marginal cases, subsidies have been provided in other parts of the State for the first $10K cost to raise a particular house, with the homeowner required to pay the difference.

4.4.2 Previous Schemes

South Grafton

The South Grafton Floodplain Management Study identified only two houses that failed to conform to minimum floor level requirements of RL 5.1m AHD for the lower floor and RL 7.1m AHD for the upper floor. These two dwellings, located in Skinner Street, are of timber construction and could be raised.[3] However, it was not recommended that the buildings be raised because of "questionable" structural integrity and an unfavourable benefit-cost ratio. The works, however, could be justified on a basis of social equity, so that all dwellings in South Grafton would have the same level of protection (Paterson Consultants, 2000, p.52).

Carrs Island/Peninsula

The South Grafton Levee Augmentation EIS identified 16 houses as adversely affected by the South Grafton Levee works during major flooding in the Carrs Peninsula area. Levels in the 100 year flood were expected to rise by a maximum of 300mm. To compensate for this adverse effect, Council offered house raising to residences with floor levels below a level of 1% (post levee) + 300mm. Floors were to be raised to a minimum of 1% (post levee) + 500mm, at Council's cost (CRCC, 1992).

Figure 4.6 shows the actual works undertaken. Of the 16 houses believed to be adversely affected, three did not qualify because their floor levels were above the 1% + 300mm threshold, two were derelict (presumably, these could not be raised without damaging the structure, or were not worth raising), eight were raised between 1992 and 1999, and one that had been raised in 1987 was retrospectively paid for by Council. At one property, Council funded a "new shed on a mound" that included a living area. Council also funded raising an existing ring levee by 300mm, as well as construction of three stock mounds. The total cost of works was about $309K (Frank Rasborsek, Floodplain Services, pers. comm., Jul 2005).

[3] The South Grafton Floodplain Management Study (Paterson Consultants, 2000) contains available floor level data (derived in the main from a floor level survey by Clarence River County Council in 1970) in Appendix B. The two Skinner Street dwellings to which the text of the study refers could not be identified from the list of properties in Appendix B. Of the two Skinner Street dwellings identified as timber dwellings, No. 77 Skinner Street was a non-raised dwelling with a floor level of 6.78m AHD, well above the minimum requirement for lower floor levels (though not for upper floors), and No. 91 Skinner Street was so elevated that its floor level was not surveyed.

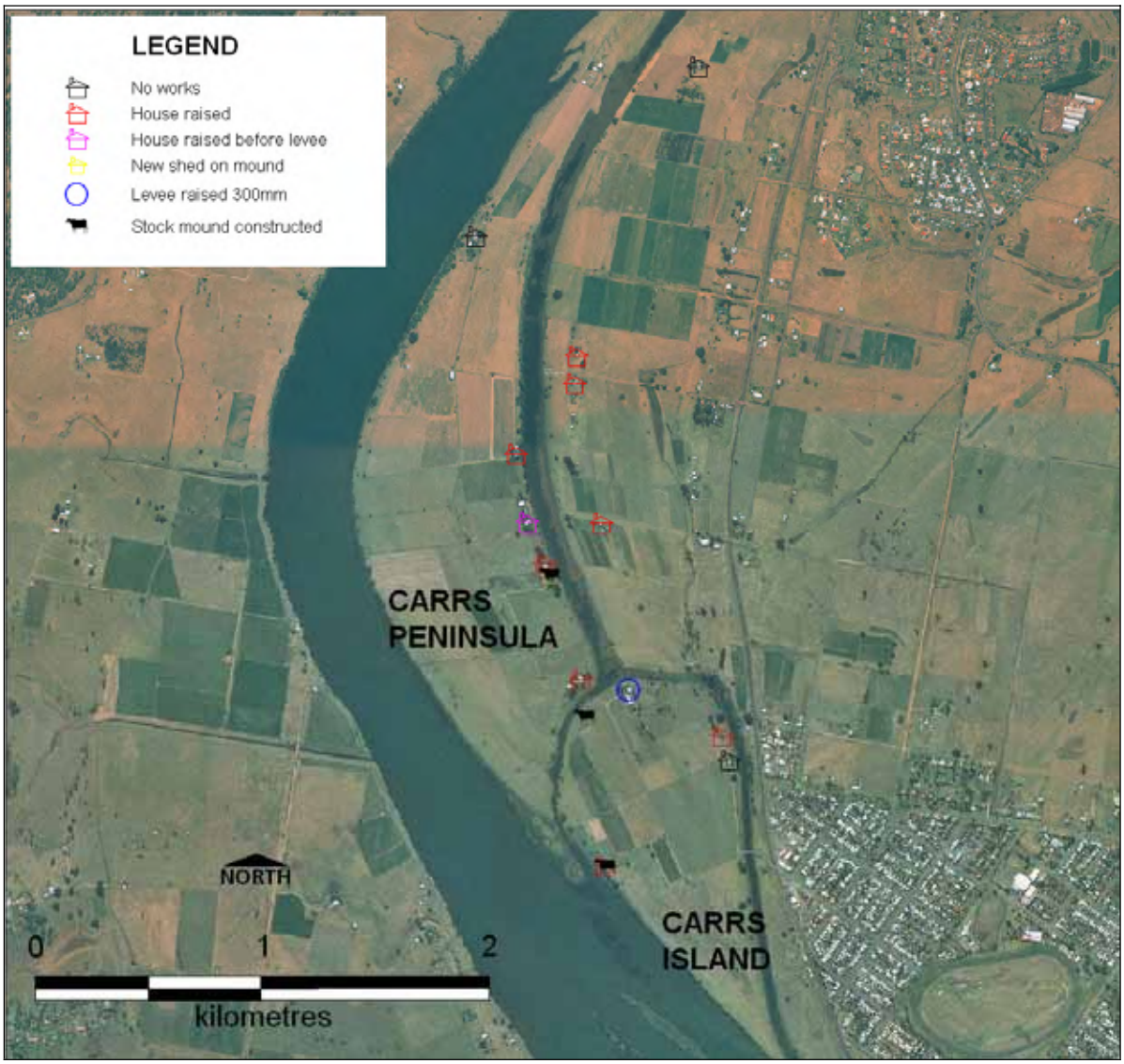


FIGURE 4.6
Carrs Island/Peninsula House Raising, 1992
Based on data from Clarence Valley Floodplain Services

4.4.3 Other Recommendations

The Lower Clarence River Floodplain Management Study (Paterson Consultants, 1993) identified voluntary house raising as a "feasible" option for several locations, listed in **Table 4.5**. House raising was regarded as feasible only for timber-framed buildings with timber floors. The Study did not clearly distinguish the number of residential buildings from the number of commercial buildings that could be raised. House raising was not recommended at Maclean, which is afforded some protection by a levee, or at Yamba, where there is a high proportion of brick veneer and concrete slab-on-ground dwellings.

The 1995 Lower Clarence River Floodplain Management Plan, however, did not recommend voluntary house raising, which it regarded as expensive and generally impractical (Connell Wagner, 1995, p.21).

TABLE 4.5
House Raising Options for Lower Clarence River
Source: Paterson Consultants, 1993

Location	Number of premises with floor levels below designated flood (p.11,42)	Number of premises that could be raised above designated flood	Cost (1993$)	Benefit-cost ratio
Maclean	299 (195 houses)	Impractical	–	–
Yamba	419 (all houses)	Impractical	–	–
Iluka	31 (all houses)	29 (all houses)	$780K	0.67
Harwood	50 (35 houses)	40 (32 houses)	$1.0M	0.27
Brushgrove	15 (all houses)	11 (all houses)	$275K	0.35
Palmers Island	10	9	$290K	0.21
Chatsworth	11	9	$230K	0.15
Lawrence	20	15	$380K	0.16
Rural Areas	~400	~200	$7M	Not assessed

The revised 1999 Lower Clarence Floodplain Management Plan (Maclean Shire Council, 1999) recommended that 15 houses in village centres (excluding Maclean) with floor levels below the 20% AEP (5 year ARI) flood be raised to the level of the 1% AEP flood plus 500mm freeboard. It was estimated that perhaps another 15 houses in rural areas would meet this criterion for house raising.[4] The benefit-cost ratio was thought to exceed 0.5. Only timber framed and clad dwellings were included in the proposal. The Plan recommended that a full subsidy be offered to owners of suitable houses with floor levels below the 20% AEP flood level. The aggregate cost of this option was estimated at $1M (1999 dollars).

In addition to the full subsidy for low level houses, the 1999 Plan also recommended that a part subsidy of $10K/house be offered to owners of houses in rural areas with floor levels below the 2% AEP (50 year ARI) flood level. It was estimated that up to 400 houses in villages and another 100-200 in rural areas would meet this criterion. The Plan allowed $6M for these part-subsidies (1999 dollars), subject to the availability of Council and Government funds. **Table 4.6** shows that only 81 houses were explicitly identified as meeting the criteria, suggesting that a figure of $6M is quite conservative.

An assessment of floodplain management options at Brushgrove (WM&A, 2001) recommended house raising as the most affordable and practical solution to reducing the costs of flooding. Of the 14 houses with floor levels below the then 1% AEP (100 year ARI) flood level, three were brick and one was a two-storey timber dwelling, so the study recommended raising the remaining 10 houses on a prioritised basis depending on funding and owner acceptance. A full subsidy of $30K/house was recommended for 7 houses with floor levels below the 3% AEP level, and a part subsidy of $10K/house was recommended for 3 houses with floor levels between the 1% and 3% AEP levels, at a total cost of $300K (1997 dollars), with a benefit-cost ratio of 0.65.

Council has yet to develop and adopt a house raising policy for houses other than those on Carrs Island/Peninsula. Any other house raising that has occurred within the Valley would have been initiated and funded by home-owners.

[4] The Plan recommended that in rural areas, if a home-owner expressed interest in voluntary house raising, Council would first obtain an accurate floor level survey to ensure that a particular house met the criteria.

TABLE 4.6
House Raising Recommendations for Lower Clarence River
Based on Maclean Shire Council, 1999

Location	Number of houses offered full subsidy (floors below 5 year flood)	Number of houses offered part subsidy (floors below 50 year flood)	Comment
Maclean	-	-	Not recommended due to very low BCR. Protection already afforded by levee (to 3% event)
Yamba	-	Suitable houses only (not quantified)	Majority not feasible due to high proportion brick veneer and concrete slab-on-ground buildings; however, any suitable houses could be raised
Iluka	8 (4 houses in Marandowie St, 2 in Cave St, 1 in Spencer St, and 1 in Riverview St)	20	All houses could feasibly be raised, except for two-storey brick residences
Harwood	3 (4,6 Martins Point St; 8 Morpeth St)	31	
Brushgrove	2 (29,32 Donaldson St)	7	
Palmers Island	2 (6,14 Gordon St)	9	
Chatsworth	0	6	
Lawrence	0	8	
Other villages#	0	0	No existing flood liable houses
Rural areas	0	?	No survey available for rural dwellings.
TOTAL NUMBER OF HOUSES	15	Approx est. 600	
TOTAL COST	$0.5M (1999 dollars) (15 houses @ $33,333/house)	$6M (1999 dollars) (600 houses @ $10,000/house)	

Other villages include Woombah, Ashby, Ilarwill and Tyndale.

4.4.4 Further Discussion

Two different types of subsidy arrangements were identified for voluntary house raising (VHR) in the Lower Clarence Valley Floodplain Management Study, namely:

- a full cost subsidy for properties below the 5 year flood level; and
- a partial subsidy payment of $10K for properties between the 5 year and the 50 year flood level.

Full cost subsidy schemes have a number of disadvantages. Apart from the additional costs to implement, there are a number of equity issues to consider. For example, should owners of a brick home receive more funds to raise/rebuild their home (say, $80K) than the owner of a timber clad home that can be easily raised (say $40K)? Or should homes that are more difficult to raise be excluded from the VHR scheme? Also, because Council is subsidising the full cost of house raising, there is more onus on Council to fully manage the project – from negotiations with builders, signing contracts, supervising works, making part payments, handling disputes between builder and owner, etc. In all, full cost subsidy schemes can result in a significant administrative burden on Council.

In contrast, a partial subsidy scheme could be much simpler to administer. The partial subsidy does not cover the full cost of house raising, but is intended to provide a financial incentive for owners to raise their own homes. As the owner is committing a large proportion of their own funds, it is reasonable to expect that they would be happy to accept responsibility for their own building work, resulting in less administrative burden on Council. Of course, Council would still need to promote the Scheme, approve design drawings and make a one-off subsidy payment (to the owner) at some stage during the project.

Another advantage of the partial subsidy scheme is that it provides the owner more flexibility to incorporate other building improvements or modifications at the same time, providing that the ultimate goal of raising habitable floor levels to a minimum of 0.5m above the 100 year flood is achieved. With such flexibility, it should be possible for any building type to be raised (or modified) to achieve this goal. This may be through physically raising existing dwellings, demolition and rebuilding, or through relocation/rebuilding of an existing dwelling to higher ground within the property (particularly suited to rural dwellings). Under this scheme there is no discrimination on the type of existing dwelling.

Under the partial subsidy scheme, each resident whose house met the criteria for house raising (discussed below) would be offered the same financial *incentive*, to encourage works. In our view the subsidy should be of the order of $15K/house. Interested house-holders would be required to submit an application for building approval, providing a photograph and relevant details (including current ground and floor level, building material, proposed raising, etc). Where exact ground and floor levels are unknown, Council could arrange survey by a registered surveyor upon payment of a nominal fee. Alternatively, the assembly of a comprehensive property database would form the basis of determining property numbers and eligibility. At some time *after* works have begun, Council would pay the subsidy.

An important issue concerns the criteria used to qualify a house for voluntary house raising. Where floodplain management works such as levees at Grafton, South Grafton and Maclean already provide a level of protection to dwellings, further floodplain management works to provide a second form of protection are difficult to justify. House raising at such locations is unlikely to be cost-effective, even when considering the issue of internal ponding as well as levee overtopping. At North Grafton, it is understood from Council staff that ponded water in the 1974 flood did not rise above floor level of any house in the levee area. At South Grafton, only one or two houses would be affected by the 100 year ponding event. At Maclean, the maximum predicted 1% ponding level of 2.75m AHD in the River Street ponding area (Paterson Consultants, 1989, p.18) was compared with available residential floor levels (Paterson Consultants, 1993, App. C). It was found that only six residential floor levels between No. 41 and No. 203 River Street were situated below the 1% ponding level: No. 73 (FL 1.5m AHD), No. 117 (1.9m), No. 123 (2.0m), No. 155 (2.1m), No. 165 (2.6m) and No. 167 (2.6m). Based on this assessment, there may be some grounds for offering VHR to the four worst affected houses at Maclean, but it is considered unduly conservative to base assessments for VHR on the 100 year event, and no information is available about the extent and depth of ponding in more frequent events, such as the 20 year event. Moreover, flooding of areas protected by levees is expected to be of low velocity.

For other areas, selecting criteria for voluntary house raising partly reflects the numbers of houses exposed to flooding for each design flood. In the absence of a current, GIS-based database of flood-prone properties (including floor levels), this is very difficult to assess. Some information is available from previous studies, but these sometimes excluded non-timber houses, sometimes failed to distinguish residential from commercial buildings, and do not incorporate the latest design flood levels. Given these uncertainties, **Table 4.7** presents some very preliminary estimates of the numbers of properties exposed to flooding.

TABLE 4.7
Preliminary Estimate of Residential Dwellings Exposed to Flooding
Note: Excludes ponding behind levees.

Location	5 year ARI	20 year ARI	100 year ARI	500 year ARI	Source (below table)
Carrs Island	0	0	0	0	4
North Grafton (within levee)	Levee	Levee	2,550	2,800*	2
South Grafton (within levee)	Levee	Levee	198	220*	2
Ulmarra	10*	20*	80	100*	2
Southgate	8	8	10	10	5
Cowper	0	8	17	17	3
Brushgrove	2	8	13	35	1
Lower Southgate	0	1	3	3	3
Lawrence	0	7	14	17	1
Tucabia	0	6	10	13	5
Tyndale	0	10	10	10	5
Ilarwill	0	0	0	0	5
Maclean (within levee)	Levee	Levee	189	211	1
Ashby	0	0	0	0	5
Harwood	3	2	28	37	1
Chatsworth	0	0	7	12	1
Palmers Island	2	6	16	21	1
Iluka	8	8	28	30	1
West Yamba	0	0	153	203	1
Mid Yamba	0	42	290	293	1
Rural Areas (Lower Clarence)	50*	100*	400	500*	1
Rural areas (Mid Clarence)	50*	100*	400*	500*	
TOTAL NUMBER OF HOUSES	133	326	4,416	5,032	
TOTAL COST ($15K subsidy)	$2.0M	$4.9M	$66M	$75M	

* Number not quantifiable at this stage. Indicative number provided.

Source: 1 = Lower Clarence River Floodplain Management Study, 1993 (Appendix C using revised flood data)
2 = Clarence Valley Floodplain Management Study, 1980
3 = Assessment of Brushgrove Floodplain Management Options (Appendix G)
4 = pers. comm. Frank Rasborsek, Floodplain Services, Jul 2005)
5 = Preliminary estimate from aerial photography

In our view, an appropriate threshold for inclusion in a voluntary purchase scheme would be above-floor flooding in the 20 year flood. This would mean that possibly in the vicinity of 300 houses would qualify for VHR (excluding houses protected by levees). If part subsidies were offered, this would cost about $4.5M.

4.5 PLANNING CONSIDERATIONS

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Lower Clarence Valley. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

There are various forms of planning instruments and associated controls which apply to the study area, which can be used to implement flood-related planning controls to guide future development within the study area. These are discussed below.

4.5.1 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared by the Department of Planning that deals with matters of significance for environmental planning for the State. No State Environmental Policy has been prepared dealing specifically with the issue of flooding.

As the Floodplain Development Manual is aimed at encouraging a merit based approach to floodplain planning for individual areas, it is unlikely to be desirable to establish a global policy for floodplain development through the application of a SEPP.

4.5.2 Regional Environmental Plans

A Regional Environmental Plan (REP) is prepared by the Department of Planning, and provides objectives and controls for environmental planning for a region, or part of a region.

The study area is affected by the North Coast Regional Environmental Plan, 1988. The plan contains planning principles to guide councils' preparing local environmental plans and provides specific development controls in regard to various land uses. The plan prevails over any other regional environmental plan or local environmental plan where there is an inconsistency.

Clause 45A generally requires that LEPs do not facilitate the intensification of development on flood liable land, or permit development without consent in high hazard flood areas, unless this is justified in a Floodplain Risk Management Plan. The extent of flood liable land is defined in the Floodplain Development Manual to include all land potentially affected by flooding up to the PMF.

The North Coast REP provides an appropriate context for the more detailed controls to be implemented within Council's LEP and DCP. There is no reason to amend the REP for the purposes of implementing planning controls recommended in the floodplain management plan.

4.5.3 Regional Planning Strategies

Various regional planning strategies have been published in past years, affecting the study area. Generally, these strategies are currently subject to review but are briefly outlined and discussed below.

The original local Councils in the Clarence Valley region adopted a Valley-Wide strategic approach to future planning, referred to as the "Clarence Valley Settlement Strategy" (March 1999). The Strategy had been prepared to demonstrate how growth may occur over a 20 year period, in particular by locating population growth in areas that will have the least cost

in environmental, social and economic terms. This Strategy originally formed part of the Northern Rivers Regional Strategy.

The settlement strategy provides for most new growth being focused close to Grafton and Maclean in several areas close to services. These areas comprise Grafton, South Grafton, Maclean, Yamba, Junction Hill Village, a future village of Clarence and possible village type development at Waterview Heights. As a general principle, the strategy states (among many other principles) that urban settlement should be free of flooding hazard and consistent with any Floodplain Management Plan (pg. 11). In regard to Grafton (including South Grafton), the strategy proposes urban infill and only minor additions to the existing residential zone. Potential urban expansion areas have generally been located in areas of no or low flood risks, such as the Junction Hill and Clarence urban expansion areas located to the north and south of Grafton respectively.

The Northern River Regional Strategy was formulated through a partnership between the Northern Rivers Regional Economic Development Organisation, the Northern Rivers Regional Organisation of Councils and the Department of Planning. This Strategy is based on the principles of sustainable development and builds on the findings of the North Coast Urban Planning Strategy. The Strategy covers 10 LGAs from the Queensland border in the north to the Clarence Valley in the south.

The North Coast Urban Planning Strategy covers the area from Port Macquarie to the Queensland border. This Strategy identifies the areas that can accommodate more people and development while maintaining and protecting the region's environmental qualities. The Strategy nominates the specific centres that are best capable of accommodating further development.

It is understood that all regional strategies are under review and that this will be taken into consideration in the finalisation of Council's current review of its LEPs and DCPs to produce consolidated comprehensive instruments.

It will be important to utilise this Floodplain Risk Management Plan in all strategic planning exercises, particularly in the identification and detail planning of any new urban areas. Due to the highly hazardous nature of floods in the valley, due to depth, new urban areas should generally be located outside of the floodplain. Minimal infill development should be allowed within the floodplain, including areas surrounded by flood levees as overtopping and failure can occur.

4.5.4 Advisory Circulars

The Department of Planning is responsible for providing advice to local councils to ensure that best practice is maintained in the planning process. A Planning and Environment Commission Circular was issued in 1977 advocating prescriptive floodplain planning controls and the adoption of the 100 year ARI flood standard. Subsequently, a Departmental Circular (No. 122) was issued by the Department of Planning (and more recently as Circular No. C9) to assist Councils to relate the flood policy of the State Government and the Floodplain Development Manual to the requirements of the EPA Act and the Department's general approach to floodplain planning.

The original State Flood Policy (1984) disbanded the 100 year ARI flood standard and required local Councils to implement floodplain management based on a merit based approach. The Circular states that in accordance with the Floodplain Development Manual, Councils should prepare single comprehensive local environmental plans to implement their Floodplain Risk Management Plans, and so avoid an ad hoc, piecemeal approach to planning within floodplains.

4.5.5 Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Section 117(2) Direction No G25 (in regard to 'flood liable land') had been in existence for sometime, prior to a recent review. This direction was aimed specifically at enforcing the principles contained within the Floodplain Development Manual.

Section 117(2) directions were reviewed within a report prepared by PlanningNSW (*"Review of Section 117(2) Directions"*, 1997). A further review was undertaken as part of the NSW planning reforms and new Section 117 ministerial directions have recently been issued by the Department of Planning (dated 30 September 2005). Direction 15 deals specifically with flood prone land and has the following two objectives:

> *"To ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.*
>
> *To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land".*

The direction would apply to all councils that contain flood prone land when an LEP proposes to "create, remove or alter a zone or provision that affects flood prone land". In such cases, the direction requires draft LEPs to ensure the following:

> Consistency with the principles of the Floodplain Development Manual;
>
> Do not rezone flood prone zoned special use areas, recreation, rural or environmental protection to a residential, business, industrial or special use area zone;
>
> Do not permit development in floodways that would result in significant flood impacts on others, permit a significant increase in development on the floodplain, require substantial government spending on flood mitigation, or allow development without consent except for agriculture or flood mitigation works.

The direction provides that an LEP can be inconsistent with the above requirements subject to the rezoning being in accordance with the Floodplain Development Manual (and consequently a Floodplain Risk Management Plan prepared under the Manual) or is of minor significance. Accordingly, this direction re-emphasises the necessity for the Floodplain Risk Management Plan to provide a basis for planning provisions in any future draft LEP within the LGA. The direction also requires development consent be necessary for all development in the floodplain except agriculture and exempt development.

Direction No. 15 was recently (subsequent to the preparation and exhibition of the original version of this report) reviewed as part of the new 'flood planning guideline' issued by the Minister of Planning on 31st January, 2007. The review of this Direction principally extended its application to limit the imposition of LEP controls on residential development above the 100 year flood. The implication of this recent amendment to the Section 117 Directions is discussed further in **Section 4.5.9**.

4.5.6 Local Environmental Plans

A Local Environmental Plan (LEP) is a plan prepared in accordance with the EPA Act which defines zones, permissible uses within those zones and specific development standards and other special matters for consideration with regard to the use or development of land.

The Clarence Valley Council is an amalgamation of pre existing local government areas, and consequently remains subject to five LEPs. The Council is undergoing a process of review of the five LEPs to produce a comprehensive consolidated LEP in accordance with the recently gazetted "LEP template". A draft of this LEP for exhibition purposes is unlikely to be available prior to the end of 2006.

The importance of the LEP to floodplain management can be summarised as follows:

> To provide objectives for the application of floodplain management principles in the assessment of development applications.
>
> To appropriately identify areas subject to flooding in order that development applications in such areas may be specially considered and that Council has a basis for notifying the public of the potential for flooding on individual parcels of land in accordance with Section 149 Certificates issued under the Act.
>
> To outline general matters for consideration with more detailed controls being the subject of a DCP in accordance with accepted practice.
>
> To clearly define terminology used in the LEP which relates to floodplain management.
>
> To ensure that the permissibility and prohibition of uses is consistent with the Floodplain Risk Management Plan, in order that flood sensitive land uses are clearly prohibited within areas subject to significant and hazardous levels of flooding. In this regard we note that the prohibition of land uses is a matter which must be clearly outlined within the LEP as this function cannot legally be transferred to a DCP.

It is recommended that Council's proposed LEP be augmented to provide some reference to floodplain management, principally to satisfy the above potential functions of an LEP in the floodplain management process. Draft recommended LEP provisions, in a format suitable for inclusion in the LEP Template, are outlined within **Appendix A**. In summary, the recommended inclusions with the LEP are as follows:

• **Definitions** – It is recommended that the definition of flood liable land be included within the LEP which refers to the whole of the floodplain, that is, up to the probable maximum flood. This would be consistent with the provisions of the Floodplain Development Manual, would resolve issues of confusion with the public in regard to why there is land not deemed to be flood liable (i.e. above the flood planning level but still at risk of flooding), and provide a more appropriate framework for more detailed planning controls to be embodied within a DCP. This will also assist in providing some continuity between current LEPs which provide a variety of definitions of flood liable land, up to and including land affected by the PMF.

• **Flood Related Clause** – Consideration regarding the inclusion of a clause specifically identifying the matters for consideration in the assessment of development applications of flood liable land. The intention of such a clause would be to recognise any Floodplain Risk Management Plan prepared by Council in accordance with the Floodplain Development Manual, and identify the primary matters for consideration generally being to minimise risk to persons and property, minimising impact upon others within the floodplain, and ensuring that development is not reliant on uncommitted government expenditure on flood mitigation works or the capacity of the SES to achieve an acceptable level of risk. The inclusion of such a clause will also provide continuity from council's existing LEPs so as to not present to the public a perception of decreasing importance of floodplain management in the LGA, being a significant environmental hazard in the local planning context.

At the time of finalising Council's proposed consolidating LEP, consideration can also be given to the inclusion of floodways upon the LEP Map, and prohibiting the majority of land uses on land identified to be within a floodway. This exercise will need to be undertaken with regard to broader planning considerations and involve an assessment of existing development that would be located within such an area proposed to be mapped as a "floodway". The implications for the continuation of existing development in such a location will need to be considered and, for example, if there is minimal existing development, a voluntary purchase program could be developed to provide for the gradual removal of all development within this area.

4.5.7 Development Control Plans

A Development Control Plan (DCP) is a plan prepared in accordance with Section 72 of the Environmental Planning & Assessment Act which provides detailed guidelines for the assessment of development applications.

Clarence Valley Council does not have a singular floodplain risk management related DCP based on an adopted Floodplain Risk Management Plan and relies on interim policy provisions. These interim policy provisions are reflected within a number of DCPs adopted by the former Councils.

Consistent with the intention to review Council's inherited LEPs and provide a consolidated planning instrument, Clarence Valley Council has embarked on a process of preparing six DCPs, which relate to individual zones as follows:

Residential
Industrial
Commercial
Rural residential
Rural
Open space/environmental protection

The intention is that each DCP will exist as a stand-alone document but will, by necessity, replicate generic provisions. Flood-related controls are proposed to be provided as a separate chapter within each of the DCPs. The proposed chapter for the Residential DCP is provided in **Appendix B**. A similar chapter would apply for the other five DCPs, with some minor changes to specific standards.

The flood-related controls are summarised in a matrix of planning controls. These controls vary dependent upon the relevant flood management area and individual land use categories. The matrix provides a singular consolidated list of controls appropriate for the purposes of this report. However, the controls will need to be selectively transferred to each of the six DCPs proposed by Council depending on their relevance to the land use category for which each DCP applies.

Separate planning control matrices have been prepared for Grafton (including South Grafton) and the Lower Clarence Valley. These are included as schedules to the flood management chapter of the proposed DCPs (which are included in Appendix B). Other matrices can also be prepared where other site specific floodplain risk management studies and plans are prepared.

In the case of Grafton and the Lower Clarence Valley, six areas of development control considerations have been proposed. These are listed in the relevant planning control matrix and are further discussed below.

Floor and Pad Level

In principle, all habitable floor levels of dwellings should be no lower than the 100 year flood level plus freeboard unless there is a good reason to depart from this standard. Additionally, where practical, extended floors associated with minor additions to existing development should be provided at this level, but should never be at a level lower than the existing floor level.

In regard to strategic planning for new residential areas, detailed investigations would be required to determine that urban residential development can practically occur by being located either outside of the floodplain, or on filled land that is proven to not have a flood impact upon properties elsewhere within the floodplain.

In regard to rural properties, there may be a reasonable expectation to provide elevated fill pads for the location of rural dwellings and associated uses such as car parking and storage sheds. The height and dimension of such fill pads will need to be assessed on the merit of the individual proposal, to ensure that they do not give rise to any unacceptable environmental or amenity impacts.

Floor levels of industrial and commercial development should be at the 100 year flood level plus freeboard, where possible. An alternative floor level control is provided for commercial uses in order to allow for floor and street levels to relate in a manner consistent with existing development in a centre, subject to elevated storage space being provided.

Less “flood sensitive” land uses such as buildings associated with open space or some non-residential or urban uses could have buildings located with floor levels at the 5 year flood level plus freeboard, sufficient to avoid nuisance flooding.

The exceptions to the above would be in regard to infill development in the established urban areas of Grafton and South Grafton (including the Heber Street catchment). These areas have been substantially developed based on historic flood levels, and compliance with the new flood levels may be inappropriate with the streetscape and character of the locality. In these circumstances the historic flood level may be an acceptable minimum. The DCP is to establish guidelines for the implementation of this principle.

Flood Compatible Building Components

All structures below the design flood level for individual land uses should be constructed of flood compatible materials. With regard to the identification of appropriate flood compatible materials, an appropriate general list of materials and fittings is provided within the recommended DCP chapter.

Structural Soundness

An engineer’s report is considered to be appropriate to ensure structures located within floodway areas are capable of withstanding the forces of floods including debris and buoyancy factors.

The issue of structural soundness should also be considered elsewhere within the floodplain, but it is not considered that an engineering report would be necessary in each case. The applicant would still need to demonstrate that the issue has nonetheless been addressed, by either explaining how such an issue is not relevant in any particular case, or that the design has minimised any impacts to the maximum practical extent. Council engineers may require an engineer’s report once the matter is assessed or the applicant could elect to provide such a report in recognition of the issue.

External Flood Effects

An appropriate principle in floodplain management is to ensure that development within the floodplain does not increase the flood affectation or hazard upon other properties or persons. Hence, it is recommended that an engineer's report is provided for any development within the Floodway, (or flood storage areas) or for any subdivision works and filling in the General Floodplain to prove that the development will not increase flood affectation elsewhere. This matter will also need to be considered with regard to other land uses in the floodplain but an engineering report may not be necessary in each case. As above, the applicant would be required to demonstrate that the issue has been addressed and Council engineers will assess the matter and determine whether an engineering report is nonetheless required in any particular case.

Evacuation

These controls are aimed at ensuring that human life is protected by maximising opportunities to safely evacuate people outside of or above the floodplain.

In principle, the direction of evacuation will be dependent on warning times, duration of floods and available evacuation routes. For example, if warning times and flood duration are short, and roads out of the floodplain are blocked early in a flood, it can be more appropriate to require a refuge on-site above the PMF. In this case, due to the substantial warning time and period of inundation, it is generally considered appropriate that persons are able to evacuate to areas outside of the floodplain (ie. above the PMF level). This may not be practical in all cases, such as more remote rural properties and in such cases, vertical evacuation to a refuge on the property (eg. a loft or attic area within the rural dwelling) could be considered acceptable. Flexibility is to be provided within the planning controls for assessment of the individual circumstances of each application, on its merit.

Management and Design

Special consideration of the design and management of individual proposals can also reduce the flood risk and potential damage to property and persons. These measures may involve the provision of a flood plan for individual sites which ensures that individuals consider and plan means to minimise the likelihood of flood damage, including providing for the movement of goods above the flood level within the likely available flood warning time. Other specific considerations are for the storage of certain goods above the design flood level and requiring the implementation of mitigating measures to prevent pollution of the waterway and floodplain potentially occurring during floods.

4.5.8 Section 149 Planning Certificates

A Section 149 Planning Certificate is basically a zoning certificate issued under the provisions of the EPA Act, and must be attached to a contract prepared for the sale of property. The matters to be contained within the Section 149(2) Certificate are prescribed within Schedule 4 of the Environmental Planning and Assessment Regulation, 1994, which includes the following specific matters in regard to flooding.

> *"12. Whether or not the Council has by resolution adopted a policy to restrict the development of land because of the likelihood of landslip, bushfire,* ***flooding****, tidal inundation, subsidence or any other risk".* [Our emphasis]

The wording of the above prescribed matter is such that inconsistencies arise between local councils in regard to the extent of information they provide on flooding. It has been argued that on literal interpretation, councils are only required to provide a 'yes' or 'no' answer as to

whether such a policy exists. Further, there is potential equivocation when a council is aware of a flood risk, (eg. that a property is known to be located between the 100 year ARI and PMF extents), and there are no policies restricting development subject to the risk. A principal issue which arises is whether there is a legal or moral obligation for council to advise of the risk (Mawson J, Prior N, and Bewsher D, 1994).

A Section 149(5) Certificate, being a more complete but more expensive certificate, requires Councils to advise of *"other relevant matters affecting the land of which it may be aware"*. These more complete certificates are not mandatory for inclusion with property sale contracts – a Section 149(2) Certificate being the minimum required. Where a Section 149(5) Certificate is obtained, this would more clearly require a Council to notify of flood risks of which it is aware.

Generally, the recommendations of this study are to advise all persons, through the use of Section 149 Certificates (and other methods) of all potential flooding up to the PMF. These Section 149 notices should ultimately be reviewed upon adoption of the Floodplain Risk Management Plan and any policies emanating from that document, as well as the findings of the earlier Flood Study Review.

While there may be some concern about property owners having such a notation, there is an expectation by prospective purchasers that it would be provided, as indicated by the legislation and Manual. Further, it should be recognised that this approach is not intended to lead to any significant alteration to the permissibility of development but is more directed towards providing factual information (important due to liability issues) and increasing awareness of the potential flood risk known to Council and the relative degree of such risk.

There is also a critical need to review flood related information currently disseminated by Council, as part of Section 149 Certificates or other means. Statements within Council's DCPs advising that certain areas (eg Grafton and South Grafton) are protected by levees built to prevent inundation by the 100 year flood do not appear to be accurate based on current flood modelling.

There are two potential sources of inundation that need to be addressed on Section 149 Certificates:

- inundation for creeks and rivers; or
- inundation for local catchment "major drainage", as defined in the Floodplain Development Manual.

It should be recognised that inundation could occur from either or both sources and the Section 149 Certificates can reflect this. Usually the most severe form of inundation will dominate the planning controls to be applied to new development.

Suggested Section 149 Notations are provided in **Table 4.8**, depending on the status of flood information available for a particular property.

Table 4.8
Suggested Wording for Section 149 Notations

Inundation defined by Flood Study and property included in a **floodway area**	**Inundation defined** by Flood Study and property included in the **General Floodplain**	**Inundation not defined** in a Flood Study, but **thought to be affected** by flooding	**Inundation not defined** in a Flood Study, but **not thought to be affected** by flooding
Part or all of the property is located within a Floodway area. [Plus Notes 1 & 2]	Part or all of the property is located within a General Floodplain area. [Plus Notes 1 & 2]	Part or all of the property is potentially affected by creek/river flooding. [Plus Notes 1 & 2]	Based on the information available to Council, the property is not affected by creek/river flooding. [Plus Note 1]

Notes: 1. This certificate provides notations based on the status of inundation from creeks/rivers only. Separate independent advice will need to be sought to confirm whether the property is affected by stormwater flooding.

2 Council's Development Control Plans apply to this property. These DCPs specify controls on development to manage potential flood risks within the property and adjacent areas.

4.5.9 Flood Planning Guidelines

On 31st January, 2007 the NSW Planning Minister announced new guidelines for development control on floodplains. These guidelines were issued subsequent to the preparation of the draft Floodplain Risk Management Plan, but require some consideration by Council when implementing the final Plan.

An overview of the new guidelines and associated changes to the Environmental Planning and Assessment Act and Regulation was issued by the Department of Planning in a Circular dated 31st January, 2007 (Reference PS 07-003). The new guidelines issued by the Minister in effect relate to a package of directions and changes to the Act, Regulation and Floodplain Development Manual, the implications of which are summarised as follows:

a) Guideline on Development Controls in Low Flood Risk Areas – Floodplain Development Manual

A discreet Guideline has been issued to provide additional guidance on matters dealt with in the Floodplain Development Manual. This Guideline effectively provides an amendment to the Manual. The Guideline confirms that unless there are "exceptional circumstances", Council's are to adopt the 100 year flood as the flood planning level (FPL) for residential development. The guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstances" justification being agreed to by the Department of Natural Resources (now Department of Environment and Climate Change) and the Department of Planning prior to the exhibition of a Draft LEP or Draft DCP.

b) Amendment to Regulation on Section 149 Certificates

Schedule 4 of the Regulation was amended, commencing on 16th February, 2007, to specify flood related information that can be shown on Section 149(2) Certificates. The amendment will require Councils to distinguish between the situation where there are flood related development controls on nominated types of "residential development" and all other development. More sensitive land uses such as group homes or seniors living is excluded from the limitation of notations for residential development.

Clause 7(A)(1) of the Regulation means that Council should not include a notation for residential development on Section 149(2) Certificates in "low risk areas" if no

flood related development controls apply to the land. Under Clause 7(A)(2) Council can include a notation for critical infrastructure or more flood sensitive development on Section 149(2) Certificates in low flood risk areas if flood related development controls apply. Low flood risk areas are undefined, but in the context of the Circular it is assumed to be a reference to that part of the floodplain between the 100 year flood and the PMF extents.

With regard to the recommended planning controls (discussed later in this report), these could only be notified in full on Section 149 Certificates if they are lawfully adopted by Council. For those recommended controls that would apply to residential development (other than sensitive land uses such as seniors living housing or critical infrastructure) it is recommended that the Council seeks the concurrence of the Department of Planning and the Department of Environment and Climate Change to prepare Draft Development Control Plans and its future consolidated LEP in accordance with the recommendations discussed later in this report, on the basis of "exceptional circumstances".

c) Section 117 Ministerial Direction No. 15 – Flood Prone Land

Section 117 Direction No. 15 – Flood Prone Land, was revised on 31st January, 2007. The principal implication of the revision of the Direction was to introduce provisions to limit the imposition of LEP controls on residential development within that part of the floodplain above the 100 year flood level. This limitation is specifically set out in Clauses (4) and (5) of the Direction as follows:

"*(4) A draft LEP must not impose flood related development controls above the residential flood planning level for residential development on land, unless a council provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

(5) For the purposes of a draft LEP, council must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a council provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General)."

Clause (6) of the Direction specifies circumstances which must be satisfied in order for the Director-General or nominee to allow for a variation to the Direction, as follows:

"*(6) A draft LEP may be inconsistent with this Direction only if council can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that any particular provision or area should be varied or excluded having regard to the provisions of section 5 of the Environmental Planning and Assessment Act, and*

(a) the rezoning is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual, 2005, or

(b) the rezoning, in the opinion of the Director-General (or an officer of the Department nominated by the Director-General) or minor significance."

In our view, the LEP recommendations provided later in this report (to be implemented as Council progresses its consolidated "template" LEP) would unlikely

be considered to be of "minor significance". However, the LEP recommendations would be able to be considered consistent with the objects provided at Section 5 of the Act, and will be in accordance with a Floodplain Risk Management Plan prepared in accordance with the Manual and adopted by Council.

We have liaised with the Department of Planning generally in regard to issues associated with the new flood planning guidelines. It is understood that the Department is in the process of preparing further clarification in regard to the guideline in the form of a "Q & A" information sheet. The guidelines, the specific exemption provisions of the Section 117 Direction, and our understanding of the further clarification to be provided by the Department of Planning, are all directed towards establishing a basis for councils to seek variations to the restrictions of the guidelines and the Direction on the basis of "exceptional circumstances". The basis for the variations required for the recommended LEP provisions would equally apply to the variations sought in regard to the recommended DCP controls. The relevant grounds to justify "exceptional circumstances" in this case are summarised as follows:

- Preparation of the Plan commenced preparation before the introduction of the new guidelines, and substantial effort and involvement from government departments, Council and the community have provided for the ultimate adoption of the Plan in a manner which now creates some limited inconsistency with the new guidelines. The recommended flood related controls were debated by the Floodplain Management Committee formed in accordance with the Manual, taking into account local factors, and endorsed the controls.

- The Draft Plan was subject to a substantial public consultation process and despite a number of submissions being received, there were effectively no objections to the planning controls.

- Due to the specific topographic characteristics of the catchment, the subject floodplain is broad with minimal horizontal variation between the 100 year flood and PMF extents. Consequently, Council has adopted a two precinct categorisation of the floodplain, being either the "Floodway" or "General Floodplain" (the later being the remainder of the area within the PMF extent after excluding the floodway). This categorisation provides a simple, effective and efficient means of implementing flood risk controls in the floodplain.

- Those controls to be imposed upon residential development in that relatively small portion of the floodplain between the 100 year extent and PMF primarily relate to the setting of floor levels at the 100 year plus freeboard level, requiring flood compatible building components below that level, ensuring the structure is sound and impacts on other development in the floodplain are considered, and most importantly to address emergency evacuation issues.

- The exclusion of controls on residential development between the 100 year flood and PMF extents would principally have the effect of not requiring floor level and similar controls on residential development in the "shadow zone" (ie. in that part of the floodplain between the 100 year extent plus freeboard) which would apply in exactly the same manner to residential development within the 100 year flood extent. More critically, there would be an absence of consideration on an integrated and comprehensive basis of evacuation issues for all residential development across the floodplain.

- The catchment has a history of substantial flooding and, consequently, significant flood risk primarily due to flood depths. Due to the topographic nature of the catchment and settlement patterns, residential areas are potentially

subject to being isolated during periods of major flooding (the “shrinking islands” phenomenon up to and greater than the 100 year flood) which creates added risk to occupants unless fully aware of flood risk, prepared to evacuate and able to evacuate because of the manner in which development has occurred.

- As outlined above, there is little horizontal variation between the 100 year flood and the PMF extents, so it is practical to adopt the PMF as the upper limit for the imposition of controls consistently across all land uses, without any major consequence in limiting development potential above the 100 year flood.

As discussed later, it is recommended that the above grounds form the basis of a submission to the Department of Planning and the Department of Environment and Climate Change seeking endorsement for the DCP and LEP controls on the basis of “exceptional circumstances”. The endorsement of the recommended DCP and LEP controls by the Departments and the ultimate adoption would effectively allow for their notification on Section 149 Certificates, without contravention of the new guidelines.

5 MEASURES FOR SPECIFIC AREAS

Many of the valley-wide measures previously discussed will form appropriate floodplain management measures for the towns and villages throughout the study area. Specific issues and measures that may also be relevant to these areas are discussed in this Section.

5.1 GRAFTON

5.1.1 Background

Grafton has experienced frequent and significant flooding in the past. Construction of various levee banks and drainage improvements has been progressively undertaken over the years to help reduce the frequency of flooding.

These works commenced in about 1890 with the construction of drainage improvements and minor levees along low sections of the riverbank. However, it was not until the 1960's that a major program of levee construction at Grafton and South Grafton was initiated. Since that time, additional levee banks were gradually constructed, or the height of existing levees increased, to further reduce the frequency of flooding.

By the 1970's it was generally regarded that the levees were providing a level of protection at Grafton equivalent to a 100 year flood (SL&M, 1980). South Grafton had a lower level of protection, until in the 1990's these levees were raised with the intention of providing a similar level of protection as provided for Grafton.

The flood which occurred in March 2001 came close to overtopping the levees protecting Grafton and South Grafton. The flood raised questions as to whether the levees were providing the level of protection perceived by Council and the community.

5.1.2 Description of the Grafton Levee Description

Grafton is currently protected by a series of seven levees that, in addition to natural high ground and the elevated railway embankment, surround the town. The levees are shown on **Figure 5.1** and are commonly referred to as:

- Pine Street levee;
- Alice Street levee;
- Grafton Levee (sometimes referred to as the Ulster Lodge levee)
- Great Marlow Wall;
- North Street Levee;
- Butterfactory Lane levee; and
- Westlawn levee (sometimes referred to as the Trenayr levee).

As levees have been constructed and/or extended over many years, there is no single report or other documentation that explicitly defines the design criteria for these works, or the level of protection that the complete levee system was envisaged to provide. One report suggests that the Grafton City Levee (it is uncertain whether this refers to the complete levee system at Grafton) is overtopped at a gauge reading of 8.25m at Prince Street, which was estimated at the time as being a 180 year flood (PWD, 1980). Another report suggests that levee work undertaken in 1969/70 for the Alice Street levee, Ulster Lodge levee and North Street levees were designed to give the city protection from floods at least as severe as the worst recorded event in 1890, although elsewhere in the same report it suggests that the levee

system provides protection against a 100 year flood (SL&M, 1980). Other advice has been that the riverfront levees were designed on the basis of recorded river levels from the 1967 flood, with an additional freeboard that was thought to increase the level of protection to about 100 years.

The design criteria for the levees that protect Grafton from backwater flooding via Alumy Creek is also uncertain. Originally, a small levee had been constructed along the north bank of Alumy Creek, to prevent floodwater spilling onto the Trenayr flats to Junction Hill, and then across into Bakers Swamp. The original levee, known as the Trenayr levee, was estimated to provide protection for floods up to the 5 year event. This mode of flooding was subsequently blocked by the construction of the Westlawn levee. It has been suggested that this levee provided protection up to the 10 year flood (Water Studies 1992). The levee appears to have been further raised since this date, although no documentation on this was sighted.

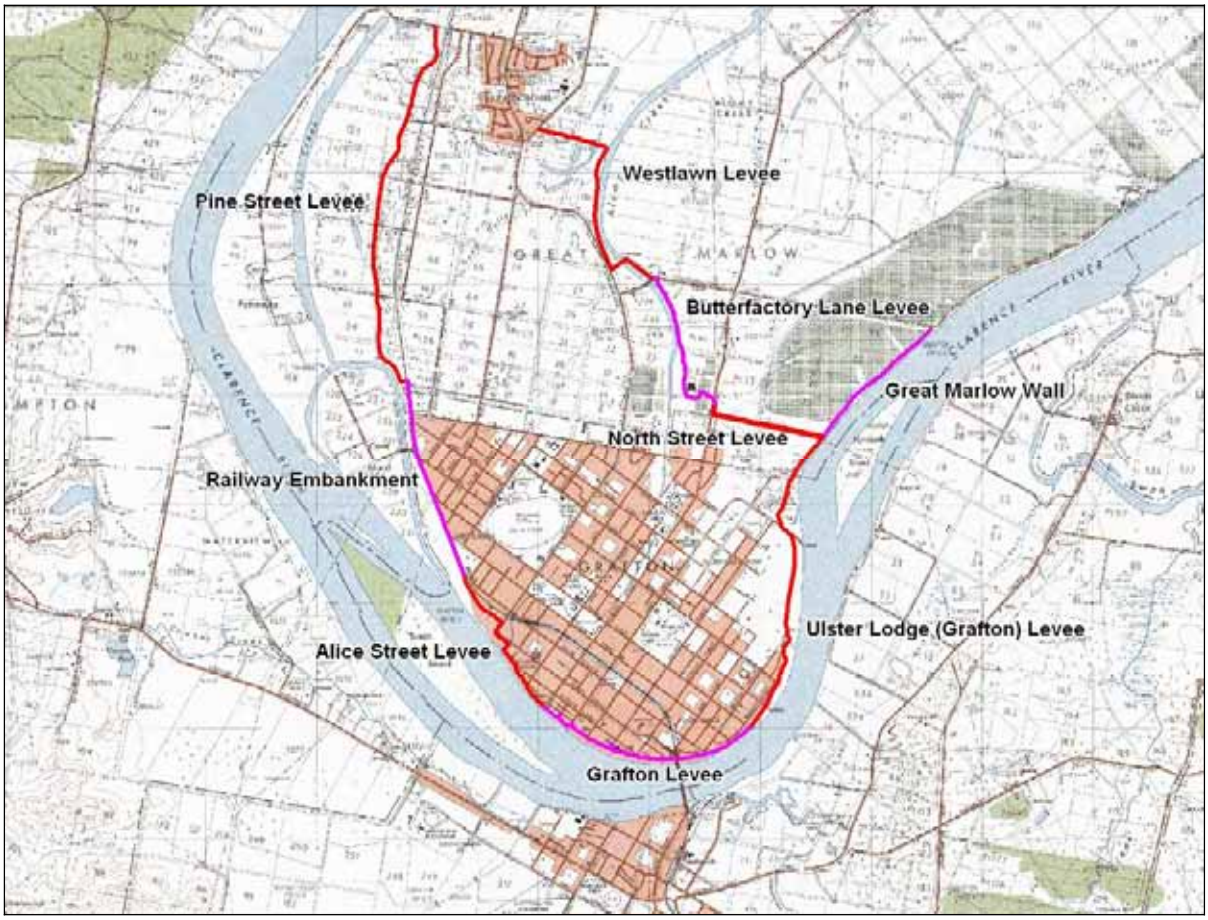


FIGURE 5.1
Grafton Levee System

5.1.3 Risk of Levee Overtopping/Failure

It is not possible to build the levees at Grafton high enough to prevent overtopping in all floods. At some point in the future, the levees will be overtopped and floodwater will inundate the town. When overtopping occurs, the flood hazard in the town can be very high, due to rapid inundation and the depth of flooding that is likely to occur. At or before overtopping, there is also the potential for the levee banks to scour or fail, which can further exacerbate the flooding problems within the town.

An investigation of flooding at Grafton caused by levee overtopping was commissioned by Clarence River County Council in 1991 (Water Studies, 1992). The investigation looked at the impact of different floods with peak discharges ranging from 20,000m^3/s to 55,000m^3/s. No recurrence interval was assigned to the different events. However, based on flood studies at the time, the lower discharge was just below the estimated 100 year flood discharge (WBM, 1988).

It was estimated that overtopping would occur for the 20,000m^3/s event. Overtopping was estimated to occur first at the Ulster Lodge (Grafton) levee downstream of the Grafton Bridge, before spreading west to include much of the Alice Street Levee. The northern reaches of the Pine Street levee and the remainder of the Alice Street levee were noted as being on the verge of overtopping for this event.

More detailed information on potential overtopping and the progression of flooding within Grafton over time is provided in the recent overtopping study (WBM, 2006). Flood behaviour has been investigated for the 20 year, 50 year and 100 year flood events. Results indicate that the majority of the Grafton Levee system is above the 20 year flood, with only minor overtopping in this event occurring at the Westlawn and Butterfactory Lane Levees adjacent to Alumy Creek. Overtopping is mainly confined to Alumy Creek and has little impact on the town. More significant overtopping occurs during the 50 year and 100 year floods, with up to 70% of the total length of the Grafton levees overtopped in the 100 year flood.

The sequence of overtopping for the 100 year flood is depicted in **Table 5.1**. Similar overtopping behaviour is evident for the 50 year flood.

TABLE 5.1
Sequence of Levee Overtopping at Grafton (100 Year Flood)
Source: WBM, 2006

Location	Timing*	Prince St Gauge Level	Comment
Pine Street Levee North of Grafton	43.0 hr	8.05 m AHD	Minor overtopping This flow ponds behind the North Coast Railway line north of Grafton
Grafton Levee Between Dobie and Bacon St	43.0 hr	8.05 m AHD	Minor overtopping
Grafton Levee Upstream of bridge near sailing club	43.5 hr	8.11 m AHD	Minor Overtopping This flow heads north following Clarence St
Grafton Levee Between Prince Street and Clarence St	43.5 hr	8.11 m AHD	Major overtopping This flow heads north following Duke Street
Grafton Levee Between Mary and Turf St	43.5 hr	8.11 m AHD	Minor overtopping This flow heads north following Duke St
Grafton Levee Between Cranworth and Maud St	44.0 hr	8.18 m AHD	Minor overtopping
Grafton Levee Adjacent to Sewerage Treatment Plant	45.0 hr	8.25 m AHD	Minor Overtopping
North Coast Railway Line North of Grafton	45.5 hr	8.26 m AHD	Major overtopping This flow heads east and fills low land north of Grafton
Westlawn and Butterfactory Lane Levees adjacent to Summerland Way and Alumy Creek	47.0 hr	8.29 m AHD	Major overtopping This flow enters Alumy Creek. A portion of the flow also heads west filling low land north of Grafton.

* Timing relative to commencement of flood

5.1.4 Flood Behaviour in Overtopping Events

Overtopping of the levees at Grafton will result in flooding of the town. The extent and depth of flooding will depend on the magnitude of the flood, the duration of overtopping, and whether additional breaching of levees occurs due to scour or other failure.

Flood behaviour within the town was assessed as part of the overtopping study (WBM, 2006). The study provides flood inundation depth maps for the town in the 50 year, 100 year and extreme floods. Results indicate that flood levels within Grafton are still significantly below river flood levels, despite significant overtopping of the levees in these events. A summary of flood levels in Grafton is provided in **Table 5.2**.

TABLE 5.2
Peak Flood Levels at Grafton (m AHD)
(Source: WBM, draft, 2006)

Location	20 year	50 Year	100 Year	Extreme
River (Prince Street Gauge)	7.95	8.31	8.36	9.75
West of Queen Street Extending to Junction Hill	Not flooded	4.3*	6.2*	9.0 to 9.75*
East of Queen Street	Not flooded	3.2 to 6.2*	4.2 to 6.4*	9.0 to 9.75*

* These are preliminary values which are subject to further model investigations using new levee crest survey data

The overtopping study also provides a time sequence illustration of flooding within Grafton for the 50 year and 100 year floods. **Figure 5.2** shows the progress of the 100 year flood through Grafton following overtopping of the levees. This indicates that for floods similar to the 100 year event, a significant area of Grafton will be inundated within about 10 hours of the commencement of overtopping. This highlights the very short time frame available for evacuating the town should this be delayed until overtopping is imminent. Information from the overtopping study provides valuable data that should be incorporated in the SES Flood Plans for Grafton.

The significance that the duration of flooding has on flood behaviour was examined in the overtopping study. The design flood had previously been based on the duration of flooding experienced in the 1974 flood (WBM, 2004). Sensitivity tests were undertaken for shorter floods (based on the 1980 flood) and longer duration floods (based on the 2001 flood). The longer duration floods resulted in minimal increases in river flood levels, but significant increases in flooding within Grafton. This is mainly a result of the additional time that the levees overflow and the increased volume of floodwater that enters Grafton. Flood levels for the 100 year flood west of Queen Street increased from 6.2m AHD to 6.8m AHD. East of Queen Street the lower flood levels increased from 4.2m AHD to 5.4m AHD, whilst the levels closer to the river levees did not significantly change. Conversely, the shorter duration flood led to reduced flood levels.

The above findings indicate that the level of protection provided by the levee banks in overtopping events is sensitive to the assumed duration of flooding. That is, the flood risk for Grafton is increased for longer duration floods.

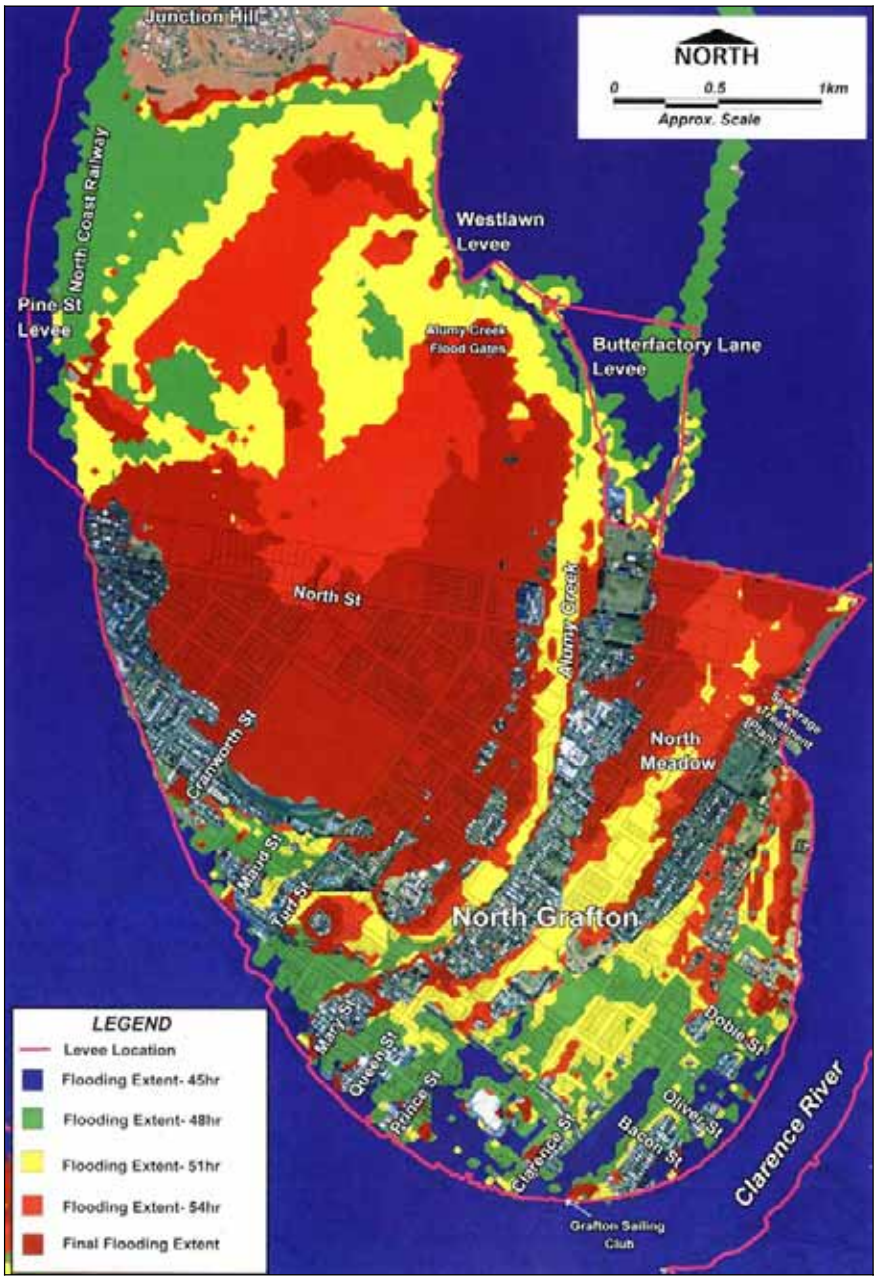


FIGURE 5.2
Sequence of Flooding at Grafton (100 Year Flood)
Source: WBM, 2006

Another factor that will significantly influence flood behaviour in Grafton is the potential for the earthen embankments to erode and scour during overtopping. This can lead to a breach in the levee (ie a failure or collapse of the levee) and the sudden inrush of additional floodwater. The potential for levee scour depends on the slope of the embankment, the vegetative cover on the embankment, and the time in which overtopping occurs. The overtopping study briefly looked at the potential for levee scour and noted that the onset of scouring was likely to occur within the first 5 hours of overtopping on all earthen levees at Grafton. The onset of scouring was estimated to be less than 1 hour for three of these levees (Westlawn Levee, Butterfactory Lane Levee and the Grafton Levee between the bridge and Queen Street). The impact of levee breaching on flood behaviour was not included in the overtopping study.

An earlier study (Water Studies, 1992) indicated that substantial erosion was likely to occur to the overtopped reaches of the levees protecting Grafton. It was noted that the subsequent erosion in overtopping events could result in at least half of the overtopped levee being washed away and a breach to at least one-half levee height being opened. This advice was qualified by noting that there is a high degree of uncertainty due to absence of key soil data for the levees, the complexity of overtopping behaviour, the variety of levee profiles (masonry walls, etc) and the limiting effects of ponded waters backing up against the internal levee face.

The rate of rise of floodwater in Grafton, and the eventual flood height that is attained, will therefore be influenced by the potential for the earthen levees to scour and breach at some point in the overtopping period. This highlights the importance of regular levee bank inspections and maintenance, and the need to maintain a sturdy grass cover over the embankment. Further assessment of the impacts of levee breaching is also warranted.

5.1.5 Potential Levee Augmentation Works

Grafton is surrounded by a number of separate levee banks that have been constructed and augmented over a number of years. The intended level of protection provided by these banks is not well documented, although there appears to have been a general perception that the levees provided protection up to the 100 year flood. The flood which occurred in March 2001 came close to overtopping the levee in a number of places, and raised concerns that the levees were providing a lower level of protection. Subsequent flood investigations suggest that overtopping of the levees will commence in floods at about the 20 year event, although some protection (in the form of reduced flood levels) is still provided up to the 100 year design flood.

There are two types of levee augmentation works that could be considered for Grafton:

i) on-going maintenance of the existing levee system (as already undertaken by Council), including minor adjustments to account for damage or settlement of existing banks to ensure accordance with original design plans; and

ii) significant levee augmentation, including raising and /or realignment of the existing levees;

Maintenance and Minor Levee Adjustments

On-going, regular maintenance is an essential requirement of any levee system. Restoration of damaged levees may be required following events that overtop the levee, or come close to overtopping the levee. Other maintenance may be required to ensure that undermining, slumping, erosion, settlement or other potential weakness does not jeopardise the integrity of the levee.

An audit of Grafton's levees by the Dams and Civil Unit of NSW Department of Commerce identified the need for filling some low spots along the Westlawn Levee and other minor repairs in order to ensure protection up to the 20 year flood, at an estimated cost of $364,000 (Dams & Civil Unit, 2004).[5] General conclusions of the audit were:

- Generally the levees are in sound condition, with the exception of the Westlawn Levee, which has minor stability problems such as localised erosion and slips, slumping, cracking and scouring.

[5] Note that Dams & Civil (2004) did not include the Pine Street Levee in their review, so these costs may be an underestimate of the total costs of levee raising and repairs.

- Two outlet pipes were found to be missing flap gates or penstocks: one at the end of Dobie Street on Grafton Levee, and one on Westlawn Levee [6].
- Further investigation was required to assess whether buildings that formed part of the Grafton Levee provided an adequate barrier to floodwater.
- The concrete retaining wall constructed behind the Crown Hotel on the western side of Prince Street contained a prominent vertical crack [6].
- The concrete retaining wall below the timber wall erected on the western side of Crown Hotel contained several vertical cracks [6].
- Levee maintenance needs to be improved by establishing a regular maintenance program to monitor the condition of the levees [6].

One priority measure that is warranted is an up-to-date survey of the complete levee system that protects Grafton, including natural high ground, the railway embankment and other structures that form part of the levee system. The survey can be compared to original design drawings to verify construction details and check on areas where settlement or slumping may have occurred. When available, it would also be advisable to verify the representation of the levee crests included in the TUFLOW overtopping model, prior to further investigations with this model.

Significant Levee Augmentation

If the standard of protection that is required for Grafton is the 100 year flood (with no freeboard), then based on the information currently available, it appears that the levee banks would need to be raised by generally 0.2 to 0.3m. This is a significant adjustment to the Grafton levees that would require thorough consideration of the costs, benefits and implications of these works.

The levee audit noted that the Alice Street, Grafton, North Street and Westlawn Levees would all require raising by between 0.1m and 0.8m to provide protection against overtopping to the 100 year flood, at an estimated cost of $2.18M (Dams & Civil Unit, 2004). This estimate did not include the consideration of the Pine Street levee, which would also need to be raised, or the cost of required investigations such as environmental reviews. There could also be some problems in further raising the Westlawn Levee, as this earth levee is already quite steep and there are some stability concerns even at its current height.

There are a number of issues that need to be considered in relation to significant levee augmentation. On the basis of the information currently available, it is apparent that there is insufficient data to make definitive recommendations, and additional investigations will be required, including detailed survey of levees and site constraints, hydraulic investigations, geotechnical assessments, environmental reviews, economic assessments and community consultation. A flow diagram of the necessary investigations is provided at **Figure 5.3**. These investigations have been arranged in 5 sequential steps.

The first stage of investigations involves the collection of additional levee survey data and feasibility investigations into rasing the levees. These tasks should be undertaken, and a decision whether to proceed with the additional staged investigations can be made on consideration of these findings.

[6] These works have since been completed (pers. comm., Ian Dinham, CVC, 2006).

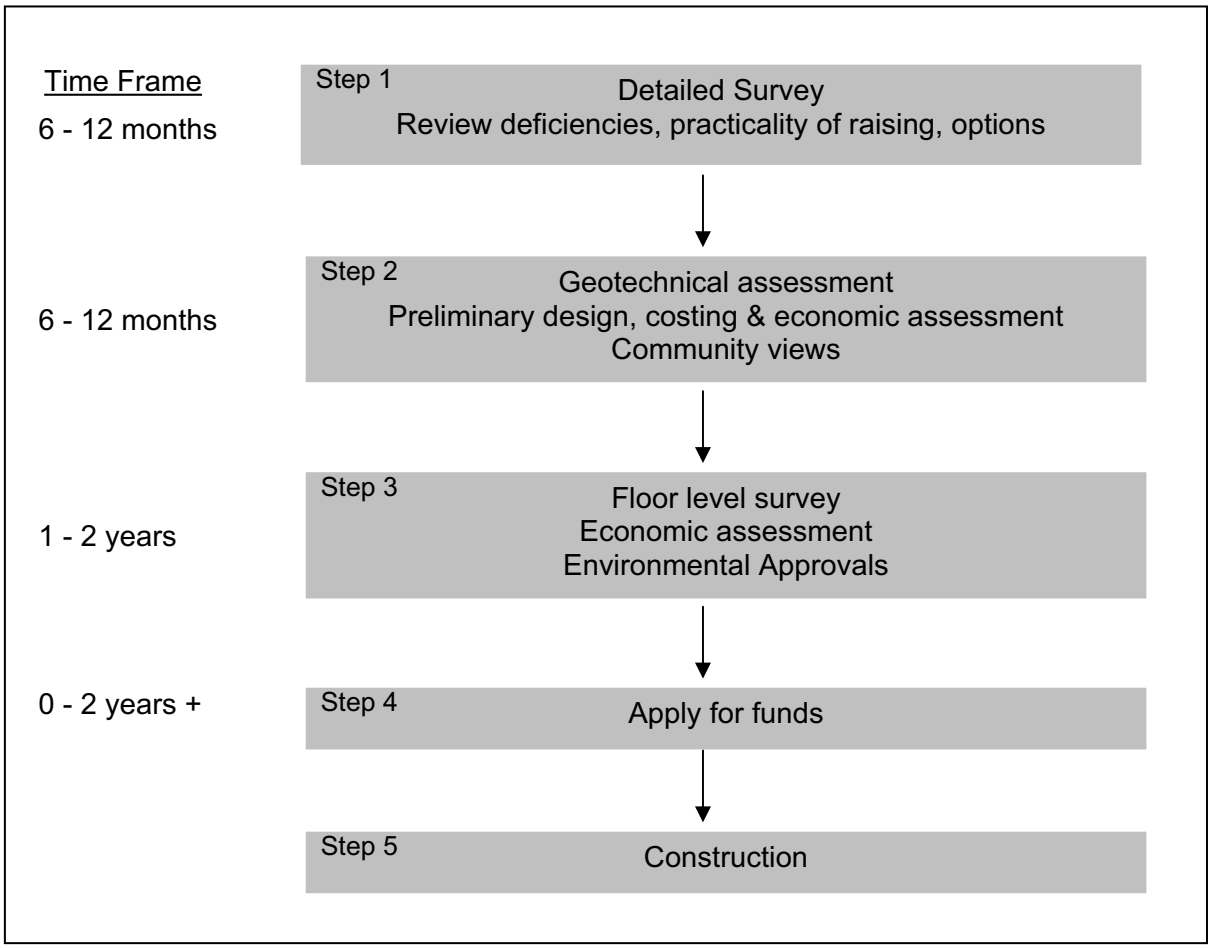


FIGURE 5.3
Necessary Investigations to Evaluate Significant Levee Augmentation

Whilst further investigations will be required to assess all issues associated with levee augmentation, a major impediment is anticipated to be the impact of these works on flood behaviour. **Table 5.3** shows the likely impact of raising the Grafton levees (all levees on the north side of the river) above the 100 year flood. This indicates that river levels at Prince Street could be expected to increase by +0.015m. This increase in height would allow additional overtopping into South Grafton, where flood levels could increase by up to +0.30m unless these levees were also raised.

TABLE 5.3
Increase in Flood Levels due to Raising the Grafton Levees
(Source: presentation to FPMC Meeting on 16/3/06, based on results from overtopping study (WBM, 2006)

Location	Change in 100 year Flood Level (m)
Clarence River at Prince Street	+0.015
Clarence River at Maclean	+0.01
South Grafton (behind levee)	+0.30
Alumy Creek Basin	+0.04
Coldstream Basin	+0.03

Another problem associated with increasing the height of the existing levees is that this further increases the potential for catastrophic failure. Stability issues become increasingly critical as the height of levees increase, and the potential for levee breaching is much more likely. Further community complacency against the risk of flooding may also develop if residents believe that levees have been raised to the 'magical' 100 year flood, which could then hinder attempts to evacuate the town when this is required.

An alternative scheme of constructing a floodway around the north side of town into Alumy Creek, as would have occurred in the 1890 flood prior to the construction of the Pine Street levee and the railway embankment, was briefly assessed as part of the overtopping study (WBM, 2006). The scheme was found to marginally reduce flood levels in the main river adjacent to Grafton, but increase flood levels behind the town. This then led to further overtopping of the Westlawn levee and increased flood levels within the town itself. The scheme is also likely to be extremely expensive due to land acquisition costs and the need to construct a large opening in the railway embankment (500m or more in length). The scheme was not considered further.

Whilst there are several negative issues associated with raising the Grafton levees, there may be some scope for fine-tuning the existing levee scheme to ensure that overtopping is restricted from undesirable locations (eg where there is greatest potential for levee breaching) or in critical areas of town. This may involve partial raising of the levee system in some places only. Additional investigations, as indicated in Figure 5.3, will be required to fully assess these options.

Other measures should also be considered for Grafton, especially those measures that improve emergency management operations and community awareness of the risk of overtopping and the need to evacuate the town. An investigation into options to improve flood free access to Junction Hill (via The Summerland Way) is also warranted, either through road raising or modifications to the Westlawn Levee. On the basis of the data that is currently available, it is likely that these measures will be preferable to further levee raising options.

5.1.6 Internal Drainage

The levee banks that surround Grafton provide some protection against river flooding. However, flooding can also occur within the town due to internal drainage problems, or when drainage to the river is prevented due to high river levels.

Grafton is divided into two main drainage compartments, separated by the high banks along Alumy Creek.

The area to the west of Alumy Creek either drains in an easterly direction through the stormwater drainage pipes to Alumy Creek, or in a northerly direction to Bakers Swamp and eventually into Alumy Creek at the Summerland Way. Stormwater runoff will pond in these two areas when the flood gates on Alumy Creek are closed due to high river levels. It has been noted that extensive ponding has occurred in the past in the Bakers Swamp area and some isolated pondage areas near the racecourse, although this was not thought to be of significant concern (PWD, 1984).

The area to the east of Alumy Creek generally drains in an easterly direction through a series of stormwater pipes to the Clarence River. Each pipe line is fitted with a flap gate and penstock gate at the outlet to prevent backflow of water into the town when the Clarence River is in flood. This also prevents the drainage of stormwater, causing ponding of water in the low lying areas of town. There are a number of depressions where stormwater will pond at different levels. The two main areas noted from past studies have been in the vicinity of

Kent Street (between Pound Street and Oliver Street) and a more significant storage area to the north of town (between Prince Street and Duke Street). The northern storage area is the lowest part of the town and contains mostly open space.

Previous reported flood levels from stormwater ponding are included in **Table 5.4**.The worst case of stormwater ponding appears to have occurred in March 1974. In this event, prolonged rainfall over Grafton coupled with a prolonged rise in the river resulted in inundation of part of the area inside the city levees. It was also noted that a leaking floodgate at Queen Street also contributed slightly to this internal flooding, and that only a few houses were flooded (SLM, 1980). Another report notes that Council staff had indicated that ponded water in this flood did not rise above the floor level of any house (PWD, 1984).

TABLE 5.4
Recorded Ponding Levels at Grafton

Date	Recorded Level	Location	Source
Mar 1974	4.0 m 3.9 m 3.35 to 3.55 m *	Kent Street Showground area Northern storage area	PWD, 1984
Mar 1974	4.06 m AHD 3.93 m AHD	Kent Street Fisher Park	Paterson Consultants, 1996
April 1988	3.70 m AHD 3.65 m AHD	Kent Street Fisher Park	Paterson Consultants, 1996
April 1989	3.22 m AHD 3.28 m AHD	Kent Street Fisher Park	Paterson Consultants, 1996
May 1996	3.68 m AHD 3.67 m AHD	Kent Street Fisher Park	Paterson Consultants, 1996

* It was noted that the extent of recorded inundation exceeded the 4m contour in places (PWD, 1984)

The maximum height reported in Grafton for the 1974 event was RL 4.0m. The storm was estimated to exceed the design 100 year event for periods up to 72 hours. It was also estimated that only 25% of the 72 hour storm runoff would have drained to the river prior to flood gates being closed by elevated river levels (PWD, 1984).

A number of floodplain management measures were investigated as part of the North Grafton Drainage Study (PWD, 1984), including:

- developing a landuse planning scheme;
- improving internal drainage and temporary storage within the levee area;
- constructing culverts to increase outflows prior to the flood gates closing, and to speed the removal during the falling stage of the river flood;
- installing pumping stations; and
- a combination of the above.

Landuse planning was seen as a key mechanism to ensure that the potential damage to assets and disruption to services is not increased in the future. Although not explicitly stated in the report, this would include the specification of minimum floor levels for new buildings and also ensuring that there is no filling in areas required for the temporary storage of stormwater runoff. Council subsequently adopted a development control plan for Grafton that generally prohibits subdivision of land below RL 4.2m AHD; prohibits filling on land below RL 4.2m AHD (except beneath the confines of a building); requires main floor levels to be a minimum of RL 6.4m AHD; and requires lower floor levels to be a minimum of 350mm above the assessed 100 year ponding level at the site.

Internal drainage improvements were briefly investigated as part of the drainage study. This included upgrading the culvert under Dobie Street to allow better transfer of ponded stormwater towards the main northern storage area. Excavation to increase the available storage area was also considered. Both measures were found to be relatively ineffectual, and neither measure was recommended.

Twin 2.1x2.1 box culverts through the river bank levee near North Street was suggested as a possible measure to increase outflows prior to the floodgates closing, and to speed up the drainage of impounded stormwater once river levels have fallen, at an estimated cost of $185,000 (1984). It was also noted that the Clarence River County Council prepared working drawings of such a scheme in the early 1970's. To date, this measure has not been implemented. Whilst it is unlikely that this measure would lead to a significant reduction in ponded water levels, its main benefit lies in the improved drainage times once river levels have fallen. It would also prove most beneficial in speeding up the recovery time after a major flood that overtops the Grafton levees. Under the current drainage regime (9 relatively small drainage lines to the river) it is estimated that it could take up to 2-3 days to remove the impounded floodwater on the eastern side of Alumy Creek after an overtopping event. The proposed culvert could reduce these times to little over 1 day. It is regarded that this measure warrants further consideration.

The provision of two pumping stations was also investigated in the drainage study. One station was investigated in the Pound Street area, with a pumping capacity of $3m^3/s$. The second station was investigated in the vicinity of North Street, with a pumping capacity of $4.5m^3/s$. These stations were estimated to cost $750,000 and $900,000 respectively (1984). It was recognised that these pumping stations could not eliminate ponded stormwater. Due to the high costs involved and the minimal damages to residences in the 1974 storm, it was concluded that these works would be difficult to justify on economic grounds.

A further study on stormwater ponding in the Kent Street area was undertaken following a storm in May 1996 (Paterson Consultants, 1996). The report reviewed previous reports, submissions from local residents, and various pumping alternatives including mobile pumps. Mobile pumps were not seen as a viable proposition due to the general lack of availability of high capacity pumps and the mobilisation time required setting this up. An alternative permanent pumping fixture was suggested consisting of a low head axial flow pump with a capacity of either $0.5m^3/s$ or $0.9m^3/s$. The cost of the pumping facility was estimated at $72,000 and $90,000 respectively (1996).

A small pump was installed in the Kent Street area subsequent to the 1996 study (Tony Smith, CVC, pers. comm., April 2006).

5.2 SOUTH GRAFTON

5.2.1 Description of the South Grafton Levee System

A series of levees along the southern bank of the Clarence River provides protection to South Grafton and adjoining rural areas. The levees, shown on **Figure 5.4**, include:

- The Waterview levee;
- South Grafton Rural Levee;
- South Grafton Urban Levee;
- Alipou Basin Levee;
- Clarenza Levee; and
- Heber Street Levee.

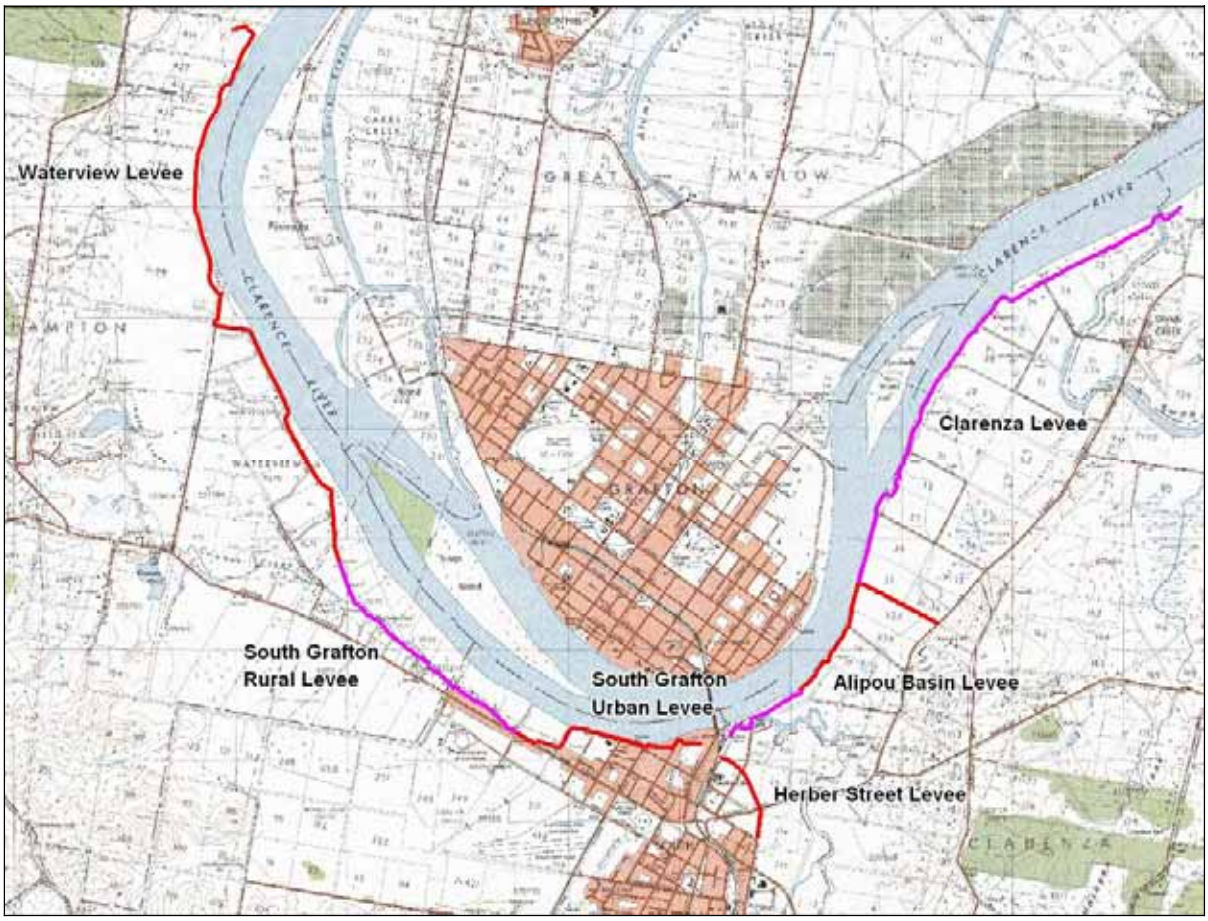


FIGURE 5.4
South Grafton Levee System

The program of flood mitigation works in South Grafton commenced in the 1960's, with drainage improvements and floodgating of various drains, levees at Waterview and South Grafton, and other levees downstream of the railway line, to reduce backwater flooding into the town under the railway viaduct, via the Clarenza and Swan Creek levees. By the 1980's it was regarded (Paterson Consultants, 2000) that the levee scheme provided protection against:

- a 20 year flood overtopping the riverbanks upstream of South Grafton; and
- an 8 year flood backing up from downstream of South Grafton.

In 1985 Clarence River County Council commissioned investigations to examine increasing the level of protection from the levee scheme to provide protection up to the 100 year flood. These investigations recommended the following levee crest heights:

- Waterview Levee at 0.1m below the 100 year flood;
- South Grafton Rural Levee at the 100 year flood profile;
- South Grafton Urban Levee at 0.5m above the 100 year flood profile;
- Heber Street Levee, protecting against backwater flooding downstream of the railway, at 0.25m above the 100 year flood profile; and
- adjustments to the Alice Street and Pine Street Levees on the north side of the river.

These works were completed over the period 1990/96.

5.2.2 Risk of Levee Overtopping/Failure

At some point in the future, the levees at South Grafton will be overtopped and floodwater will inundate the town, as is the case for Grafton. When overtopping occurs, the flood hazard throughout South Grafton can be very high, due to rapid inundation and the depth of flooding that is likely to occur. At or before overtopping, there is also the potential for the levee banks to scour or fail, which can further exacerbate the flooding problems.

Detailed information on potential overtopping and the progression of flooding within South Grafton over time is provided in the recent overtopping study (WBM, 2006). Flood behaviour has been investigated for the 20 year, 50 year and 100 year flood events.

Results from the overtopping study indicate that the majority of the South Grafton Levee system is above the 20 year flood, with only minor overtopping of the Waterview Levee west of South Grafton occurring. This results in minor localised inundation near the point of overtopping only, and no portion of South Grafton town is affected.

More significant overtopping occurs during the 50 year and 100 year floods, with up to 77% of the total length of levees overtopped in the 100 year flood. At the downstream end of the levee system, the Heber Street levee and the South Grafton Urban Levee is close to or above the estimated 100 year flood profile, providing some protection to the town. The South Grafton Rural Levee is overtopped in both the 50 year and 100 year floods. Further upstream, the Waterview Levee is just above the estimated 20 year flood profile.

The sequence of overtopping for the 100 year flood is depicted in **Table 5.5**. Similar overtopping behaviour is evident for the 50 year flood, which is only 0.05m lower than the 100 year flood.

TABLE 5.5
Sequence of Levee Overtopping at South Grafton (100 Year Flood)
Source: WBM, 2006

Location	Timing*	Prince St Gauge Level	Comment
Waterview Levee West of the Gwydir Highway	42.5 hr	7.97 m AHD	Minor overtopping This flow heads south filling the basin north of Gwydir Highway
South Grafton Rural Levee Upstream end adjacent to the Gwydir Highway	44.0 hr	8.18 m AHD	Major overtopping This flow overtops the Gwydir Highway filling the basin west of South Grafton
South Grafton Rural Levee At the end of James St	44.5 hr	8.21 m AHD	Minor Overtopping This flow overtops the Gwydir Highway filling the basin west of South Grafton
Heber Street Levee Between Lolanthe Lane and the Pacific Hwy	48.0 hr	8.31 m AHD	Minor overtopping

* Timing relative to commencement of flood

5.2.3 Flood Behaviour in Overtopping Events

Overtopping of the levees at South Grafton will result in flooding of the rural land to the west of the town, with floodwaters flowing over the Gwydir Highway in an easterly direction into the South Grafton Common and eventually to the urban centre of South Grafton. The extent and depth of flooding will depend on the magnitude of the flood, the duration of overtopping, and whether additional breaching of levees occurs due to scour or other failure.

The overtopping study (WBM, 2006) provides flood inundation depth maps for the town in the 50 year, 100 year and extreme floods. Results indicate that flood levels within South Grafton are relatively uniform across the urban centre and the rural land on the south-western side of town ('The Common'). Flood levels are also significantly lower than river flood levels, despite significant overtopping of the upstream levees in these events. A summary of flood levels in South Grafton is provided in **Table 5.6**.

TABLE 5.6
Peak Flood Levels at South Grafton (m AHD)
(Source: WBM, draft, 2006)

Location	20 year	50 Year	100 Year	Extreme
River (Prince Street Gauge)	7.95	8.31	8.36	9.75
Upstream of South Grafton, north-west of the Gwydir Highway	Negligible flooding	5.9*	7.2*	10.0 to 10.25*
South Grafton Urban Centre and The Common	Not flooded	4.2*	6.4*	9.5 to 10.0*

* These are preliminary values which are subject to further model investigations using new levee crest survey data

The overtopping study also provides a time sequence illustration of flooding within South Grafton for the 50 year and 100 year floods. The sequence of flooding at South Grafton in the 100 year flood is shown on **Figure 5.5**.

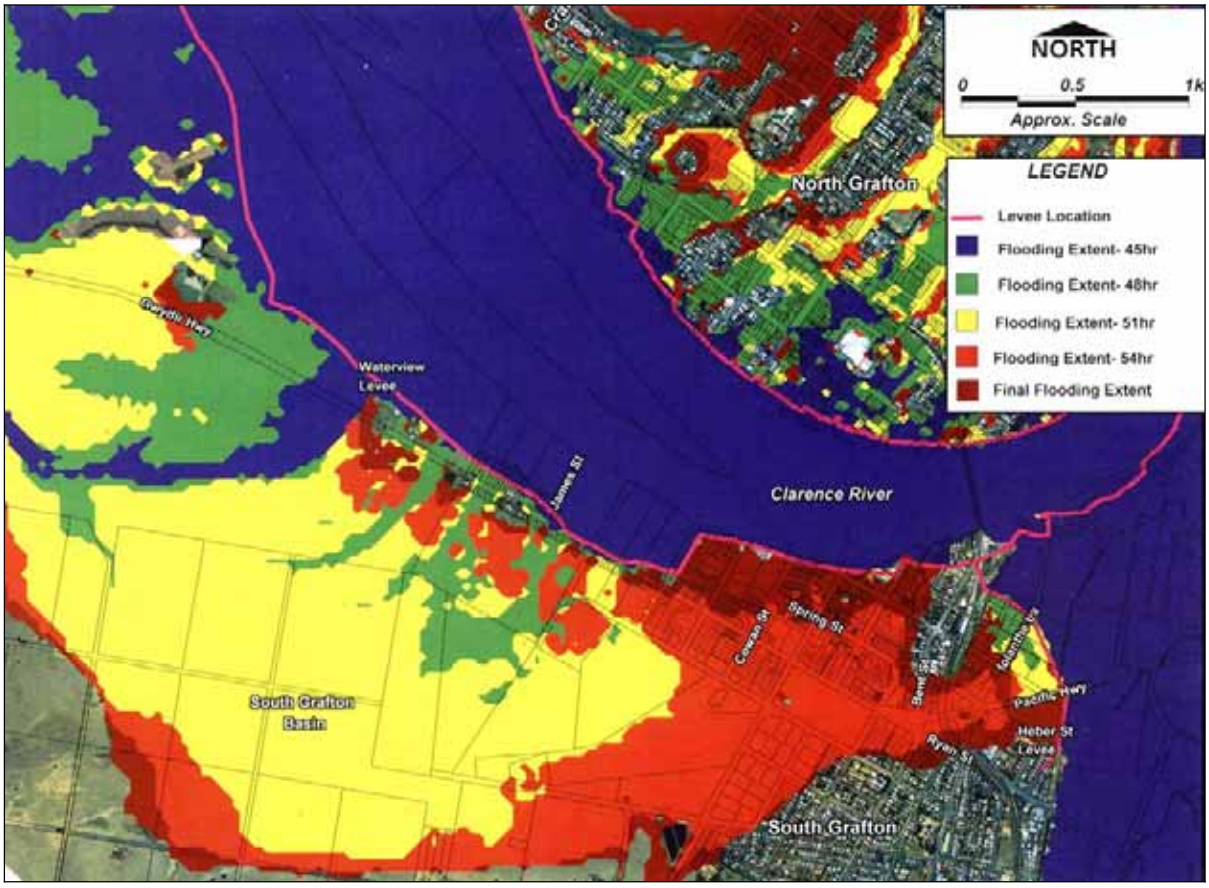


FIGURE 5.5
Sequence of Flooding at South Grafton (100 Year flood)
Source: WBM, 2006

The study shows that for 100 year design flood, overtopping of the South Grafton Rural Levee will be evident approximately 45 hours into the flood simulation. Within the next 6 hours, all of the rural area in 'The Common' will be inundated, with floodwater starting to approach the urban centre. Within the next 3 hours, much of the urban centre will be inundated. Once overtopping commences, there is only a matter of 9 hours prior to widespread flooding occurring.

The significance that the duration of flooding has on flood behaviour was also examined as part of the overtopping study, as was undertaken for Grafton. The longer duration floods resulted in minimal increases in river flood levels, but significant increases in flooding within South Grafton. This is mainly a result of the additional time that the levees overflow and the increased volume of floodwater that flows into the South Grafton area. Flood levels in the urban centre and The Common increased from 6.4m AHD for the design 100 year flood to RL 8.4m AHD for the longer duration 100 year flood. Under these conditions, flood levels in South Grafton are very similar to the levels experienced in the river. This is a more pronounced effect than was evident for Grafton.

The potential for the earthen embankments to erode and scour during overtopping can further exacerbate flood behaviour. The amount of scouring depends on the slope of the embankment, the vegetative cover on the embankment, and the time in which overtopping occurs. The overtopping study briefly looked at this issue and noted that the onset of scouring was likely to occur within the first 2 hours of overtopping on the South Grafton Rural Levee and the Waterview Levee. Again, this highlights the importance of regular levee inspections and maintenance, and the need to maintain a sturdy grass cover on the embankments.

5.2.4 Potential Levee Augmentation Works

The overtopping study (WBM, 2006) suggests that the Heber Street Levee and South Grafton Urban Levees provide protection against overtopping that is close to the 100 year flood, whilst the South Grafton Rural Levee and the Waterview Levee would first start to overtop in a 20 year flood. Despite the overtopping of the levees upstream of South Grafton, some protection (in the form of reduced flood levels) is still provided to South Grafton for events up to the 100 year design flood.

Further augmentation of the South Grafton Levee system could include:

i) on-going maintenance of the existing levee system (as already undertaken by Council), including minor adjustments to account for damage or settlement of existing banks to ensure accordance with original design plans; and

ii) significant levee augmentation, including further raising and/or realignment of the existing levees;

<u>Maintenance and Minor Levee Adjustments</u>

On-going, regular maintenance is an essential requirement of any levee system. Restoration of damaged levees may be required following events that overtop the levee, or come close to overtopping the levee. Other maintenance may be required to ensure that undermining, slumping, erosion, settlement or other potential weakness does not jeopardise the integrity of the levee.

An audit of the levees at South Grafton by the Dams and Civil Unit of NSW Department of Commerce found that minor repair works to the South Grafton Urban Levee and the Heber Street Levee were required, including repairing a vertical crack in the low level concrete wall

at the end of Riverside Street, at an estimated cost of $12,000 (Dams & Civil, 2004, p.19). Other conclusions of the levee audit were:

- Generally the levees are in sound condition, though some minor stability problems such as localised erosion and slips, slumping, cracking and scouring were identified.
- One outlet pipe on the Urban Levee was found to be missing a floodgate structure.
- Levee maintenance needs to be improved by establishing a regular maintenance program to monitor the condition of the levees.

Significant Levee Augmentation

The Heber Street Levee and the South Grafton Urban Levee appear to be close to or above the 100 year flood. The South Grafton Rural Levee and Waterview Levee will begin to overtop in a 20 year flood. This will result in floodwater spilling into rural land upstream of South Grafton and eventually filling the storage area in the South Grafton Common. The recent levee augmentation scheme intended overtopping of the Waterview Levee in the 100 year flood (by a depth of 0.1m) to minimise the impacts of the levee scheme on flood behaviour. The latest flood investigations indicate that additional overtopping occurs to both the Waterview Levee and the Rural Levee.

Further increases to the height of the South Grafton Rural Levee and the Waterview Levee by about 0.3 to 0.4m would be required to provide the level of protection originally intended from the scheme. This is a significant adjustment to these levees that would require thorough consideration of the costs, benefits and implications of these works.

The levee audit noted that some low spots in the South Grafton Urban Levee would need to be filled to increase the level of protection to the 100 year flood, at an estimated cost of $87,000[7]. This estimate only relates to a few minor low spots and does not include consideration of raising the South Grafton Rural Levee and the Waterview Levee, which would be required to ensure complete protection against the 100 year flood.

There is currently insufficient information available to make definitive recommendations concerning significant levee augmentation works. Additional investigations would be required if this option is to be further pursued, including detailed survey of levees and site constraints, hydraulic investigations, geotechnical assessments, environmental reviews, economic assessments and community consultation. The necessary investigations are similar to those that would be required the assessment of the Grafton levees, which was shown on **Figure 5.3**.

The first stage of investigations involves the collection of additional levee survey data and feasibility investigations into raising the levees. These tasks should be undertaken, and a decision whether to proceed with the additional staged investigations can be made on consideration of these findings.

Whilst further investigations will be required to assess all issues associated with levee augmentation, a major impediment is anticipated to be the impact of these works on flood behaviour. **Table 5.7** shows the likely impact of raising both the Grafton levees (all levees on the north side of the river) and the South Grafton Levees (including the Rural Levee and the Waterview Levee) above the 100 year flood. This indicates that river levels at Prince Street could be expected to increase by +0.28m, and hence levees on both sides of the river would need to be further increased accordingly.

[7] Note that Dams & Civil (2004) did not include the Waterview, Rural, Alipou Basin or Clarenza Levees in their review, so these costs would be an underestimate of total costs for levee raising and repairs.

TABLE 5.7
Increase in Flood Levels due to Raising South Grafton & Grafton Levees
(Source: presentation to FPMC Meeting on 16/3/06, based on results from overtopping study (WBM, 2006)

Location	Change in 100 year Flood Level (m)
Clarence River at Prince Street	+0.28
Clarence River at Maclean	+0.05
Alumy Creek Basin	+0.13
Coldstream Basin	+0.11

Another problem associated with increasing the height of the existing levees is that this further increases the potential for catastrophic failure. Stability issues become increasingly critical as the height of levees increase, and the potential for levee breaching is much more likely.

Other measures should also be considered for South Grafton, especially those measures that improve emergency management operations and community awareness of the risk of overtopping and the need to evacuate the town. On the basis of the data that is currently available, it is likely that these measures will be preferable to further levee raising options.

5.2.5 Internal Drainage

Flooding problems at South Grafton can also be experienced due to ponding of stormwater when drainage to the river is restricted due to elevated river levels. This can also be exacerbated by floodwater from the river that overtops the levees, either at South Grafton or further upstream across the Waterview Levee.

The local catchment area behind the South Grafton Levees drains to the Clarence River through a number of Drains and smaller pipe systems. The major drains with structures under the levees include:

- Seelands Drain (2x2.1x2.1 culverts);
- Waterview Drain (4x2.1x2.1 culverts); and
- Ardent Street Drain (5x2.1x2.1 culverts).

Smaller drainage systems to the river include:

- Cowan Creek (2x2100 pipes);
- Christopher Creek (1500 pipe); and
- Heber Street Levee (2100 pipe).

All drains and smaller drainage systems are fitted with floodgates to prevent backwater flooding into South Grafton when the river is in flood. Consequently, pondage of stormwater within the levee area will occur when river levels are elevated. The main storage area is the South Grafton Common; which in conjunction with rural land at Waterview is capable of storing over 9 million m^3 of floodwater below RL 4.0m AHD (Paterson Consultants, 2000). A separate, smaller storage area is available for the Heber Street area.

The adequacy of the internal drainage system at South Grafton was reviewed as part of the South Grafton Levee Augmentation Study (Cameron McNamara, 1985). The report concluded that the local runoff alone could be adequately accommodated by existing works, and that no additional works were justified.

An investigation of the level of stormwater ponding in South Grafton was undertaken as part of the South Grafton Flood Study (Paterson Consultants, 2000). The study compared daily rainfall totals at South Grafton with coincident historical river flooding. It was concluded that the rainfall associated with the March 1974 flood was the largest rainfall event to coincide with river flooding over the period of 1867 to 1996. The rainfall associated with this event was also estimated to be 30% larger than the 100 year 24 hour rainfall provided by Australian Rainfall & Runoff.

The flood study estimated that ponding levels in the South Grafton Common for the 1974 flood would have reached RL 4.63m AHD had the current levee system been in place at that time. Whilst other calculations were provided for the 10, 20, 50 and 100 year synthetic floods, it appears that the March 1974 flood was chosen to represent the general design ponding level for the South Grafton Common. A level of RL 5.2m AHD also appears to have been adopted for the Heber Street Levee area.

5.3 MACLEAN

5.3.1 Background

Maclean is located on the right bank of the Clarence River, some 20km upstream of the ocean. The town, with a population of just over 3,000 has a history of flooding. A levee bank was constructed in 1975 to reduce the frequency of flooding to both commercial and residential property at Maclean.

Floodplain management measures at Maclean were reviewed as part of the Lower Clarence River Floodplain Management Study (Paterson Consultants, 1993). The option of raising the levee height by between 0.3m to 0.8m was assessed. A height increase of 0.3m was estimated to increase the level of protection provided by the levee to the 100 year flood, at an estimated cost of $1.2M (1993) and a benefit-cost ratio of 0.72. A height increase of 0.8m provided an additional 0.5m freeboard above the 100 year flood, at an estimated cost of $1.7M (1993) and a benefit-cost ratio of 0.75.

The floodplain management study noted that construction of the existing levee generated considerable protest and that any further proposal to raise the levee may generate similar community concerns. Whilst the option was not dismissed outright, other floodplain management measures were put forward, including additional investigation of flood behaviour when the levee is overtopped, evacuation planning, public awareness and the application of appropriate development controls.

The subsequent floodplain management plan (Connell Wagner, 1995) confirmed preferred options for Maclean as being the non-structural measures, including flood warning, flood evacuation planning, increased public information, and development controls on future development.

5.3.2 Levee Description

The location of the Maclean levee is shown on **Figure 5.6**. It commences to the south of the RSL club at the McNaughton Street boat ramp, and extends some 3.5km adjacent to the riverbank and finally ties into high ground just downstream of Goddards Lane. The levee is a mix of reinforced concrete wall, mass concrete wall and earthen embankment. The cost of the levee was $1.65M in 1980 prices (SL&M, 1980, p.9-28), which today corresponds to a value of about $5.0M.


FIGURE 5.6
MACLEAN LEVEE
0
500m
Scale
N
Earth Fill Embankment (on opposite side of road)
River
Goddards Drain
Mass Concrete Wall
Essex Drain
Earth Fill Embankment
Clarence
Wherrett Park
Earth Fill Embankment
CENTRAL AVE
Mass Concrete buried beneath Earth Fill
Reinforced Concrete Wall
FLOODPLAIN MANAGEMENT CONSULTANTS
BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
EPPING NSW 2121
P.O.BOX 352
EPPING NSW 1710
A.C.N. 003 137 068
Phone: (02) 9868 1966
Facsimile (02) 9868 5759
Email : postmaster@bewsher.com.au
Plot file : J1276-fig5.6
Plot scale : 15 (a4 @ 1:15000)
GRAFTON AND LOWER CLARENCE

The levee was designed with a uniform crest height at 3.54m Standard Datum (approximately 3.5m AHD). This level was based on the record 1890 flood, which was also just above the 1974 flood and thought to be close to a 100 year level of protection (SL&M, 1980). Revised flood level estimates derived as part of the Lower Clarence River Flood Study (PWD, 1988) indicated that the crest height was closer to a 33 year flood.

5.3.3 Risk of Levee Overtopping/Failure

The flood which occurred in March 2001 renewed debate on the level of protection provided by the levee at Maclean. The flood, which was estimated to be less than a 20 year flood, came within about 0.3m of the crest height of the Maclean levee.

Further evaluation of the risk of overtopping was undertaken in conjunction with other detailed studies on overtopping at Grafton and South Grafton (WBM, 2006). Flood level estimates from the overtopping study for the 20 year, 50 year and 100 year floods are provided in **Table 5.8**. Flood levels in the river are very similar to results from the previous Flood Study Review.

Table 5.8
Design Flood Levels at Maclean from Overtopping Study (WBM, 2006)

Location	Flood Level Estimate (m AHD)		
	20 year	50 year	100 year
Clarence River, adjacent to:			
Stanley St (start of levee)	3.2	3.6	3.7
Hogues Lane	3.2	3.6	3.7
Goddards Lane (end of levee)	3.1	3.4	3.6
Maclean Township (inside levee)	N/A*	1.2 to 3.0	3.7

* Only ponding of local stormwater likely in the 20 year floods.

The Overtopping Study indicates that the levee crest will be overtopped in the 50 year flood. Overtopping first commences between Bakers Lane and Hogues Lane, some 75 hours into the flood simulation. Within the next 3 hours overtopping extends to cover approximately 1km of the levee length. Overtopping continues for a further 15 hours until river levels subside. The volume of overtopping floodwater is not sufficient to totally fill the 'protected' basin area behind the levee. Flood heights vary from RL 3.0m AHD on the higher ground adjacent to the levee down to a level of 1.2m AHD on the lower ground to the east of Maclean. Velocity-depth products are less than $0.05m^2/s$.

Overtopping in the 100 year flood is more extensive, with the 'protected' basin area totally filling to the same level as the river (ie RL 3.7m AHD). The majority of this filling occurs approximately 3 hours after overtopping first commences. Velocity-depth factors have increased to 0.15 m^2/s, but this is still relatively low due to low flood velocities.

The extent of flood inundation throughout Maclean for the 50 year and 100 year floods is shown on **Figure 5.7**. Whilst the computed 100 year flood level behind the levee is similar to the earlier Flood Study Review, the extent of flood inundation has varied due to better definition of the ground terrain that has been incorporated into the overtopping study.


FIGURE 5.7
EXTENT OF FLOOD INUNDATION AT MACLEAN
(Source : WBM, 2006)
0
500m
Scale
Legend
50 year flood extent
100 year flood extent
N
River
Clarence
Goddards Drain
Esses Drain
Wherrett Park
CENTRAL AVE
UNION ST
ANGLE ST
FLOODPLAIN MANAGEMENT CONSULTANTS
BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
EPPING NSW 2121
P.O.BOX 352
EPPING NSW 1710
A.C.N. 003 137 068
Phone: (02) 9868 1966
Facsimile (02) 9868 5759
Email : postmaster@bewsher.com.au
Plot file : J1276-fig5.7
Plot scale : 15 (a4 @ 1:15000)
GRAFTON AND LOWER CLARENCE

Results were found to be sensitive to the duration of flooding assumed for the design flood, which had been based on the historical 1974 flood. Reducing the flood duration reduced flood levels in the lower river and also reduced the time available for overtopping. Under this scenario, no overtopping of the Maclean levee is predicted for the 50 year flood, and reduced flooding predicted for the 100 year flood. Conversely, the longer duration flood resulted in higher flood levels for both the 50 year and 100 year floods. The 100 year flood was predicted to increase by 0.2m, both in the river and within the 'protected' area.

The sensitivity of flood levels to the assumed flood duration highlights some of the uncertainties in the estimation method. It provides a sound case for the inclusion of freeboard (currently 0.5m) with the design 100 year flood when specifying minimum floor level controls.

5.3.4 Potential Levee Augmentation Works

The Maclean levee was constructed shortly after the 1974 flood. It was designed to have a crest height similar to the 1890 flood, which is the largest flood to have been recorded at Maclean. Subsequent estimates for the 100 year flood have suggested that the levee is 0.2 to 0.3m below the 100 year flood.

Proposals to raise the levee by between 0.3 to 0.8m have been investigated as part of the Lower Clarence River Floodplain Management Study and subsequent floodplain management plan. The floodplain management study noted that the height of the reinforced concrete section of the levee could not be further increased, and that substantial reconstruction would be required (Paterson Consultants, 1993). The estimated cost of raising the levee by 0.3m was estimated at $1.2M (1993) with a benefit-cost ratio of 0.72. Raising the levee by 0.8m was estimated to cost $1.7M (1993) with a benefit-cost ratio of 0.75. Neither option was recommended in the floodplain management plan for 'a variety of environmental, social and economic reasons' (Maclean Shire Council, 1999).

An investigation was recently undertaken to assess the stability of the riverbank and the existing levee (Coffey, 2003a). The investigation reviewed both the existing structure and the potential to raise the levee by 0.3m in order to provide protection up to the 100 year flood. The investigation indicated that the stability of the earthfill embankment segment of the levee was generally acceptable, and could be raised by placing an additional 0.3m of fill or by alternatively constructing a 0.3m high wall on top of the earthfill levee. However, there were some concerns regarding the stability of the mass concrete and reinforced concrete section of the levee. The main area of concern was in relation to the positioning of reinforcement shown on the design drawings, which could lead to failure of the wall by sliding. It was also noted that these sections of the levee would be at risk by the proposed raising, unless further structural modification was undertaken.

Raising the Maclean levee by 0.3m was recently estimated to cost $1.04M (excluding GST) consisting of $0.32M for earth fill and $0.71M for mass concrete and reinforced concrete. This costing was based on a conceptual design only and did not include any works required to modify existing buildings to accommodate the raising (Coffey, 2003b).

A decision on whether or not to raise the levee by 0.3m (or higher) cannot be taken lightly, and the following issues need to be considered:

i). The costs of raising the levee just 0.3m are high, with estimates from two studies putting the cost above $1M.

ii). The incremental flood benefit of raising the levee by 0.3m is expected to be outweighed by these costs.

iii). Social issues, including disruption during construction and reduced visual amenity make this option less attractive.

iv). The performance standard for the levee has not changed. It was designed to provide protection against the record 1890 flood. Despite the levee being below the estimate for the 100 year flood, no flood to date has exceeded the height of the levee.

v). Since its construction in 1975, the levee has protected Maclean from at least 6 major flood events in 1976, 1980, 1988, 1989, 1996 and 2001.

vi). The latest Flood Study Review provides a slightly lower estimate for the 100 year flood, which now puts the levee just 0.2m below the 100 year flood.

vii). The levee will be overtopped some time in the future, regardless of whether it is raised by 0.3m or not. Whilst increasing the height of the levee can reduce the frequency of overtopping, when it does overtop the flood hazard can be considerably more severe. This is due to public complacency that flooding will no longer occur and the rapid increase in flood levels, up to the level in the river, which can occur over a short period of time when overtopping occurs. There is also greater potential for levee failure, either prior to overtopping or during overtopping, as the levee height is increased.

viii). Other non-structural options have previously been recommended for Maclean.

A review of the data that is available to assess the merits of raising the existing levee was undertaken. Some of the data available is relatively old (eg the floor level survey) and in other cases there is insufficient data to properly assess the levee raising proposal (eg detailed survey, community support, environmental impacts and the likely increase in risk due to overtopping or catastrophic failure as the levee height is increased).

Whilst additional information would be required to confirm the feasibility of proceeding with the levee raising proposal, on the balance of the information that is available, it is difficult to come to a different conclusion than was reached in the previous floodplain management plan. That is, non-structural options are preferred for Maclean. These options, which include development controls, flood warning, evacuation planning and public awareness initiatives, are considered to provide a better solution for large floods that exceed the existing height of the levee.

Should the levee require major reconstruction in the future, then opportunities to provide an increased level of protection could be reconsidered at that time.

Irrespective of whether or not the levee is raised, a number of recommendations have previously been provided for the levee (Coffey, 2003a). These include:

- The stability of the riverbank and levee is at risk in the gabion basket retained section of the bank in the area immediately in front of the RSL Building and in a short section of repaired riverbank just to the north of the Fish Cooperative. Remedial measures are required as a priority in these areas to improve the stability of the river bank.
- There is a long term risk of riverbank instability and potential instability of the levee along the full length of the mass concrete construction to the north of the Fish Cooperative. Scouring of the bank above and behind the rock facing and undercutting of the bank is evident at numerous locations. This needs to be regularly monitored and actions taken to repair damaged sections. The riverbank is unlikely to be at risk during an actual flood event but instability may occur during draw down of the floodwaters. Due to constraints on space between the road, the levee and the crest of the riverbank, long term improvements in this area may require the construction of a stabilising rock fill berm along the riverbank.
- There are no significant concerns relating to the stability of the earth fill embankment sections of the levee. Erosion of the face should be monitored and repaired as

required. Cracks observed at some locations are assessed to be due to shrinkage and should be regularly monitored and repaired. It is recommended that the crest is regularly scarified, moisture conditioned and recompacted to seal up any surface cracking that occurs. (Council has since advised that this option is not practicable, and alternative measures are under consideration).

- There are concerns about the stability of some sections of the reinforced concrete levee where steel reinforcement in the heel of the footings may be incorrectly placed resulting in a risk of failure due to sliding.

5.3.5 Internal Drainage

Flooding at Maclean can occur due to levee overtopping or due to impoundment of stormwater behind the levees when drainage to the river is blocked by high river levels.

Eight pumps were initially installed as part of the levee scheme. The main objective of the pumps was to help drain the impounded water behind the levee bank should overtopping occur. It was later recognised that the pumps could also assist in reducing impounded stormwater when river levels are high.

A flood that occurred in 1988 highlighted deficiencies in the pumps to remove impounded stormwater, when four of the eight pumps could not be started. Subsequent investigations (Paterson Consultants, 1989) reviewed the effectiveness of the pumps and the gravity drainage system. A number of recommendations to improve internal drainage were provided, including:

- Construction of a 2.1m x 2.1m box culvert at Essex's Drain, to provide additional drainage from the commercial and residential areas of Maclean that would be affected by overtopping, at an estimated cost of $153,000 (1989).
- Provision of two new pump pits, a new 600 l/s pump, and another nominally sized pump to replace Pump No.1, at an estimated cost of $175,000 (1989).
- Diversion of Argyle Street Drain to Wherrett Park, and thence to Essex Drain, during flooding, at an estimated cost of $185,000 (1989).

The desirability of drainage improvements and/or pump improvements was reiterated in both the floodplain management study (Paterson Consultants, 1993) and the floodplain management plan (Maclean Shire Council, 1999).

Council has indicated that the majority of the drainage improvements previously recommended have now been implemented, with the exception of the drainage diversion to Wherrett Park.

5.3.6 Other Measures

Non-structural measures, as recommended in the previous floodplain management study and subsequent plan, form the majority of the recommended measures for Maclean. These include:

application of appropriate development controls for new development and redevelopment as this occurs;

improved emergency management planning, including development of a standard flood warning template for Maclean, updating flood intelligence cards and the Local Flood Plan, based on the latest flood results; and

implementation of a measured education campaign to dispel the perception that the town enjoys full protection from flooding as a result of the levee.

5.4 BRUSHGROVE

5.4.1 Background

Brushgrove is a rural village with a population of almost 200 (Maclean Shire Council, 2003), located on the southern tip of Woodford Island in the Clarence River floodplain. Brushgrove has about 62 residential properties and 5 non-residential properties (WMA, 2001). The village has 2 heritage buildings listed in the Maclean Local Environmental Plan 2001, namely the post office and the old police station and residence.

Flood Levels derived from the Flood Study Review (WBM, 2004) are approximately 0.2m higher than the previous estimates (PWD, 1988) at this location for the 20 year and 100 year floods.

With the exception of the natural levees facing the Clarence River and the South Arm, most of the village is flooded in the 5 year flood. Much of this flooding is due to downstream backwater effects. The natural levee facing the Clarence River is overtopped in the 20 year flood, with only the higher ground adjacent to the South Arm free from flooding in this event. The 100 year flood would inundate practically all of Brushgrove, with flood depths exceeding 2 metres through most of the village.

5.4.2 Previous Recommendations

The Lower Clarence River Floodplain Management Study (Paterson Consultants, 1993) investigated several floodplain management options for Brushgrove, including various levee proposals, house raising, and other non-structural measures.

Three levee options were considered in the floodplain management study:

- a low-level levee at about 4.5m AHD to prevent backwater flooding;
- a full ring levee, with crest level similar to the 100 year flood (5.6m AHD); and
- a full ring levee, with crest level similar to the 100 year flood plus 0.5m freeboard (5.9m AHD).

All levee options were noted as having low benefit-cost ratios. Although the levees options were not rejected totally, the study also presented a range of non-structural measures which were noted as having high benefits and low costs.

The Lower Clarence River Floodplain Management Plan (Maclean Shire Council, 1999) recommended the following measures for Brushgrove:

(i) Ensure that the evacuation plan is kept current and workable;

(ii) Establish a public information program;

(iii) Implement development controls;

(iv) Minimum floor levels for residential development;

(v) House raising offered to owners of suitable houses;

(vi) Undertake a feasibility study onto providing a low level levee.

Further investigation of the feasibility of levee options for Brushgrove was subsequently undertaken (WMA, 2001), which included three community meetings. The study investigated four different levee scenarios and compared these with other options previously recommended. A description, costs, and the economic merit of each option is summarised in **Table 5.9**.

TABLE 5.9
Floodplain Management Options, Brushgrove
Source: WM&A, 2001

Option	Description	Cost ($1997)	BCR
Levee: 6.1m AHD crest level (100 year ARI + 500mm freeboard)	Earth and concrete	$2,660,000 (incl. $450K riverbank protection)	0.16
Levee: 5.7m AHD crest level (33 year ARI + 500mm freeboard)	Earth and concrete	$2,090,000 (incl. $450K riverbank protection)	0.19
Levee: 5.1m AHD crest level (10 year ARI + 500mm freeboard)	Earth and concrete	$1,610,000 (incl. $450K riverbank protection)	0.15
Levee: 4.1m AHD crest level (5 year ARI without freeboard)	Earth	$200,000	0.05
House raising to 100y ARI level + freeboard	Full subsidy for 7 houses and part subsidy for 3 houses	$300,000	0.65
Flood awareness	Not detailed	Not assessed	

Community meetings and submissions summarised in the report indicate mixed views about how to manage Brushgrove's flood problem. The overall outcome of the first community workshop in July 1997 was that a majority of the community were in favour of a levee, though one group was staunchly against a levee. The outcome from the second workshop in December 1997 was that the community were generally in support of a levee provided that properties east of the Cowper Bridge between Clarence Street and the South Arm were not affected, and provided that the tennis courts would not be lost. Of the 23 submissions received after this workshop, 2 submissions supported construction of a levee, including one with 90 signatures supporting a 3% levee with no freeboard, while 18 submissions opposed construction of a levee due to the expense, low economic merit, loss of land, loss of views and access to the river, increased catastrophe potential, and perceived adverse effect on flood levels at Cowper. A third community meeting in September 1997 was thought to be of little value, as it was brief and no real outcomes were achieved. Following public exhibition of the draft report in September/October 2000, 29 submissions were received of which 18 submissions (27 signatures) were in favour of a levee, 7 submissions (8 signatures) were against a levee, 7 submissions (10 signatures) supported house raising, 8 submissions (11 signatures) supported flood awareness and 3 submissions advocated the "do nothing" option. A repeated theme from those in support of the levee was the problem of overflowing septic tanks during flooding, which house raising would not address. Of those in support of the levee, five preferred the 3% levee while one preferred the 10% levee.

Overall, the assessment found that the implementation of a house raising scheme is the most affordable and practical solution to reduce the costs of flooding to the Brushgrove community. However, it was acknowledged that house raising would not resolve the issue of nuisance flooding (and health risks from flooded septic tanks).

Interestingly, at its meeting of 11 July 2001, Maclean Shire Council adopted the recommendations of the Maclean Floodplain Management Committee and resolved:

> *'That Council confirm the preferred option as being the construction of a 20% levee with a minimum crest level of 4.1m AHD, with some allowance for a freeboard being made that will have a minimal impact on the properties affected, and for associated drainage which includes a drainage outlet to the north-west, through the road reserve'.*

5.4.3 Review of Levee Proposals

During the course of this review, it became apparent that previous studies had very low benefit-cost ratios for all the levee options. This is because most of the damages prevented would be to yards, as shown on **Figure 5.8**.

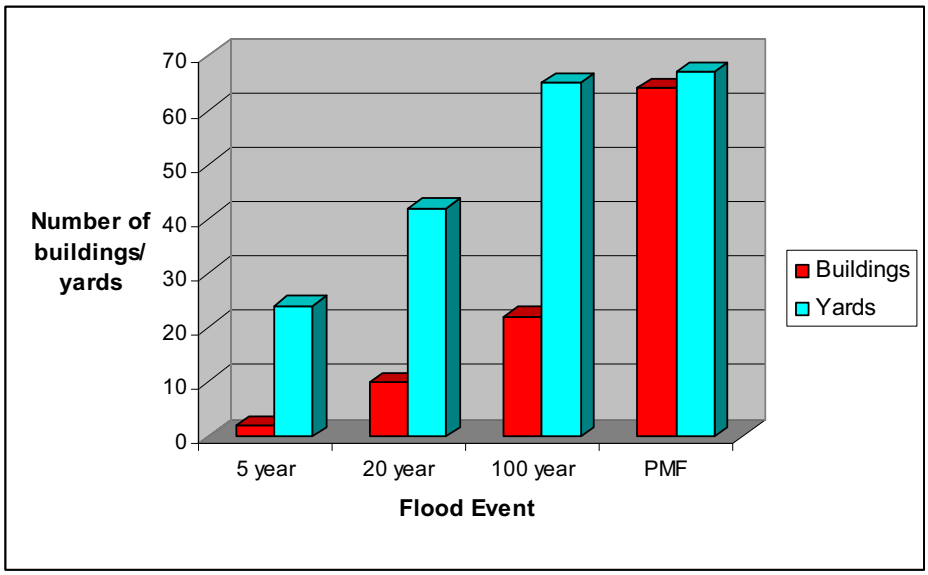


FIGURE 5.8
Number of Properties Affected by Flooding at Brushgrove

The Webb McKeown report adopted a maximum damage to garages and laundries of $1,000 per property (WM&A, 2001, p.E-11). This allowance probably represents a lower bound estimate of 'external' damages. In June 2004, DIPNR (now DNR) issued guidelines for the standard estimation of residential flood damages across the State (DIPNR, 2004). The new stage-damage curves give more weight to external flood damages (i.e. garage, shed, yard etc). DNR lists a base figure of $6,700/house for 'low-set' houses to a maximum of $20,164 for 'high-set' houses (in 2001 dollars). There are also some other differences in damage estimation approaches recommended by DNR, including allowance for infrastructure and social losses.

For this review, we have quoted the WMA estimates as a lower bound estimate. Also, we have followed the revised residential damage procedure to provide alternative estimates, which are provided in **Table 5.10**. This shows that all levee options considered are sensitive to the method used to estimate damages. The higher benefit-cost ratios derived from the new DNR procedure result mainly from the greater weight given to external damages. Despite this apparent emphasis, it is worth noting that DNR's perspective is that floodplain management measures should be justified primarily on the basis of reduced damages to houses and contents, rather than reduced external damages (DIPNR, 2004, p.11).

The levee designed to protect against the 100 year flood has a benefit-cost ratio of 0.2–0.7. Whilst it would protect 19 houses from over-floor flooding in the 100 year flood, it has a capital cost ($3.3M) that exceeds the present value of flood damage ($2.7M), which would present some difficulty in justifying it financially. Also, the community may not accept the interruption to their access and views of the river. Another problem is the false sense of security that a levee of this size could engender, exacerbating the risk to life when the levee is one day overtopped, with rapid inundation of the area perceived to be protected.

TABLE 5.10
Revised Economic Assessment of Levee Options

Levee Proposal	Intended Protection	Actual Protection	Houses Protected (to design level)	Capital Cost ($2004)	BCR*
6.1m AHD	100y + 0.5m	100y + 0.2m	19	$3.2M	0.2–0.7
5.7m AHD	33y + 0.5m	33y + 0.3m	10	$2.5M	0.2–0.5
5.1m AHD	10y + 0.5m	10y + 0.5m	3	$1.9M	0.2–0.4
4.1m AHD	5y	5y	1	$240K	0.1–0.4

* Lower bound value based on previous assessment. Other value based on DNR's residential flood damage calculations.

The levee designed to protect against the 33 year flood has a benefit-cost ratio of 0.2–0.5. This option would protect 10 houses from flooding (up to the design level), gained good support from the community, and looks to be the most attractive of all the levee options. However, its benefit-cost ratio is considerably less than 1, so it is difficult to justify purely from an economic point of view.

The levee designed to protect against the 10 year flood has a benefit-cost ratio of 0.2–0.4. This option would protect only three houses from flooding (up to the design level) and therefore does not seem justified.

The levee designed to protect against the 5 year flood has a benefit-cost ratio of 0.1–0.4. This option was previously identified by the Floodplain Management Committee and Council as the preferred option for Brushgrove. However, it has the lowest benefit-cost ratio and is difficult to justify on economic grounds. Another problem is that it only provides minimal benefits in terms of reduced frequency of inundation (from 4 years to 5 years). This change in flood behaviour is unlikely to be noticed by residents.

One reason why levee options have been favoured at Brushgrove is the problem of surcharging septic tanks during flooding. Reducing the frequency of flooding would bring about intangible benefits such as reduced health risks. However, there may be alternative, cost-effective methods to achieve this goal (e.g., fitting flap valves) which could be separately investigated by Council.

Further, whilst there appears to be considerable community support for a lower level levee, DNR support and funding would be unlikely as the levee primarily reduces external damages, which is regarded by the Department as a low priority compared to the reduction in house and contents damage.

5.4.4 Other Measures for Brushgrove

The favoured options for Brushgrove are voluntary house raising or house reconstruction, improved flood response measures, and revised planning and development controls.

Many houses in Brushgrove are already raised. This review recommends offering voluntary house raising to 8 further houses currently flooded above floor level in the 20 year flood. The valley-wide scheme proposed earlier in this report suggests that a $15,000 subsidy be provided to property owners to assist them in raising their homes above the 100 year flood level. As Brushgrove is a highly flood-prone community, and due to the frequency of

nuisance flooding experienced in this area, there may be special grounds for providing added incentive by offering a subsidy up to the full cost of house raising (estimated at approximately $50,000 per house). The scheme has a highly favourable benefit-cost ratio (estimated at 1.2), and may also provide some extra time for evacuation of residents by boats should this be required (notwithstanding that it is preferable to evacuate all residents of Brushgrove by road prior to access being cut by floodwater).

Brushgrove is a high flood hazard area, and any proposal to raise additional houses above the 100 year flood should be supplemented with improved flood warning, flood intelligence and evacuation planning. Despite the floor level of many houses being above the 100 year flood (and more under a voluntary house raising scheme), it is clearly desirable to evacuate all residents at an early stage of flooding. Should evacuation planning show that this is not feasible, then consideration could be given to constructing a multi-purpose community building with sufficient floor space above the PMF flood level to temporarily accommodate residents that fail to evacuate the area in time.

Improved flood response measures can be achieved by the Bureau issuing flood predictions specific to Brushgrove, and by revising the SES Local Flood Plan in view of the additional flood intelligence contained in this report. In particular, it is recommended that the trigger to commence emergency evacuations be reviewed given that all evacuation needs to be completed prior to about the 5 year flood level (RL 4.1m AHD) being reached.

Development controls are an important mechanism of ensuring no increase in property exposed to flood risks. Future subdivision at Brushgrove needs to be avoided. Some 'infill' development may be permissible subject to planning controls referred to in Section 4.5.

5.5 OTHER TOWNS AND VILLAGES

5.5.1 Ashby

Ashby is located on the north bank of the Clarence River, opposite Maclean. The majority of the town is located on land that is above the PMF flood, and there appears to be little flooding problems except for isolation during major floods and the possible inundation of one dwelling in the 100 year flood.

5.5.2 Brooms Head Road

Brooms Head Road connects Maclean with Brooms Head. Various subdivisions along the road are occurring a few kilometres from Maclean at Gulmarrad and Causley Farm. The majority of existing development is located on land that is above the PMF flood and there does not appear to be a significant flood threat apart from access being cut in large floods. Care still needs to be exercised to ensure that future development does not encroach onto the floodplain.

5.5.3 Chatsworth

The village of Chatsworth is located on Chatsworth Island, about 13km from the coast. The village is located on a ridge of higher land adjacent to the North Arm. There are some 40 dwellings in Chatsworth village, 11 of which have been noted as being below the 100 year flood (Maclean Shire Council, 1999).

There is a relatively high flood risk at Chatsworth. Much of the island will be inundated in a 5 year flood, and floodwater will surround the majority of dwellings in the 20 year flood. Access to the island will be cut an early stage, leaving the village isolated and subject to flooding in major events. Early evacuation of all residents should be sought. Any intensification of

existing development through future subdivision or rezoning should be avoided. Some existing dwellings may qualify for the valley-wide house raising scheme.

5.5.4 Cowper

Cowper is a small village situated immediately to the south of Brushgrove on the South Arm of the Clarence River. A property survey at Cowper lists 23 buildings within this locality, of which 17 were noted as having floor levels below the 100 year flood (WMA, 2001). Minor flood inundation is estimated to first occur in the 5 year flood, with the whole area being inundated in the 20 year flood. Access east and west along the Pacific Highway will also be inundated at a relatively early stage.

It is considered that there is a moderate to high flood risk for Cowper. Evacuation requirements will be an important consideration for the town. Any intensification of existing development through future subdivision or rezoning should be avoided. Some existing dwellings may qualify for inclusion in the valley-wide house raising scheme.

5.5.5 Harwood

Harwood village is located on the north bank of the Clarence River adjacent to the Pacific Highway crossing to Harwood Island. There are some 61 residential buildings, 17 commercial/industrial buildings and a sugar mill complex. It has been noted that 35 residential buildings and 15 non-residential buildings are below the 100 year flood (Maclean Shire Council, 1999). Significant inundation occurs over the island in the 5 year flood, with the entire island, including Harwood village, inundated in the 20 year flood.

There is a relatively high flood risk associated with Harwood village due to the number of buildings that are affected and possible isolation problems if early evacuation is not achieved. Evacuation plans for the village will be an important consideration for the village. Any intensification of existing development through future subdivision or rezoning should be avoided. Some existing dwellings may qualify for inclusion in the valley-wide house raising scheme.

5.5.6 Illarwill

Illarwill is located just upstream of Maclean, on the south bank of the Clarence River. The town is located on relatively high ground which slopes steeply up from the floodplain. The majority of the village is located on relatively high ground that is above the PMF flood, and there appears to be little flooding problems for this locality, apart from possible isolation during large floods.

5.5.7 Junction Hill

Junction Hill is a larger town which is located upstream of Grafton, on high ground which is mostly above the PMF flood. All of the dwellings within the town boundaries appear to be above the 100 year flood level, with the majority of dwellings also located above the PMF flood. Access south of Junction Hill to Grafton will be cut by floodwater; however, flood free access will be available to the north of town via the Summerland Way.

5.5.8 Lawrence

Lawrence is a larger town which is located on the north bank of the Clarence River, at the junction with Sportsman Creek, about half way between Brushgrove and Maclean. Most of the town is above the PMF flood, although some 20 residential and 8 non-residential buildings are estimated to have floor levels below the 100 year flood (WBM, 1998). There is

ready access to high ground within the town, and there does not appear to be a significant flood risk (apart from those properties that are inundated). Any intensification of existing development should occur on land that is above the 100 year flood. Those dwellings that are subject to inundation may qualify for inclusion in the valley-wide house raising scheme.

5.5.9 Palmers Island

The village of Palmers Island is located on the west side of Palmers Island, adjacent to the Clarence River, approximately 6km upstream of Iluka. The whole island would be inundated in a 20 year flood. It has been noted that there are 54 premises located within the village, 10 of which are considered to be flooded above flood level in the 100 year flood (Maclean Shire Council, 1999). There is also significant riverbank erosion that has threatened a number of properties, and prompted a voluntary purchase scheme to remove those properties at greatest risk (ie subject to both river bank erosion and flood risk).

Palmers Island is considered to represent a high flood risk, due to the number of buildings potentially affected by flooding and likely isolation problems if early evacuation is not achieved. Any intensification of existing development through future subdivision or rezoning should be avoided. There may still remain one or two dwellings that qualify for voluntary purchase due to the continuing bank erosion and flooding threat. Other dwellings may qualify for inclusion in the valley-wide house raising scheme.

5.5.10 Southgate

Southgate is a small rural village that is located on the banks of Alumy Creek, on the northern floodplain of the Clarence River, opposite the town of Ulmarra. The majority of the village area would be inundated in the 100 year flood, and the entire area inundated in the PMF. There are at least 8 dwellings fronting Lawrence Road that appear to be inundated in the 100 year flood, and another 9 dwellings on the outskirts of the village similarly affected (aerial photo, 1998).

Despite the small size of this village, it is considered that there is a high flood risk associated with Southgate. Access will be cut in the 100 year flood along Lawrence Road to the east and west of Southgate. Access to ground above the PMF flood may be available to the north, via School Lane. It is evident from Council's cadastre that there are numerous vacant lots within the village. Many of these also appear to have been previously subdivided into smaller allotments, some as small as 420m^2, although many of these remain vacant. Further subdivision or rezoning that potentially increases the intensity of future development below the 100 year flood should be avoided. Some existing dwelling may qualify for inclusion in the valley-wide house raising scheme.

5.5.11 Townsend

Townsend is located several kilometres south-east of Maclean, on the South Arm of the Clarence River. Recent subdivision of land has intensified the development at this locality, especially on the north side of Diamond Street. Much of the land on the south side of Diamond Street and Jubilee Street is affected by the 100 year flood. There are about 13 residential dwellings and 4 rural/commercial buildings which appear to be below the 100 year flood (aerial photography, 1998).

There does not appear to be a serious flood risk at Townsend. Much of the village is above the PMF flood, and there is ready access to high ground. Further intensification of development through subdivision or rezoning should be restricted to land that is above the 100 year flood, on the north side of Diamond and Jubilee Street. Some of the dwellings

affected by the 100 year flood may qualify for inclusion in the valley-wide house raising scheme.

5.5.12 Tucabia

Tucabia is located on the east bank of the Coldstream River, approximately 12km upstream of its junction with the South Arm of the Clarence River. Tucabia is located on the side of a hill, with the majority of the village on land that is above the 100 year flood. Most of the village would be inundated in a PMF flood, although there is still some access to higher ground immediately to the east of the village. There does not appear to be a significant flood risk to Tucabia, with only some rural dwellings on the outskirts of the village likely to be susceptible to inundation in a 100 year flood. Any further development within the village should be encouraged on the eastern side of the village, on land that is above the PMF flood.

5.5.13 Tyndale

Tyndale is located on the Pacific Highway, halfway between Cowper and Maclean. There are about 24 residential dwellings and several rural/commercial premises in the village of Tyndale (aerial photos, 1998). There are a number of other rural properties, a motel and a caravan park beyond the village proper. Much of Tyndale is located on high ground that is above the 100 year flood. There is also ready access to high ground above the PMF behind the village. There does not appear to be a serious flood risk to Tyndale Village, although the village may become isolated with access cut along the Pacific Highway to the east and west during floods.

5.5.14 Waterview Heights

Waterview Heights is located on the south side of the Clarence River, about 7km upstream of South Grafton. Recent subdivision of land has intensified the development at this locality, which has extended within close proximity to the floodplain on the eastern side of town. Much of the existing development is located above the 100 year flood, with possibly as few as 6 dwellings affected by the 100 year flood at the end of Swan Hill Drive. There does not appear to be a serious flood risk to Waterview Heights, with much of the town located above the PMF flood. Further subdivision of land to the east (below the 100 year flood) should be avoided.

5.5.15 Woombah

Woombah is a small village located approximately 8km from the coast, on the road to Iluka. Much of the village is located on land that is above the PMF flood. It has previously been noted that no existing dwellings are thought to be flooded above floor level (Maclean Shire Council, 1999). However, the eastern end of the village is below the 100 year flood and some inundation of this area can be expected. Any further development within the village should be encouraged to the north and west, on land that is above the PMF flood.

5.6 RURAL AREAS

Much of the floodplain within the study area consists of rural lands, used principally for dairy production, grazing and sugar cane. A number of measures have been undertaken by the former Clarence River County Council to improve these agricultural lands, including the construction of drains and low level levees to prevent nuisance flooding.

A number of rural dwellings are located throughout the floodplain, and many of these will be at risk of flooding. Unfortunately, there is no extensive floor level survey covering these rural properties, and the exact number and location of these dwellings is uncertain.

There will be other rural properties within the floodplain that do not contain a dwelling at present, but where an entitlement to erect a dwelling may exist subject to compliance with other building regulations and policies. Flood management controls will be an important mechanism to ensure that there is not a significant increase in flood risk over time, and that this can be adequately managed.

The previous floodplain management plan for the lower Valley suggested that there was approximately 400 residential dwellings distributed through the rural flood liable lands (within the former Maclean Shire LGA), and that 200 of these could be flood liable (Maclean Shire Council, 1999). Based on this previous estimate, there are likely to be about 400 flood liable dwellings throughout the current study area.

More definitive information on the number of rural dwellings at risk is not presently available. The extent of aerial photography that is available to count potentially affected properties is limited, and the resolution of the photography is not sufficient to distinguish between dwellings and other buildings such as sheds or garages. There is also no floor level data in which to determine whether or not the dwelling is flooded above floor level.

Most of the flood liable rural dwellings will be widely spread throughout the 750 km^2 floodplain. Structural measures, such as the construction of levee banks, will be impracticable due to high costs and the relatively few dwellings that can be protected within a particular area. The only feasible floodplain management measures are therefore likely to be restricted to those measures which modify property or people's response to flooding.

The removal of high risk properties through voluntary purchase schemes have been considered in the past in the Clarence Valley. A voluntary purchase scheme to remove properties at Palmers Island (due to a combined flood and riverbank erosion risk) is now nearing completion. Whilst it is unlikely that an extensive voluntary purchase scheme would be viable throughout the valley, there may be some dwellings that are subsequently identified where the flood risk is great enough to warrant their removal from the floodplain. Further clarification of floodway locations and property survey is required to confirm how many properties (if any) might be included in a voluntary purchase scheme.

A voluntary house raising scheme has been recommended for the study area, and it is anticipated that many rural dwellings would qualify for inclusion in such a scheme. Further identification of eligible properties through a valley-wide property survey will be required.

Development controls and land use planning are key mechanisms by which Council can manage flood affected areas. These mechanisms influence future development and redevelopment so that benefits accrue gradually over time. Proposed development controls for rural dwellings in the Clarence Valley includes provision of elevated fill pads to contain the dwelling, car parking, storage sheds and temporary stock refuge. Minimum floor levels at the 100 year flood level plus 0.5m freeboard has also been proposed as the main floor level control for new dwellings.

Flood warning, emergency management operations, and public awareness of the risk of flooding are measures that influence people's response to flooding (both occupants and emergency management personnel). A flood-aware community will be able to quickly respond to flood warnings and requests to evacuate an area. A flood-aware community is also more likely to take measures to minimise the consequences of flooding, such as relocating stock and equipment to higher ground.

One of the main difficulties in formulating an appropriate strategy for rural areas is the absence of sound data on the number and location of dwellings likely to be affected by various sized floods. This applies not only to rural dwellings, but also to many dwellings located within the various towns and villages throughout the floodplain. A comprehensive property survey throughout the Clarence Valley floodplain would rectify this situation. The property survey would identify the location of all buildings within the PMF flood extent, including property type, floor levels, and photographic reference. The property survey would be incorporated within a computer-based GIS system, so that all dwellings affected by various sized floods can be identified. This will greatly assist the SES in developing flood evacuation requirements and strategies for various parts of the valley. It will also assist in translating flood warning forecasts into maps showing which properties are likely to be affected.

Good quality digital aerial photography covering the whole floodplain (rectified and registered) would also provide a valuable supplement to the property survey.

5.7 CARAVAN PARKS

About 26 caravan parks are thought to be located within the Lower Clarence Valley floodplain. SES Flood Plans suggest that many of these parks occupy flood-prone locations. As well as providing tourist accommodation, the majority of these parks (notably in Grafton, South Grafton, Maclean, Palmers Island, Yamba and Iluka) provide at least some sites for long-term stays, which means that residents are permitted to live there. Council needs to pay special attention to this exposure.

Clarence Valley Council could also consider the recommendations of a recent report on management of flood-prone caravan parks in NSW (Yeo & Grech, 2005). These recommendations include:

- A distinction should be drawn between tourist related developments (traditional caravan parks which often evolve into modern tourist complexes) and permanent housing (residential parks and manufactured home estates).
- The flood related development controls that would normally apply to standard residential housing, should at a minimum be applied to residential parks (e.g., ground and floor level controls). (This is recognised in the proposed flood DCP). It could be argued that more stringent controls should be imposed, since residents tend to be less equipped to cope with flooding. This must be balanced against the social cost of discouraging affordable housing.
- Conversely, lower standards could be applied to purely tourist related developments on the basis that the social and economic consequences of flooding would be less than those associated with permanent housing. This position recognises the economic planning imperative of locating tourist related developments in proximity to natural features such as rivers.
- There should be no distinction between tourist parks and residential parks when considering risk to human life. If depths and velocities are high, and if the rate of rise of floodwaters is such that people could be trapped in dangerous conditions, then development should not be permitted.
- The specific structural characteristics of caravans, rigid annexes and manufactured homes need to be individually recognised within planning controls. Measures to prevent structures floating away during floods, and to minimise physical damage, need to be employed, requiring engineering solutions.
- More needs to be done to require managers of all flood-prone caravan parks to advise occupants of the risk and to prepare current, site-specific, written Flood Action Plans.

An approval system could provide a mechanism to implement, monitor and review awareness programs and evacuation strategies. Means of raising awareness of flood risk include constructing flood markers and displaying the Flood Action Plan in all dwellings. Among other points, plans should take into account the unique circumstances of each park: the extent and depth of the 20 year, 100 year and probable maximum floods; the number and manoeuvrability of dwellings; the number and mobility of tourists and residents; and the route, resources and time required to achieve a safe evacuation.

Whether to prohibit caravan parks and manufactured home estates within floodplains is ultimately a strategic planning decision. This may not lead to the removal of existing caravan parks and manufactured home estates, but could prohibit new development in highly hazardous areas of floodplains and act as a clear statement of policy to assist in restricting the expansion of existing developments. Development Control Plans (DCPs) can provide an appropriate mechanism to impose controls on new development and the expansion of existing ones. DCPs could be extended in application to provide policies for the continuing licensing of caravan parks under the Local Government Act and Regulations, to manage flood related risks through awareness programs and the establishment of Flood Action Plans.

Given the large number of potentially flood-prone caravan parks located within the area of Clarence Valley Council, it is recommended that Council in liaison with the SES conduct an investigation of flood risk on a site-specific basis. This risk assessment should identify:

the location of caravan parks within the floodplain and the degree of hazard they are subject to;

the warning times available to the park and the available evacuation routes;

the resources required to evacuate the people and moveable property from the park; and

policies for both existing parks and future parks within the floodplain.

The risk assessment should also be mindful of the particular "elements at risk" within each park - the number of permanent residents, the number of tourists during peak season, the number of moveable vans, etc.

6 RECOMMENDED FLOODPLAIN MANAGEMENT PLAN

Given the review of flood behaviour throughout Grafton and the Lower Clarence Valley, and previous floodplain management studies, plans and other investigations completed to date, a plan of future works and measures to manage the flood risk has been prepared (see **Table 6.1**).

Most of the recommended measures include non-structural measures that will apply throughout the valley. These include the assembly of additional flood information, emergency management improvements, improved community awareness, a voluntary house raising scheme, and adoption of sound planning controls.

Other measures have also been recommended for specific areas within the study area.

6.1 RECOMMENDED VALLEY-WIDE MEASURES

6.1.1 Property Survey and Database

One of the main limitations in formulating an appropriate floodplain management plan for the Lower Clarence Valley has been the absence of a detailed property database that identifies the number and location of properties affected by flooding. It is recommended that:

a) A property survey is undertaken of all buildings within the Lower Clarence Valley floodplain (excluding the main towns that are protected by levees);

b) A GIS property database is assembled of all flood affected buildings, including floor levels, flood levels, building type, and property location.

c) The database is used to evaluate which buildings may qualify for inclusion in a voluntary house raising scheme (and to review any potential voluntary purchase properties).

d) The database is used to assist in emergency management planning and to translate flood warning predictions into more meaningful maps showing property at risk.

6.1.2 Further Flood Modelling

Further flood modelling of potential levee overtopping at Grafton and South Grafton is recommended. The existing overtopping model needs to be updated to include additional levee survey and to provide input on flood behaviour and the consequence of levee failure for an evacuation capability assessment to be undertaken by the SES.

Other model updates are recommended to improve the representation of the general floodplain throughout the valley (for example by incorporation of ALS survey) and to use the model to more accurately delineate floodway areas.

6.1.3 Emergency Management

Improving flood warning systems, emergency management, and flood awareness is a very cost-effective means of reducing flood damages. Recommended strategies include:

Flood Warning System

a) Consider installing a few more rain gauges above Copmanhurst.

b) Review Grafton's rating curve and any correlations to other gauges.

c) Incorporate tides and tidal anomalies into Bureau flood predictions, with direct links to the Yamba water level recorder (operated by Manly Hydraulics Laboratory).

d) Educate and train SES personnel to debunk myths, explain science-based prediction, and practise responses to extreme (levee-overtopping) floods.

e) Develop standard warning templates for all major urban developments that can be inundated and isolated, similar to warning templates developed for Grafton, and develop operational guidelines to decide which evacuation message template to broadcast.

f) Develop an integrated flood warning web-site.

Emergency Planning

g) Consider merging four local flood plans into one.

h) Revise all flood plans and flood intelligence cards in view of the Flood Study Review, with particular attention to design flood magnitudes and levee overtopping levels and frequencies.

i) Revise evacuation plans for levee-overtopping events in view of proposed levee overtopping studies and evaluate strategies to improve community readiness to respond to flood warning messages and evacuation orders when provided.

6.1.4 Community Awareness

Raising and maintaining flood awareness will provide residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods. Recommended strategies include:

a) Revise FloodSafe brochures in view of new Flood Study, with particular attention to design flood magnitudes and levee overtopping levels and frequencies. For Grafton, mention level that an 1890 flood would reach today. For Ulmarra and Maclean, detail evacuation procedures in event of levee-overtopping floods.

b) Develop a new “one-stop shop” flood web-site, and promulgate its existence on rate notices and future FloodSafe brochures.

c) Supplement the recent installation of flood signs on telegraph poles with further strategic signage to warn of the potential risks of levee overtopping and/or failure during floods.

d) Prepare a property database to facilitate periodic distribution of flood certificates to all flood-prone residents.

e) Consider installing meter-box flood labels

f) Institute annual flood awareness weeks.

g) Evaluate effectiveness of flood awareness strategies.

6.1.5 Voluntary Purchase

Apart from the Palmers Island Voluntary Purchase Scheme, which is currently nearing completion, no major voluntary purchase schemes appear to be warranted within the Clarence Valley. Recommended measures include:

a) Completion of the Palmers Island Voluntary Purchase (2 houses).

b) Review other potential properties for voluntary purchase on completion of the property database and the improved delineation of floodways.

6.1.6 Voluntary House Raising

A broad Voluntary House Raising Scheme is recommended throughout the Valley. The recommended Scheme would provide a partial subsidy of $15,000 as an incentive for owners of eligible dwellings to raise/rebuild/relocate their home to a level at least 0.5m above the 100 year flood. The suggested eligibility criteria for inclusion in the Voluntary House Raising Scheme are those dwellings with floor levels below the 20 year flood, and are not protected by other flood mitigation measures such as levees. Owners of these homes would be required to fund the difference in costs, and to manage the rebuilding process.

Recommended actions include:

a) Prepare list of eligible properties, based on the proposed property database;

b) Develop guidelines for Council (and owners) outlining eligibility criteria and other administrative procedures to be followed in implementing the scheme;

c) Prepare a brochure to promulgate the scheme.

d) Progressive implementation of the house raising scheme (preliminary estimate of 300 dwellings at a total subsidy of $4.5M).

6.1.7 Planning Considerations

Landuse planning and development controls are key mechanisms by which Council can manage flood affected areas within the Clarence Valley. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

The following planning measures are recommended:

a) The Floodplain Management Committee endorses the planning approach outlined within this report. This approach basically requires a graded set of planning controls for different land uses relative to different levels of flood risk in the study area, consistent with the requirements of the Floodplain Development Manual.

b) That the Committee formally endorses the recommended inclusions with Council's future LEP (presented in **Appendix A**). This will then be a matter for Council to review and incorporate within its future consolidating LEP based on the "LEP template" to be prepared in accordance with the process outlined in the EPA Act.

c) That the Committee endorses the defining of the two flood management areas within the floodplain (Floodway and General Floodplain).

d) That the Committee formally endorses the model DCP chapter (**Appendix B**), providing detailed controls relating to floodplain management for inclusion in Council's future consolidated DCPs. At this stage, Council proposes the preparation of 6 DCPs relating to different land use zones. It will subsequently be a matter for Council to review the model DCP chapter, include appropriate controls derived from the matrix of recommended controls and provide for its inclusion within each of the future DCPs, to be prepared in accordance with the process outlined within the EPA Act.

e) That Council refer a copy of the adopted Floodplain Risk Management Plan to the Department of Planning and the Department of Environment and Climate Change to seek their endorsement to the recommendations for the preparation of the DCP and LEP controls, and to vary from the prescriptive provisions of the new flood planning guidelines on the basis of 'exceptional circumstances". The grounds that could be included within a submission to the Departments to justify the variations are inclusive of those outlined in **Section 4.5.9** of this report.

f) That Council finalise and adopt flood maps which delineate the two flood management areas and all flood storage areas as currently known to Council. These maps are to effectively form a referenced component of the DCPs.

g) That Council consider the need to include flooding advice on Section 149 certificates that includes the flood risk of a property and the existence of the proposed DCPs which are intended to include flood management related provisions. Any such notation should have regard to the level of information available and should preferably provide notification for all properties in a known floodplain (ie. within the PMF extent).

h) That Council undertakes a review of its current LEPs, DCPs and Section 149 Certificate notations in the interim, pending the final adoption of its consolidated LEPs and DCPs. The twofold aim of this interim review is to firstly ensure that no misleading information is disseminated by Council regarding the flood risk to different land within the LGA and, secondly, to ensure that the redefinition of the floodplain arising as a consequence of the Floodplain Risk Management Plan does not unreasonably constrain development expectations.

i) That Council, in consultation with the Department of Planning, review the Clarence Valley Settlement Strategy having regard to the flood risks and planning recommendations identified within the Floodplain Risk Management Plan and incorporate where appropriate in the Mid North Coast Regional Strategy. As a general principle, it is preferable that new urban areas are located outside of the floodplain and intensification of existing urban areas be restricted to a level that can be accommodated within the evacuation capacity of the State Emergency Services. These principles should be identified in an appropriate public education program regarding flood risks.

6.2 RECOMMENDED MEASURES FOR SPECIFIC AREAS

6.2.1 Grafton

Specific recommendations for Grafton comprise:

a) Regular maintenance of the existing levee system, including minor adjustments to account for damage or settlement of existing banks to ensure accordance with original design plans.

b) Completion of outstanding maintenance issues identified in the 2004 levee audit, if not already undertaken.

c) Collection of an up-to-date survey of the complete levee system that protects Grafton, including natural high ground, the railway embankment and other structures that are incorporated within the levee system.

d) Review of potential levee deficiencies based on the new survey, verification of the representation of the levees in the flood model (WBM, 2006) and further review of potential levee augmentation options. More detailed investigations will be required if significant levee augmentation schemes are subsequently proposed, including geotechnical assessments, preliminary designs, floor level survey, economic assessments, environmental review and identification of community views.

e) Preparation of a flood evacuation capability assessment to determine the requirements and capability of the SES to safely evacuate residents from Grafton, given the affected population, warning times, flood behaviour, available evacuation routes, and the potential for catastrophic levee failure.

f) Improved emergency management operations and evacuation planning, including updating flood intelligence cards and the SES Local Flood Plan with information from the latest Flood Study Review (WBM, 2004) and Overtopping Study (WBM, 2006).

g) Investigations into improving flood free access from Grafton to Junction Hill (via the Summerland Way).

h) Improved community awareness of the risk of flooding and the need to evacuate the town prior to levees overtopping.

i) Design and installation of twin 2.1x2.1 box culverts through the river bank levee near North Street to improve local drainage prior to floodgates closing, and to speed up the removal of impounded stormwater east of Alumy Creek once river levels subside, or following events that overtop the levees.

6.2.2 South Grafton

Recommendations for South Grafton include:

a) Regular maintenance of the existing levee system, including minor adjustments to account for damage or settlement of existing banks to ensure accordance with original design plans.

b) Completion of any outstanding maintenance issues identified in the 2004 levee audit, if not already undertaken.

c) Collection of an up-to-date survey of the complete levee system that protects South Grafton, including natural high ground and other structures that are incorporated within the levee system.

d) Review of potential levee deficiencies based on the new survey, verification of the representation of the levees in the flood model (WBM, 2006) and further review of potential levee augmentation options. More detailed investigations will be required if significant levee augmentation schemes are subsequently proposed, including geotechnical assessments, preliminary designs, floor level survey, economic assessments, environmental review and identification of community views.

e) Improved emergency management operations and evacuation planning, including updating flood intelligence cards and the SES Local Flood Plan with information from the latest Flood Study Review (WBM, 2004) and Overtopping Study (WBM, 2006).

f) Improved community awareness of the risk of flooding.

6.2.3 Maclean

The recommended floodplain management measures for Maclean include:

a) Undertake a detailed survey of the full length of the Maclean Levee. Any deficiencies in the integrity of the structure, or areas where settlement has occurred below the original design specifications, should be rectified as part of on-going maintenance operations.

b) Further review of the internal drainage strategy within the town, including the capacity and maintenance of the existing levee pumps.

c) Application of appropriate development controls for new development and redevelopment as this occurs. The primary control for residential development is the use of minimum floor levels based on the 100 year flood level (WBM, 2004) in the river with 0.5m freeboard. Other flood-proofing initiatives are recommended for commercial development.

d) Improved emergency management planning, including the development of a standard flood warning template for Maclean, updating flood intelligence cards and the Local Flood Plan, based on the latest flood results.

e) Implementation of a measured education campaign to dispel the perception that the town enjoys full protection from flooding as a result of the levee. Residents and owners need to be reminded of the risk of levee overtopping and the consequent flood behaviour.

6.2.4 Brushgrove

The recommended measures for Brushgrove include:

a) Voluntary house raising or house reconstruction for 8 houses currently below the 20 year flood level. Given the flood-prone nature of this area, and the frequency of nuisance flooding, a full cost subsidy (up to say $50,000) may be appropriate.

b) Improved emergency management planning, including evacuation planning, providing flood warnings specific to Brushgrove, updating the Local Flood Plan with new flood intelligence data, public awareness of the flood risk and further consideration of evacuation procedures.

c) Development controls on future development and redevelopment.

d) A feasibility study of providing improved flood access between the Highway and the Brushgrove Bridge.

e) Investigation of measures to reduce septic overflows and other health concerns during flooding,

6.2.5 Other towns, Villages and Rural Properties

The valley-wide measures previously outlined will be applicable to most of the other towns, villages and rural properties throughout the floodplain. Many of the flood affected dwellings in these localities may be eligible for inclusion in the voluntary house raising scheme.

Specific attention is warranted in regard to:

a) Evacuation Planning – particularly for Chatsworth, Cowper, Harwood, Palmers Island and generally for rural properties.

b) Development Controls on future development – in particular no intensification of development through subdivision or rezoning should be permitted at Chatsworth, Cowper, Harwood, Palmers Island and Southgate. Care also needs to be exercised in siting areas of future development along Brooms Head Road, Lawrence, Townsend, Tucabia and Waterview Heights.

6.2.6 Caravan Parks

Given the large number of potentially flood-prone caravan parks located within the area of Clarence Valley Council, it is recommended that Council in liaison with the SES conduct an investigation of flood risk on a site-specific basis. This risk assessment should identify:

the location of caravan parks within the floodplain and the degree of hazard they are subject to;

the warning times available to the park and the available evacuation routes;

the resources required to evacuate the people and moveable property from the park; and

policies for both existing parks and future parks within the floodplain.

6.3 FUNDING AND IMPLEMENTATION

The total estimated cost of the Grafton and Lower Clarence Floodplain Risk Management Plan, as outlined in **Table 6.1**, is $6,700,000.

The above estimate is dominated by the allowance provided for the valley-wide house raising scheme, which has assumed as many as 300 properties might be eligible throughout the Valley. This cost will need to be reviewed once the property survey and property database is established. The costs also do not allow for levee augmentation measures that may be recommended following subsequent investigations.
There are a variety of sources of potential funding that could be considered to implement the Plan. These include:

i) Council funds;

ii) State and Commonwealth funding for flood risk management measures through the Department of Natural Resources;

iii) State Emergency Service, either through volunteered time or funding assistance for emergency management measures;

iv) The Bureau of Meteorology for flood warning instrumentation and procedures.

Council can expect to receive the majority of financial assistance through the Department of Natural Resources. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is usually provided on a 1:1:1 basis (Commonwealth:State:Council).

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding of investigation and design activities as well as any works and ongoing programs such as voluntary house raising, is normally available. Maintenance, however, is normally the responsibility of Council.

6.4 ON-GOING REVIEW OF PLAN

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies.

The Plan itself contains recommendations for further data collection and investigations. As outcomes from these investigations become available, components of the existing plan may become outdated and alternate recommendations may be required. For example, further evaluation of the Grafton Levee system may lead to new levee augmentation proposals. These additional investigations have a high priority, and are expected to be completed within the next 1-2 years. It would be appropriate to review and update the Plan at this stage.

In any event, a thorough review every 5 years is warranted to ensure the ongoing relevance of the Plan.

TABLE 6.1
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)	Funding Sources*	Priority
Valley-Wide Measures				
6.1.1	**Property Survey and Database**			
	a) Property Survey	$50,000	1,2	Medium
	b) Assemble GIS database	$20,000	1,2	Medium
	c) Evaluate VP and VHR Schemes	$10,000	1,2	Medium
	d) Emergency Management planning	$20,000	1,2,3	Medium
6.1.2	**Further Flood Modelling**			
	a) Levee overtopping investigations at Grafton	$40,000	1,2	High
	b) Update floodplain topography & delineate floodways	$20,000	1,2	Medium
6.1.3	**Emergency Management**			
	a) Additional rain gauges above Copmanhurst	$40,000	1,2,4	Low
	b) Review Grafton Rating Curve in flood predictions	$5,000	4	High
	c) Incorporate tidal anomalies in flood predictions	$10,000	4	Medium
	d) SES training for potential levee overtopping scenarios	$10,000	3	High
	e) Standard warning templates for all major urban areas	$5,000	3	High
	f) Develop integrated flood warning web-site	$30,000	1,2,3,4	Medium
	g) Consider merging four local flood plans into one	$10,000	3	High
	h) Update flood plans & intelligence with new flood data	$5,000	3	High
	i) Update evacuation plans for levee overtopping events	$5,000	3	High
6.1.4	**Community Awareness**			
	a) Update FloodSafe brochures with new flood data	$10,000	3	Medium
	b) Develop web site providing flood advice	$10,000	1,2,3	Medium
	c) Strategic signage regarding risks of levee overtopping	$20,000	1,2	Medium
	d) Periodic distribution of flood certificates	On-going	1	Medium
	e) Consider installing meter-box flood labels	$40,000	1,2,3	Low
	f) Institute annual flood awareness weeks	On-going	1,2,3	Low
	g) Evaluate effectiveness of flood awareness strategies	$10,000	1,2,3	Medium
6.1.5	**Voluntary Purchase**			
	a) Complete Palmers Island VP Scheme	$600,000	1,2	Medium
	b) Review need for additional VP Scheme	$10,000	1,2	Medium
6.1.6	**Voluntary House Raising**			
	a) Compile list of eligible properties	$5,000	1,2	Medium
	b) Develop guidelines and administrative procedures	$20,000	1,2	Medium
	c) Prepare brochure	$10,000	1,2	Medium
	d) Progressive implementation of Scheme	$4,500,000	1,2	Medium
6.1.7	**Planning Considerations**			
	a) Endorse Planning approach outlined in Plan	Nil	1	High
	b) Endorse inclusions in Council's LEP	Nil	1	High
	c) Endorse adoption of Flood management areas	Nil	1	High
	d) Endorse development controls & model DCP chapter	Nil	1	High
	e) Apply to Departments for 'exceptional circumstances'	Nil	1	High
	f) Finalise flood management maps	$20,000	1,2	Medium
	g) Include flooding advice on S149 Certificates	On-going	1	High
	h) Review current policies and remove misleading info	$10,000	1	High
	i) Review Clarence Valley Settlement Strategy	$10,000	1	High

TABLE 6.1
Recommended Floodplain Risk Management Plan

Item	Description	Estimated Cost ($)	Funding Sources*	Priority
Measures for Specific Areas				
6.2.1	**Grafton**			
	a) Regular maintenance of existing levee system	On-going	1	High
	b) Complete outstanding items from 2004 levee audit	$100,000	1,2	High
	c) Up-to-date survey of complete levee system	$10,000	1,2	High
	d) Review potential levee deficiencies	$10,000	1,2	High
	e) Prepare flood evacuation capability assessment	$40,000	1,2,3	High
	f) Improved emergency management operations	$10,000	3	Medium
	g) Investigate flood free access to Junction Hill	$20,000	1,2	Medium
	h) Improved community awareness of overtopping risk	$10,000	1,2	Medium
	i) Install box culverts through levee near North Street	$300,000	1,2	Low
6.2.2	**South Grafton**			
	a) Regular maintenance of existing levee system	On-going	1	High
	b) Complete outstanding items from 2004 levee audit	$100,000	1,2	High
	c) Up-to-date survey of complete levee system	$10,000	1,2	High
	d) Review potential levee deficiencies	$10,000	1,2	High
	e) Improved emergency management operations	$10,000	3	Medium
	f) Improved community awareness of overtopping risk	$10,000	1,2	Medium
6.2.3	**Maclean**			
	a) Survey complete levee system & identify deficiencies	$15,000	1,2	High
	b) Review internal drainage strategy	$20,000	1,2	Low
	c) Apply appropriate development controls	On-going	1	High
	d) Improved emergency management operations	$10,000	3	Medium
	e) Improved community awareness of overtopping risk	$10,000	1,2	Medium
6.2.4	**Brushgrove**			
	a) Voluntary house raising of 8 houses	$400,000	1,2	Medium
	b) Improved emergency management planning	$10,000	3	Medium
	c) Apply appropriate development controls	On-going	1	High
	d) Feasibility study of improved flood access to bridge	$20,000	1,2	Medium
	e) Investigate septic overflows & health concerns	$20,000	1,2	Medium
6.2.5	**Other towns, villages & rural areas**			
	a) Review evacuation plans – Chatsworth, Cowper, Harwood, Palmers Island, rural areas	$10,000	3	High
	b) Development controls on future development	On-going	1	High
6.2.6	**Caravan Parks**			
	a) Risk assessment for flood prone caravan parks	$30,000	1,2,3	Low

TOTAL: $6,740,000

* Potential funding sources are as follows:

1 Clarence Valley Council
2 Department of Natural Resources
3 State Emergency Service
4 Bureau of Meteorology

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8 GLOSSARY

Note that terms shown in bold are described elsewhere in this Glossary.

100 year flood	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year flood	A **flood** that occurs on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year flood	A **flood** that occurs on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a **flood** that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **average recurrence interval (ARI)**.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All **flood levels**, floor levels and ground levels in this study have been provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **annual exceedance probability (AEP)**.
catchment	The land draining through the main stream, as well as tributary streams.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
DNR	Department of Natural Resources, formerly the Department of Infrastructure, Planning & Natural Resources (DIPNR).
discharge	The rate of flow of water measured in terms of volume per unit time, for example, **cubic metres per second (m^3/s)**. Discharge is different from the speed or **velocity** of flow, which is a measure of how fast the water is moving.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the *Local Government Act 1993*.

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, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.
extreme flood	An estimate of the **probable maximum flood (PMF)**, which is the largest flood likely to occur.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 7.8m AHD). Terms also used include **flood stage** and **water level**.
flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**. Note that the term flood liable land now covers the whole of the **floodplain**, not just that part below the **flood planning level**.
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain management studies** and incorporated in **floodplain management plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a **flood**.
flood stage	see **flood level**.
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**.

Floodplain Risk Management Study	Studies carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) that assesses options for minimising the danger to life and property during **floods**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in **flood levels**.
flow	see **discharge**
foreshore building line	A line fixed by resolution of Council in respect of land fronting any bay, river, creek, lagoon, harbour or ocean, which provides a setback distance where buildings or other structures would normally be prohibited.
freeboard	A factor of safety expressed as the height above the **design flood level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.
high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	metres **Australian Height Datum (AHD)**.
m/s	metres per second. Unit used to describe the **velocity** of floodwaters.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek or river flows or **discharges**. It the rate of flow of water measured in terms of volume per unit time.

merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum **flow** or **discharge** during a flood.
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in **m/s**.
water level	see **flood level**.
water surface profile	A graph showing the height of the **flood** (**flood stage**, **water level** or **flood level**) at any given location along a watercourse at a particular time.

APPENDIX A

RECOMMENDED INCLUSIONS TO THE LEP TEMPLATE

DEFINITIONS

[To be inserted into the Dictionary of the Template LEP in alphabetical order:]

Flood liable land (being synonymous with ***flood prone land*** and ***floodplain***) is the area of land which is subject to inundation by floods up to and including a probable maximum flood (PMF).

Probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location.

[Optional definition subject to further consideration by Council]

Floodway is that part of the floodplain where a significant discharge of water occurs during floods, and shown distinctively on the map.

STANDARD CLAUSE

[To be inserted as Clause 34A in the LEP Template]

34A Development in Flood Liable land

(1) Notwithstanding any other provisions of this Plan, the Council may refuse consent to the carrying out of any development on flood prone land where, in its opinion, the development may:

(a) be inconsistent with a floodplain risk management plan adopted by Council in accordance within any relevant Manual as published by the State Government;

(b) detrimentally increase the potential flood effect on other development or property;

(c) result, to a substantial degree, in an increased risk to human life; or

(d) be likely to result in additional economic and social cost which could not reasonably be managed by potentially affected persons and the general community.

(2) When undertaking an assessment required by this clause, Council shall take into consideration the impact of the development in combination with the cumulative impact of development which is likely to occur within the future, within the same floodplain.

[Optional subclause subject to further consideration by Council]

(3) Notwithstanding any other provision of this plan, development other than for the purposes of agriculture, boat launching ramp, boat repair facility, boat shed, bushfire hazard reduction, charter and tourism boating facility, commercial port facility, demolition, environmental protection works, extractive industries, flood mitigation works, jetty, marina, and recreation area, are prohibited on land identified on the Map as floodway.

EXEMPT & COMPLYING DEVELOPMENT

Amend exempt and complying development provisions so as to exclude exempt development within the generally narrowly defined but hazardous floodway and complying development within the more general floodplain extent.

Insert the following within Clause 16(3)(b) of the LEP Template which *relates* to exempt development.

"(iv) *be identified on the map as floodway."*

Insert the following *within* Clause 17(3) of the LEP Template which relates to complying development.

"(d) not be on flood liable land."

[The alternate to above recommendations for complying development is to exclude it from "land identified on the map as floodway" and to reiterate the relevant provisions recommended in the Planning Matrix (refer to Appendix B) within the DCP Standards for compliance for complying development.]

APPENDIX B

MODEL DRAFT DCP CHAPTER

PART X

FLOODPLAIN MANAGEMENT CONTROLS

PART X. FLOODPLAIN MANAGEMENT CONTROLS

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PART X. FLOODPLAIN MANAGEMENT CONTROLS

X1. What are the Aims of the Floodplain Management Controls?

This Plan aims to:-

(a) Increase public awareness of the hazard and extent of land affected by all potential floods, including floods greater than the 100 year average recurrence interval (ARI) flood and to ensure essential services and land uses are planned in recognition of all potential floods.

(b) Inform the community of Council's policy for the use and development of flood prone land.

(c) Manage the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods.

(d) Provide detailed controls for the assessment of applications lodged in accordance with the Environmental Planning and Assessment Act 1979 on land affected by potential floods.

(e) Apply a "merit-based approach" to all development decisions which takes account of social, economic and ecological considerations.

X2. How to Use this Part of the Plan?

The following is a summary of the major steps to be followed in applying this part of the DCP:

(a) Determine the relevant floodplain (eg. Grafton or Lower Clarence River and other Floodplains).

Note:
The controls applying to "all other floodplains" are interim only until catchment specific Flood Risk Management Plans are prepared as required by the Floodplain Development Manual.

(b) Determine the Flood Management Area (General Floodplain or Floodway) within which your site is situated.

(c) Verify by enquiring with Council and if necessary undertaking independent studies to determine if the property contains flood storage areas.

(d) Enquire with Council regarding existing flood risk mapping or whether a site-specific assessment may be warranted in your case (for example, if local overland flooding is a potential problem).

Note:
A property may be located in more than one Flood Management Area, in which case the assessment must consider the controls relative to each Flood Management Area.

PART X. FLOODPLAIN MANAGEMENT CONTROLS

(e) Determine the development category relevant to your proposal, by firstly confirming how it is defined by the relevant environmental planning instrument and secondly by ascertaining the applicable land use category from Schedule X2 of this Plan.

Note:
Some minor forms of development may be classified as either exempt or complying development subject to being above to satisfy certain criteria. In such cases, this DCP may not need to be applied.

(f) Check if the proposal will satisfy the prescriptive controls for different land use categories in different Flood Management Areas, as contained in the clauses below.

(g) Assess and document how the proposal will achieve the performance criteria for development or any filling.

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

The assistance of Council staff or an experienced floodplain consultant may be required at various steps in the process to ensure that the requirements of this Plan are fully and satisfactorily addressed.

X3. What Development Controls Apply?

X3.1 Performance Criteria

All development requiring Council consent must comply with the following performance criteria:

(a) The proposed development should not result in any increased risk to human life.

(b) The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner and general community.

(c) The proposal should only be permitted where effective warning time and reliable access is available for evacuation from an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy.

(d) Development should not detrimentally increase the potential flood effects on other development or properties either individually or in combination with the cumulative impact of development that is likely to occur in the same floodplain.

(e) Motor vehicles are able to be relocated, undamaged, to an area with substantially less risk from flooding, within effective warning time.

(f) Procedures would be in place, if necessary, (such as warning systems, signage or evacuation drills) so that people are aware of the need to evacuate and relocate motor vehicles during a flood and are capable of identifying an appropriate evacuation route.

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

(h) Proposed development must be consistent with ESD principles.

(i) Development should not prejudice the economic viability of any Voluntary Acquisition Scheme.

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X3.2 Prescriptive Controls

Schedules X3 and X4 outline the controls relevant to each of the floodplains to which this Plan applies.

Compliance with the prescriptive controls as defined in Schedules X3 and X4 Is deemed to comply with the performance criteria specified in Clause X3.1 unless, in Council's opinion, particular circumstances apply that require a variation in light of X3.1.

Proposals seeking a variation to the prescriptive controls specified in Schedules X3 or X4 will need to be justified in terms of the performance criteria under X3.1.

Note:
For completeness, the prescriptive controls that may apply under other DCPs for different land uses are also shown in these schedules. Additional requirements relating to fencing, filling and other uses may also apply – refer to Clauses X4, X5 and X6.

X4. Are There Special Requirements for Fencing?

X4.1 Performance Criteria

Development involving fencing must also comply with the following performance criteria:

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

(b) Ability to be certified by a suitably qualified engineer, that the proposed fencing is adequately constructed so as to withstand the forces of floodwaters, or collapse in a controlled manner to prevent the undesirable impediment of flood waters.

X4.2 Prescriptive Controls

The following prescriptive controls also apply to development involving fencing within a floodway:

X4.2.1 Fencing within a Floodway will not be permissible except for security/ permeable/ open type/safety fences of a type approved by Council. Council may require such fencing to be able to be opened at the bottom with the force of floodwaters. (This requirement may be secured by a Section 88B instrument burdening the title of the land).

X4.2.2 An applicant will need to demonstrate that the fence would create no impediment to the flow of floodwaters. Appropriate fences must satisfy the following:-

(a) An open collapsible hinged fence structure or pool type fence;

(b) Other than a brick or other masonry type fence (which will generally not be permitted); or

(c) A fence type and siting criteria as prescribed by Council.

X4.2.3 Other forms of fencing will be considered by Council on merit.

X5. Are There Special Controls for Filling of Flood Liable Land?

X5.1 Performance Criteria

Development involving filling of flood liable land must comply with the following criteria:

(a) The filling of flood liable land must not increase the flood risk on other land within the floodplain.

(b) Filling and associated works must not have any unacceptable associated environmental impacts such as detrimental affection of the ecology of riparian corridors.

X5.2 Prescriptive Controls

The following development controls apply to development involving filling on flood liable land.

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X5.2.1 The flood impact of the development to be considered to ensure that the development will not increase flood affects elsewhere, having regard to:

(i) loss of flood storage;

(ii) changes in flood levels and velocities caused by alterations to the flood *conveyance;* and

(iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required to address potential impacts.

X5.2.2 If a *Flood Storage Area* has been defined in the floodplain, any filling of the floodplain inside this area is not permitted as it will reduce the volume of flood storage available on the floodplain and increase flood effects elsewhere, except:

i) where this occurs in conjunction with compensatory excavation, or
ii) where, in Council's opinion, such impacts are likely to be negligible

X5.2.3 Notwithstanding Clause X5.2.2 no net filling of land is permitted in Grafton, South Grafton and the Heber Street Catchment within the Grafton floodplain, below levels 4.2, 4.65 and 5.7 metres AHD respectively.

X5.2.4 Where compensatory excavation and fill works are proposed in a flood storage area, an engineers report will be required to demonstrate compliance with Clause X5.2.1.

X6. Are There Other Special Considerations for Development in a Floodplain?

When assessing proposals for development or other activity within the floodplain, Council will take into consideration the following specific matters.

(a) Measures employed to mitigate the potential impact of flooding (eg. house raising) must be undertaken in a manner which minimises the impact upon the amenity and character of the locality.

(b) The design of car parking (enclosed or uncovered) and associated driveways should not result in unacceptable environmental or amenity impacts. Unacceptable impacts may include visual intrusion from elevated driveways and parking structures and overshadowing of adjoining residential properties in excess of Council's relevant standards.

(c) The proposal must not constrain the orderly and efficient utilisation of the waterways for multiple purposes.

(d) The proposal must not adversely impact upon the recreational, ecological, aesthetic or utilitarian use of the waterway corridors, and where possible, should provide for their enhancement.

(e) Proposals for house raising must provide appropriate documentation including:
i) a report from a suitably qualified engineer to demonstrate that the raised structure will not be at risk of failure from the forces of floodwaters in a 100 year flood; and
ii) the provision of details such as landscaping and architectural enhancements which ensure that the resultant structure will not result in significant adverse impacts upon the amenity and character of an area.

(f) Notwithstanding any other provision where a property is identified within a Voluntary Acquisition Scheme area, Council will only consent to further development being "concessional development"; provided:

(i) the development is for only minor works such as small awnings over existing

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balconies or in-ground swimming pools; and

(ii) the capital investment intended for the property is, in the opinion of Council, not greater than the minimum required to satisfy acceptable standards.

Note:
Council will not permit any type of development that would be inconsistent with the objective of discouraging intensification of development, or heightened community risk in floodways.

X7. What Information is Required with an Application for Development on Flood Liable Land?

X7.1 Applications must include information that addresses all relevant controls listed above, and the following matters as applicable.

X7.2 Applications for Concessional Development (which includes alterations and additions to existing developments or minor development – see Schedule X2) to an existing dwelling on Flood Prone Land shall be accompanied by documentation from a registered surveyor confirming existing floor levels.

X7.3 Development applications affected by this plan shall be accompanied by a survey plan showing: -

(a) The position of the existing building/s or proposed building/s;

(b) The existing ground levels to Australian Height Datum around the perimeter of the building and contours of the site; and

(c) The existing or proposed floor levels to Australian Height Datum.

X7.4 Applications for earthworks, filling of land and subdivision shall be accompanied by a survey plan (with a contour interval of 0.5m) showing relative levels to Australian Height Datum.

X7.5 For large scale developments, or developments in critical situations, particularly where an existing catchment based flood study is not available, a flood study using a fully dynamic one or two dimensional computer model may be required. For smaller developments the existing flood study may be used if available and suitable (eg it contains sufficient local detail), or otherwise a flood study prepared in a manner consistent with the "Australian Rainfall and Runoff" publication, any relevant Council Drainage Design Code and the Floodplain Development Manual, will be required. From this study, the following information shall be submitted in plan form:

(a) water surface contours (including the 100 year flood and PMF extents)

(b) velocity vectors;

(c) velocity and depth product contours;

(d) delineation of Flood Management Areas relevant to individual floodplains; and

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

This information is required for the pre-developed and post-developed scenarios.

X7.6 Where the controls for a particular development proposal require an assessment of structural soundness during potential floods, the following impacts must be addressed:

(a) hydrostatic pressure;

(b) hydrodynamic pressure;

(c) impact of debris; and

(d) buoyancy forces.

Foundations need to be included in the structural analysis.

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DICTIONARY

[Add in alphabetical order to the Dictionary of each DCP]

Adequate Warning Systems, Signage and Exits is where the following is provided:

(a) an audible and visual alarm system which alerts occupants to the need to evacuate, sufficiently prior to likely inundation to allow for the safe evacuation of pedestrians and vehicles;
(b) signage to identify the appropriate procedure and route to evacuate; and
(c) exits which are located such that pedestrians evacuating any location during any flood do not have to travel through deeper water to reach a place of refuge above the 100 year flood away from the enclosed car parking.

Australian Height Datum (AHD) is a common national plain of level corresponding approximately to mean sea level.

Average Recurrence Interval (ARI) means the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

Compensatory Works refers to earthworks where material is excavated (or "cut") from one location in the floodplain and placed (or "filled") at another location in the floodplain, with no net importation of fill material, such that the volume available for storage of flood waters is not altered for all floods.

Conveyance is a direct measure of the flow carrying capacity of a particular cross-section of a stream or stormwater channel. (For example, if the conveyance of a channel cross-section is reduced by half, then the flow carrying capacity of that channel cross-section will also be halved).

Design floor level **or** ***ground level*** means the minimum floor level that applies to the development. If the development is concessional development, this level is determined based on what land use category would apply if it was not categorised as Concessional Development.

Ecologically Sustainable Development (ESD) is using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased.

Effective warning time is 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, evacuate people and transport their possessions.

Enclosed car parking means car parking which is potentially subject to rapid inundation, which consequently increases risk to human life and property (such as basement of bunded car parking areas). The following criteria apply for the purposes of determining what is enclosed car parking:

(a) Flooding of surrounding areas may raise water levels above the perimeter which encloses the car park (normally the entrance), resulting in rapid inundation of the car park to depths greater than 0.8m, and

(b) drainage of accumulated water in the car park has an outflow discharge capacity significantly less than the potential inflow capacity.

Flood is a relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage as

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defined by the FDM before entering a watercourse.

Note: Consistent with the Floodplain Development Manual, this DCP does not apply in the circumstances of local drainage inundation as defined in the Floodplain Development Manual and determined by Council. Local drainage problems can generally be minimised by the adoption of urban building controls requiring a minimum difference between finished floor and ground levels.

Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning and evacuation procedures.

Flood compatible building components means a combination of measures incorporated in the design and/or construction and alteration of individual buildings or structures subject to flooding, and the use of flood compatible materials for the reduction or elimination of flood damage.

Note:
A list of typical flood compatible building components is provided in Schedule X1.

Flood compatible materials include those materials used in building which are resistant to damage when inundated.

Note:
A list of typical flood compatible materials is provided in Schedule X1.

Flood evacuation strategy means the proposed strategy for the evacuation of areas within effective warning time during periods of flood as specified within any policy of Council, the FRMP, the relevant SES Flood Plan, by advices received from the State Emergency Services (SES) or as determined in the assessment of individual proposals.

Flood prone land (being synonymous with ***flood liable*** and ***floodplain***) is the area of land which is subject to inundation by the probable maximum flood (PMF).

Floodplain Development Manual (FDM) refers to the document dated April 2005, published by the New South Wales Government and entitled *"Floodplain Development Manual: the management of flood liable land"*.

Floodplain Management Area means the categorisation of either Floodway or General Floodplain applicable to different parts of flood prone land.

Floodplain Risk Management Plan (FRMP) means a plan prepared for one or more floodplains in accordance with the requirements of the Floodplain Development Manual or its predecessors.

Floodplain Risk Management Study (FRMS) means a study prepared for one or more floodplains in accordance with the requirements of the Floodplain Development Manual or its predecessors.

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

Flood Storage Areas are those parts of the floodplain that are important for the temporary storage of floodwater or stormwater during a flood.

Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for a FPL is actually provided. It is a factor of safety typically used in relation to the setting of flood levels, levee crest levels, etc. (as specified at Section K5 of the FDM). Freeboard is included in the flood planning level.

General Floodplain means that part of the floodplain other than floodways or flood storage areas.

Habitable floor area means:

- in a **residential situation**: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom;

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- in an **industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

Note:
Separate considerations are specified for the car parking area of a development irrespective of the land use with which it is associated.

Hazard is a source of potential harm or a situation with a potential to cause loss. In relation to this plan, the hazard is flooding which has the potential to cause harm or loss to the community.

Infill development is development which is proposed within established existing urban area and usually involves the development of a vacant residential site, or the removal of an existing residential or retail/commercial building to provide a replacement building for a similar use.

Local drainage means small scale inundation in urban areas outside the definition of major drainage as defined in the Floodplain Development Manual. Local drainage problem invariably involve shallow depths (less than 0.3m) with generally little danger to personal safety.

Local overland flooding means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Merit approach is an approach, the principles of which are embodied in the Floodplain Development Manual which weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.

Outbuilding means a building that is ancillary to a principal residential building and includes sheds, garages, carports and similar buildings but does not include granny flats**.**

Performance criteria represent a means of assessing whether the desired outcomes will be achieved.
Prescriptive controls are preferred ways of achieving the outcome. While adherence to the prescriptive controls may be important, it is paramount that the objectives and the performance criteria are clearly satisfied.

Probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

Primary habitable floor area means the majority of habitable floor area and in a residential situation includes the majority of bedrooms, main living area, kitchen and first bathroom.

Probable maximum precipitation (PMP) is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is often the primary input to the estimation of the probable maximum flood.

Probability is a statistical measure of the expected chance of flooding (see ARI).

Raised fill pad level is a raised area of ground upon which a dwelling or ancillary buildings must be constructed on rural or other non-urban zoned lands.

Rebuilt dwelling refers to the construction of a new dwelling on an allotment where an existing dwelling is demolished.

Reliable access during a flood means the ability for people to safely evacuate an area subject to flooding, having regard to the depth and velocity of flood waters and the suitability of the evacuation route, without a need to travel through areas where water depths increase.

Risk means the chance of something happening that will have an impact. It is measured in terms of consequences and probability (likelihood). In the context of this plan, it is the likelihood of

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consequences arising from the interaction of floods, communities and the environment.

Site Emergency Response Flood Plan (not being an SES Flood Plan) is a management plan that demonstrates the ability to safely evacuate persons and include a strategy to move goods above the flood level within the available warning time. This Plan must be consistent with any relevant flood evacuation strategy, flood plan or similar plan.

Survey plan is a plan prepared by a registered surveyor which shows the information required for the assessment of an application in accordance with the provisions of this Plan.

PART X. FLOODPLAIN MANAGEMENT CONTROLS

[Include Schedule within Each DCP]

SCHEDULE X1
FLOOD COMPATIBLE MATERIALS & BUILDING COMPONENTS

BUILDING COMPONENT	FLOOD COMPATIBLE MATERIAL	BUILDING COMPONENT	FLOOD COMPATIBLE MATERIAL
Flooring and Sub-floor Structure	• concrete slab-on-ground monolith construction • suspension reinforced concrete slab.	**Doors**	• solid panel with water proof adhesives • flush door with marine ply filled with closed cell foam • painted metal construction • aluminium or galvanised steel frame
Floor Covering	• clay tiles • concrete, precast or in situ • concrete tiles • epoxy, formed-in-place • mastic flooring, formed-in-place • rubber sheets or tiles with chemical-set adhesives • silicone floors formed-in-place • vinyl sheets or tiles with chemical-set adhesive • ceramic tiles, fixed with mortar or chemical-set adhesive • asphalt tiles, fixed with water resistant adhesive	**Wall and Ceiling Linings**	• fibro-cement board • brick, face or glazed • clay tile glazed in waterproof mortar • concrete • concrete block • steel with waterproof applications • stone, natural solid or veneer, waterproof grout • glass blocks • glass • plastic sheeting or wall with waterproof adhesive
Wall Structure	• solid brickwork, blockwork, reinforced, concrete or mass concrete	**Insulation** **Windows**	• foam (closed cell types) • aluminium frame with stainless steel rollers or similar corrosion and water resistant material.
Roofing Structure (for Situations Where the Relevant Flood Level is Above the Ceiling)	• reinforced concrete construction • galvanised metal construction	**Nails, Bolts, Hinges and Fittings**	• brass, nylon or stainless steel • removable pin hinges • hot dipped galvanised steel wire, nails or similar.

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Electrical and Mechanical Equipment For dwellings constructed on land to which this Plan applies, the electrical and mechanical materials, equipment and installation should conform to the following requirements.	**Heating and Air Conditioning Systems** Heating and air conditioning systems should, to the maximum extent possible, be installed in areas and spaces of the house above the relevant flood level. When this is not feasible every precaution should be taken to minimise the damage caused by submersion according to the following guidelines.
Main power supply - Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, shall be located above the relevant flood level. Means shall be available to easily disconnect the dwelling from the main power supply.	**Fuel -** Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.
Wiring - All wiring, power outlets, switches, etc., should, to the maximum extent possible, be located above the relevant flood level. All electrical wiring installed below the relevant flood level should be suitable for continuous submergence in water and should contain no fibrous components. Earth core linkage systems (or safety switches) are to be installed. Only submersible-type splices should be used below the relevant flood level. All conduits located below the relevant designated flood level should be so installed that they will be self-draining if subjected to flooding.	**Installation -** The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to an elevation of 600 millimetres above the relevant flood level.
Equipment - All equipment installed below or partially below the relevant flood level should be capable of disconnection by a single plug and socket assembly.	**Ducting -** All ductwork located below the relevant flood level should be provided with openings for drainage and cleaning. Self draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a water-tight wall or floor below the relevant flood level, the ductwork should be protected by a closure assembly operated from above relevant flood level.
Reconnection - Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.	**Ancillary Structures (steps, pergolas, etc.) -** Suitable water tolerant materials should be used such as masonry sealed hardwood and corrosive resistant metals. Copper Chrome Arsenate (CCA) treated timber is not a suitable material.

PART X. FLOODPLAIN MANAGEMENT CONTROLS

[Include schedule with relevant categories in each DCP]

SCHEDULE X2
LAND USE CATEGORIES

Critical Uses and Facilities	Sensitive Uses and Facilities	Urban Residential & Associated Uses	Rural Residential and Associated Uses
Public administration building or public hall that may provide an important contribution to the notification or evacuation of the community during flood events (e.g. SES Headquarters and Police Stations); Hospitals.	Community facility; telecommunications facility; Institutions; Educational establishments; Liquid fuel depot; Public utility (including electricity generating works and utility installations) undertakings which are essential to evacuation during periods of flood or if affected would unreasonably affect the ability of the community to return to normal activities after flood events, residential care facility, school and seniors housing.	Backpackers' accommodation; bed and breakfast accommodation; boarding house; caravan park; child care centre; correctional centre; dual occupancy; duplex cluster housing; dwelling; dwelling house; group home; home-based child care centre or family day care home; home business; home industry; home occupancy; home occupation (sex services); hostel; hotel accommodation; moveable dwelling; multi dwelling housing; neighbourhood shop; permanent group home; place of public worship; public hall (other than critical uses and facilities); residential flat building; serviced apartments; tourist and visitor accommodation; transitional group home and utility installations (other than critical uses and facilities).	Backpacker's accommodation; bed and breakfast accommodation; caravan park; child care centre; correctional centre; dual occupancy; dwelling; dwelling house; home-based child care or family day care home; home business; home industry; home occupation; home occupation (sex services); moveable dwelling; neighbourhood shop; place of public worship; public hall and public utilities (other than critical uses and facilities); tourist and visitor accommodation and utility installations (other than critical uses and facilities).

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Commercial or Industrial	Rural	Open Space and Environmental Protection	Concessional Development
Airport; amusement centre; bulky goods premises; business premises; caravan park; child care centre; community facility (other than critical and sensitive uses and facilities); depot; entertainment facility; food and drink premises; freight transport facility; function centre; funeral chapel; funeral home; hazardous industry; hazardous storage establishment; health care professional; health consulting rooms; heavy industry; heliport; industry; liquid fuel depot; light industry; market; materials recycling or recovery centre; medical centre; mixed use development; offensive industry; offensive storage establishment; office premises; passenger transport facility; place of public worship; public hall (other than critical uses and facilities); recreation facility (major); registered club; restaurant; restricted premises; retail premises; service station; sex services premises; shop top housing; standard industry; take away food or drink premises; timber and building	Agricultural produce industry; agriculture; animal boarding or training establishment; backpackers' accommodation, bed and breakfast accommodation; biosolid waste application; caravan park; cellar door premises; child care centre; correctional centre; dwelling; dwelling house; extensive agriculture; extractive industry; farm building; forestry; helipad; home-based child care or family day care home; home business; home industry; home occupation; home occupation (sex services); horticulture; intensive livestock agriculture; landscape and garden supplies; market; materials recycling or recovery centre; mining; moveable dwelling; neighbourhood shop; place of public worship; public hall (other than critical uses and facilities); restricted diary; restriction facilities; roadside stall; rural industry; rural worker's dwelling; sawmill or log processing works; stock and sale yard; tourist and visitor accommodation; turf framing; waste	Caravan park; charter and tourism boating facility; environmental facility; environmental protection works; information and education facility; kiosk; moveable dwelling; recreation area; recreation facility (indoor); recreational facility (outdoor) and utility installations (other than critical uses and facilities).	In the case of residential development: An addition or alteration to an existing dwelling of not more than 10% or 30m^2 (whichever is the lesser) of the habitable floor area which existed at the date of commencement of this Plan; The construction of an outbuilding with a maximum floor area of 30m^2; or Rebuilt dwellings which substantially reduce the extent of flood affectation to the existing building; (b) In the case of other development: (i) An addition to existing buildings of not more than additional 100m^2 or 10% of the floor area which existed at the date of commencement of this DCP (whichever is the lesser); (ii) Rebuilding of a development which substantially reduces the extent of flood effects to the existing development; A change of use which does not increase flood risk having regard to property damage and personal safety; or Subdivision that does not involve the creation of new

PART X. FLOODPLAIN MANAGEMENT CONTROLS

Commercial or Industrial	Rural	Open Space and Environmental Protection	Concessional Development
supplies; transport depot; truck depot; vehicle body repair workshop; vehicle repair station; vehicle showroom; veterinary hospital; warehouse or distribution centre and utility installations (other than critical uses and facilities).	disposal land fill operation; waste management facility and Utility installations (other than critical uses and facilities).		allotments with potential for further development.

Schedule X3

Grafton (North & South) Floodplain

Precriptive Controls (Refer to clause X3.2)

Planning Consideration	Floodplain Management Area: General Floodplain – Critical Uses & Facilities	Sensitive Uses & Facilities	Urban Residential & Associated Uses	Rural Residential & Associated Uses	Commercial & Industrial	Rural	Open Space & Environmental Protection	Concessional Development	Floodway – Critical Uses & Facilities	Sensitive Uses & Facilities	Urban Residential & Associated Uses	Rural Residential & Associated Uses	Commercial & Industrial	Rural	Open Space & Environmental Protection	Concessional Development
Floor & Pad Levels	6	1,5	1,2	1,2,4	1,2	1,2,4	1	1,3							1	1,3
Building Components	1	1	1	1	1	1	1	1							1	1
Structural Soundness	3	1	2	2	2	2	2	2							1	1
Flood Effects	2	2	2	2	2	2	2	2							1	1
Evacuation	3,5	1,3 or 3,5	1,3 or 3,5	1,3 or 2,3	1,3 or 3,6	1,3 or 3,6	1,3 or 3,6	1,3 or 2,3 or 3,4,6							1,3 or 3,6	1,3 or 2,3 or 3,4,6
Management & Design	1,2,3,4	1,2,3,4	1,2	1,2	1,2,3,4	1	1,2,3	1,2							1,2	1,2

COLOUR LEGEND: Controls specifically applicable to this DCP; Unsuitable Land Use

General Notes

1	Freeboard equals an additional height of 500mm.
2	The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.
3	Filling of the site, where acceptable to Council, may change the Flood Management Area considered to determine the controls applied in the circumstances of individual applications. Refer to clauses providing specific controls on filling in floodplains.
4	Refer to separate recommended Model DCP clause for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and Structural Soundness planning considerations of the applicable landuse category.
5	Refer to separate recommended Model DCP clause for special considerations for properties identified for voluntary acquisition.
6	The proposed subdivision of flood liable land which creates allotments with potential for further development must be able to demonstrate that the allotments are capable of being developed in compliance with the relevant controls below. Refer to control No. 1 of the Management and design provision. Reference should also be made to other provisions of the DCP which relate specifically to subdivision.
7	Terms in italics are to be defined in the glossary of the DCP and the attached Schedule X2 specifies development types included in each land use category. These development types are generally as defined within the Template LEP
8	Where the site is protected by a levee, the "100 year flood level" quoted below refers to the flood level if the levee was removed (i.e. the River level adjacent to the site).

Floor & Pad Levels

1	Unless otherwise specified all floor levels to be no lower than the 5 year flood level plus freeboard unless justified by site specific assessment.
2	*Primary habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*. The *primary habitable floor* levels for *infill development* in Grafton, South Grafton and the Heber Street Catchment may be reduced to no lower than 6.4, 7.1 and 8.0 metres AHD respectively where the development (i) would be otherwise incompatible in the streetscape; (ii) result in unacceptable visual, overlooking or overshadowing impacts on ajoining properties; or is not part of a larger proposal which does not need to conform with the height and character of existing surrounding development. If this level is impractical for an infill development in a Business zone, the floor level should be as high as possible.
3	Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.
4	Ground level or a *raised fill pad level* with a surface level equal to or greater than the 100 year flood level. Signage, unique to each property, is required to allow aerial identification.
5	*Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
6	*Habitable floor* levels to be no lower than the *PMF* level. Non-*habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.

Building Components & Method

1	All structures to have *flood compatible building components* below the design level of the *primary habitable floor* level.

Structural Soundness

1	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below).
2	Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
3	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*.

Flood Effects

1	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood to a publicly accessible location above the PMF.
2	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level.
3	The development is to be consistent with any relevant *flood evacuation strategy, Flood Plan adopted by Council* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Safe and orderly evacuation of the site (in any size flood) has been demonstrated in a regional evacuation capability assessment prepared to the satisfaction of Council and the SES. Where such an assessment has not been prepared, development will only be permitted where, in the opinion of Council, safe and orderly evacuation can occur (in any size flood).
6	Adequate flood warning is available to allow safe and orderly evacuation (in any size flood) without increased reliance upon the SES or other authorised emergency services personnel.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.
2	*Site Emergency Response Flood Plan* required where floor levels are below the *design floor level,* (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year flood level plus *freeboard.*
4	No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.

Schedule X4

Lower Clarence River Floodplain & Other Floodplains

Precriptive Controls (Refer to clause X3.2)

Planning Consideration	Floodplain Management Area: General Floodplain – Critical Uses & Facilities	Sensitive Uses & Facilities	Urban Residential & Associated Uses	Rural Residential & Associated Uses	Commercial & Industrial	Rural	Open Space & Environmental Protection	Concessional Development	Floodway – Critical Uses & Facilities	Sensitive Uses & Facilities	Urban Residential & Associated Uses	Rural Residential & Associated Uses	Commercial & Industrial	Rural	Open Space & Environmental Protection	Concessional Development
Floor & Pad Levels		1,5	1,2	1,2,4	1,2	1,2,4	1	1,3							1	1,3
Building Components		1	1	1	1	1	1	1							1	1
Structural Soundness		1	2	2	2	2	2	2							1	1
Flood Effects		2	2	2	2	2	2	2							1	1
Evacuation		1,3 or 3,5	1,3 or 3,5	1,3 or 2,3	1,3 or 3,6	1,3 or 3,6	1,3 or 3,6	1,3 or 2,3 or 3,4,6							1,3 or 3,6	1
Management & Design		1,2,3,4	1,2	1,2	1,2,3,4	1	1,2,3	1,2							1,2	1,2

COLOUR LEGEND: Controls specifically applicable to this DCP; Unsuitable Land Use

General Notes

1	Freeboard equals an additional height of 500mm.
2	The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.
3	Filling of the site, where acceptable to Council, may change the Flood Management Area considered to determine the controls applied in the circumstances of individual applications. Refer to clauses providing specific controls on filling in floodplains.
4	Refer to separate recommended Model DCP clause for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and Structural Soundness planning considerations of the applicable landuse category.
5	Refer to separate recommended Model DCP clause for special considerations for properties identified for voluntary acquisition.
6	The proposed subdivision of flood liable land which creates allotments with potential for further development must be able to demonstrate that the allotments are capable of being developed in compliance with the relevant controls below. Refer to control No. 1 of the Management and design provision. Reference should also be made to other provisions of the DCP which relate specifically to subdivision.
7	Terms in italics are to be defined in the glossary of the DCP and the attached Schedule X2 specifies development types included in each land use category. These development types are generally as defined within the Template LEP
8	Where the site is protected by a levee, the "100 year flood level" quoted below refers to the flood level if the levee was removed (i.e. the River level adjacent to the site).

Floor & Pad Levels

1	Unless otherwise specified all floor levels to be no lower than the 5 year flood level plus freeboard unless justified by site specific assessment.
2	*Primary habitable floor levels* to be no lower than the 100 year flood level plus freeboard. If this level is impractical for an infill development in a Business zone, the floor level should be as high as possible.
3	Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.
4	Ground level or a *raised fill pad level* with a surface level equal to or greater than the 100 year flood level. Signage, unique to each property, is required to allow aerial identification.
5	*Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
6	*Habitable floor* levels to be no lower than the *PMF* level. Non-*habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.

Building Components & Method

1	All structures to have *flood compatible building components* below the design level of the *primary habitable floor* level.

Structural Soundness

1	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below).
2	Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
3	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*.

Flood Effects

1	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood to a publicly accessible location above the PMF.
2	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level.
3	The development is to be consistent with any relevant *flood evacuation strategy, Flood Plan adopted by Council* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Safe and orderly evacuation of the site (in any size flood) has been demonstrated in a regional evacuation capability assessment prepared to the satisfaction of Council and the SES. Where such an assessment has not been prepared, development will only be permitted where, in the opinion of Council, safe and orderly evacuation can occur (in any size flood).
6	Adequate flood warning is available to allow safe and orderly evacuation (in any size flood) without increased reliance upon the SES or other authorised emergency services personnel.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.
2	*Site Emergency Response Flood Plan* required where floor levels are below the *design floor level,* (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year flood level plus *freeboard.*
4	No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.

APPENDIX C

PUBLIC RESPONSE FROM DRAFT PLAN

GRAFTON & LOWER CLARENCE FLOODPLAIN RISK MANAGEMENT PLAN
PUBLIC RESPONSE FROM DRAFT PLAN

A draft copy of the Grafton and Lower Clarence Floodplain Risk Management Plan was placed on public exhibition from October 2006 to December 2006.

A public meeting was held on 27th November 2006, in which the consultant provided an overview of the study and provided details of the recommended floodplain management measures included in the Plan. A feedback form was also provided to help collate comments from the public regarding the draft Plan.

Issues Raised at Public Meeting

The majority of issues raised at the public meeting concerned flooding at Brushgrove, and that a previous proposal for a levee had not been included in the recommended Plan. Discussions included:

- the frequency of flooding within the village;
- health concerns over septic overflows, silt and debris;
- flood warning and evacuation difficulties;
- the height of previous levee proposals;
- advantages and disadvantages of different levee proposals.

Other discussions elsewhere in the Valley concerned:

- the impact of the proposed highway upgrade on flood behaviour;
- the impact of levee banks and other structure on flood behaviour;
- evacuation difficulties for Grafton and other communities;
- consideration of dredging parts of the river to reduce flooding problems.

Public Submissions Received

A total of 63 public submissions were received. This included a group submission from 50 residents of Brushgrove, and 13 other individual submissions.

<u>Submissions other than Brushgrove</u>

Only 3 submissions raised issues that weren't related to Brushgrove. These issues include:

- concern over the impact of the proposed highway upgrade on flood behaviour;
- concern that levees and other structures restrict floodwater and create siltation problems within the river;
- the desirability to dredge shallow spots in the river, including Munro Island between Southgate and Woodford;
- that evacuation of Grafton would be a most timely exercise;
- that the community needs to be prepared to withstand the effects of flooding, low houses should be raised, and assistance provided to those that need it.

Group Submission from Brushgrove

Feedback forms were submitted from 50 residents in the group submission from Brushgrove. All forms indicated (by ticking) that:

(1) they do not support the recommended Floodplain Management Measures;

(2) further consideration should be given to measures that are not recommended;

(3) other measures that have not been considered should be investigated.

Support for a levee at Brushgrove was indicated in 26 of these submissions. Preference for a higher levee was also indicated in 8 of the 26 submissions that favoured a levee. Other comments include:

concern that the levee previously proposed by Maclean Shire Council for Brushgrove had not been constructed or further pursued;

concern over septic overflow, silt & debris that occurs frequently from flooding;

that there is a health hazard in the village following floods;

that there are elderly people in the village who are unable to evacuate or help themselves during floods;

that raising houses does nothing to reduce flooding in the village.

Individual Submissions concerning Brushgrove

Individual submissions concerning Brushgrove were submitted by 11 residents. Of these, 2 submissions were in support of a levee and 9 submissions were against a levee. House raising was also noted as a preferred measure in 5 of the submissions. Other comments include:

concern that numerous studies have recommended against a levee at Brushgrove, yet investigations continue on this issue;

concern that council approved the construction of a levee contrary to recommendations provided in previous floodplain management plans;

concern over catastrophic flooding in extreme floods that overtop the levee;

internal drainage problems if levees are built, unless pumps are also included;

signs showing the “proposed height of levee” at Brushgrove should be removed;

overflow of sewerage in Brushgrove during floods is a major health problem;

Council should investigate means of reducing septic overflows in the Village;

Grafton Street should be raised to improve flood access to the Brushgrove bridge.

Consultant Response

No responses were received concerning the risk of overtopping of the Grafton, South Grafton or Maclean levees, apart from a single observation that evacuating Grafton would be a most timely exercise. This is a disappointing result given the magnitude of this flood risk and highlights the need to alert these communities to the risk and consequences of levee overtopping. Proposals for increasing community awareness are included in the Plan.

Some general comments were provided about the impact of levee banks and other structures (including the proposed highway upgrade) on flood behaviour. It is agreed that

any structure within the floodplain can impact on flood behaviour. The proposed floodplain management controls that are included in the Plan will help to ensure that flooding impacts of all proposals in the floodplain are properly considered. The proposed highway is subject to separate investigations.

Suggestions were made concerning dredging the river, with particular reference to Munro Island. This was previously investigated as part of the Lawrence Area Floodplain Management Study (WBM, 1998). It was concluded that the partial removal of Munro Island (to match conditions shown on an 1894 survey) would have only a minor impact on flood levels in the area.

The omission of a levee for Brushgrove from the draft Plan generated by far the greatest public response, both from those people that favoured a levee and those people that were against a levee. Accurate numbers for and against are difficult to ascertain. Although the group submission indicated that all 50 respondents did not support the recommended measures, only 24 of those specifically mentioned support for a levee. From the 11 individual submissions, 2 supported the levee and 9 opposed it. One resident also noted that there were additional people opposed to the levee who would not have responded as the levee had not been recommended in the draft plan. Despite these difficulties, it is still apparent that there is some division within the community concerning support for a levee. The only way to get a precise indication of community support would be for an independent party to individually poll each household.

There also appears to be some confusion over the height of the levee that had been proposed by Maclean Council. Some residents have referred to the adoption of a 30 or 33 year levee at a Council meeting of 11th July 2001. However, minutes from that meeting notes that Council adopted the following recommendation:

> *"That Council …..Confirm the preferred option as being the construction of a 20%* [ie 5 year] *levee with a minimum crest level of 4.1m AHD, with some allowance for a freeboard being made that will have minimal impact on the properties affected…."*

Reference to a 33 year levee possibly comes from the report on the "Assessment of Brushgrove Floodplain Management Options (Webb, McKeown & Associates, June 2001) which notes:

> *"Of the three alternative levee options the 10% levee is the least favoured…..The 3%* [ie 33 year] *levee appears to provide better value for money….but the 1% levee scores better when all the intangible (social and environmental) issues are taken into consideration.*

An appendix to the 2001 report includes the assessment of the 20% levee with no freeboard. It was noted that this option had the lowest benefit/cost ratio (at 0.05) and it was unlikely that it would obtain government support and/or funding. The report also concludes that:

> *"implementation of a house raising scheme is the most affordable and practical solution to reduce the costs of flooding to the community."*

Reasons for the lower levee appear to be based on minimising any adverse flooding impacts to homes at Cowper, and possibly also to reduce the visual impact of the levee on the Village.

All of the levee options that have been investigated for Brushgrove have benefit-cost ratios considerably less than 1.0, making them difficult to justify from an economic viewpoint. The highest levee option (the 100 year levee) is more favourable than the other levee options, but its benefit-cost ratio is still less than 1.0 and the increased height introduces a number of

other concerns, particularly the potential impact on flood behaviour and the visual impact of a high levee.

There are other concerns that a levee, particularly a high levee, would encourage residents to remain in their homes during future floods rather than evacuating the area. When the levee does overtop, or fails, those residents will be stranded in an area subject to extreme flood hazard. Community complacency of these flooding risks will also increase as the time since the last flood to inundate the village increases.

Previous studies have concluded that a levee at Brushgrove is difficult to justify or is unlikely to attract Government support or funding. Recent requests from Council to secure funding for a levee at Brushgrove have also been unsuccessful. Nevertheless, residents have expressed a continuing concern over septic overflows and health risks from frequent flooding. An investigation into other means of addressing these concerns, apart from the construction of a levee, is recommended and could be included as part of the floodplain management plan.

Whilst raising the lowest houses at Brushgrove will reduce property damage, improved warning and evacuation procedures are imperative for the safety of residents on this island. These measures are already endorsed in the floodplain management plan.

A suggestion has been made to raise Grafton Street to improve flood access to the Brushgrove Bridge. This is a good suggestion which warrants further consideration. A feasibility investigation, and subsequent implementation if positive, is recommended for inclusion in the floodplain management plan.