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ACHIEVING A
HAWKESBURY-NEPEAN
FLOODPLAIN
MANAGEMENT STRATEGY

*A Report prepared by the
Hawkesbury-Nepean
Flood Management Advisory Committee*

November 1997

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Hawkesbury-Nepean Flood Management Advisory
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Letter of Submission

FOREWORD

SUMMARY

The NSW Government established the Hawkesbury-Nepean Flood Management Advisory Committee in April 1997, to prepare a comprehensive strategy for floodplain management to address a serious flood problem in areas of the Hawkesbury-Nepean valley downstream of Warragamba Dam. Such a strategy would complement the Government's proposal to construct an auxiliary spillway to eliminate the threat of failure of the Dam in an extreme flood.

The Government has sought advice on a comprehensive strategy which it considers essential to enable all levels of government and the wider community to recognise more fully and respond more appropriately to the range of risks associated with flooding in the valley.

Accordingly, the Committee proposes an achievable Hawkesbury-Nepean Floodplain Management Strategy in this Report, which has the following structure:

- | | |
|---|---|
| Introduction | <ul style="list-style-type: none">• Establishment of Committee and Terms of Reference• Committee's Work Program and Consultants' Studies |
| Policy Background | <ul style="list-style-type: none">• Planning History and NSW Flood Policy• SES Responsibilities• Ministry of Urban Infrastructure Management |
| Flood Management Implications of Warragamba Dam | <ul style="list-style-type: none">• Assessment of Flood Impacts in the Valley• Auxiliary Spillway and Dam Gate Operations |
| Flood Hazard and its Management | <ul style="list-style-type: none">• Consequences of Flooding and Application of NSW Flood Policy• Need for Regional Floodplain Management Strategy |
| Consultants' Studies | <ul style="list-style-type: none">• Impacts of Flooding on Communities and Infrastructure• Engineering Studies to Modify Flood Behaviour• Land Use Planning and Development Control Measures• Emergency Response Planning and Traffic Infrastructure |
| Hawkesbury-Nepean Floodplain Management Strategy | <ul style="list-style-type: none">• Strategy Components and Regional Floodplain Management Study• Regional Works, and Policy and Planning Initiatives |
| Recommendations to Implement the Strategy | <ul style="list-style-type: none">• Strategy Components of Immediate, High and Lower Priority• Completion of Strategy Components and Regional Floodplain Management Study• Co-ordination of Local Floodplain Management Plans• Funding of the Strategy• Recommendations No.s 1 to 4 |

The Committee's Recommendations to the State Government address:

No.1:	Adoption of the Hawkesbury-Nepcan Floodplain Management Strategy;
No.2:	Establishment of a Steering Committee to co-ordinate and monitor implementation of the Strategy;
No.3:	Inclusion of an advisory regional co-ordination role relating to the preparation of each local Council's flood management plan; and
No.4:	Endorsement of funding of the Strategy in three stages, the current 1997/98 financial year, a five year program 1998/99 to 2002/03, and beyond 2003.

The Report is submitted to the Minister for Land and Water Conservation, the Hon Kim Yeadon MP; the Minister for Urban Affairs and Planning, and Minister for Housing, the Hon Craig Knowles MP; and the Minister for Emergency Services, and Minister for Corrective Services, the Hon Bob Debus MP, for their consideration and the subsequent determination of the Report's Recommendations by the State Government.

ACKNOWLEDGMENTS

The Committee thanks the General Managers of participating Councils and the Chief Executive Officers of the Hawkesbury-Nepean Catchment Management Trust and the Penrith Lakes Development Corporation for the use of their premises for the Committee's meetings.

The Committee also thanks the Department of Land and Water Conservation for its accommodation of the Project Team Secretariat and for the provision of its support services.

The Committee expresses its appreciation of the advice given by the following individual Consultants, whose firms were commissioned to undertake specialist studies:

- Dr Jeris Danielson, President, Danielson and Associates Inc., Colorado, USA;
- Mr Bruce Druery, Principal, Patterson Britton and Partners Pty Ltd;
- Mr David McConnell, Principal, Patterson Britton Partners Pty Ltd;
- Mr Chris Wilson, Principal, Masson and Wilson Pty Ltd;
- Mr Steve Webb, Director, Webb McKeown and Associates Pty Ltd;
- Mr Mark Babister, Senior Engineer, Webb McKeown and Associates Pty Ltd;
- Mr Drew Bewsher, Director, Bewsher Consulting; and
- Mr Paul Grech, Director, Don Fox Planning.

The Committee particularly thanks the following staff of the Project Team Secretariat for their advice and efficient management of the Committee's work program:

- Mr Arthur Low, Project Manager, Department of Land and Water Conservation;
- Ms Julie Conlon, Senior Environmental Planner, Department of Urban Affairs and Planning;
- Mr Stephen Opper, State Planning Co-ordinator, State Emergency Service;
- Mr John Murtagh, Civil Engineer, Department of Public Works and Services / Department of Land and Water Conservation; and
- Mr Erin Sellers, Environmental Engineer, Department of Public Works and Services / Department of Land and Water Conservation.

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Chapter 1 INTRODUCTION

1.1 ESTABLISHMENT OF THE COMMITTEE

The Hon Kim Yeadon MP, Minister for Land and Water Conservation, the Hon Craig Knowles MP, Minister for Urban Affairs and Planning and Minister for Housing, and the Hon Bob Debus MP, Minister for Emergency Services and Minister for Corrective Services announced, in April, 1997, the establishment of the Hawkesbury-Nepean Flood Management Advisory Committee (*the Committee*).

The Committee's purpose was to address a serious flood problem in areas of the Hawkesbury-Nepean valley downstream of Warragamba Dam. This was to be undertaken in a comprehensive manner in accordance with the NSW State Government's current merits based Flood Policy and to complement the proposal to construct an auxiliary spillway to protect Warragamba Dam against failure in an extreme flood.

Mr Yeadon, in addressing the Committee's inaugural meeting in May, 1997, stated:

"The Government appreciates that for this valley, an integrated plan will be difficult to achieve. Responsibilities are spread amongst many authorities and councils and the communities themselves can be very diverse. Of course, there is the large range of flooding to consider.

The complexity of the work involved also adds to a need for a higher degree of co-operation and co-ordination among the key stakeholders than might be required elsewhere.

The Government recognises these factors and has established this high level Committee to consolidate common goals and direction."

1.2 THE COMMITTEE'S TERMS OF REFERENCE

The Terms of Reference of the Committee were as announced by the above Ministers, are as follows:

- commission and oversight technical studies necessary for flood mitigation planning;
- act as a focal point for integrating agency, local government and community input to the technical studies;
- provide preliminary advice on measures to address the results of the technical studies in terms of existing and future development planning, emergency services planning and other matters. As part of this, examine options for mechanisms such as local government development controls, use of Regional Environmental Plans, one Floodplain Management Plan and Local Floodplain Management Plans;
- advise the community on the results and interpretation of the technical studies; and
- develop options for further work and matters to be considered for the Cabinet Committee's consideration.

1.3 THE COMMITTEE'S TASKS

To fulfill its Terms of Reference, for which the primary objective is to prepare a comprehensive strategy for floodplain management in the valley, the Committee set the following tasks:

- ◆ existing information, advice from government agencies and community representatives and supplementary studies were to be used to identify strategy components which would be effective throughout the entire range of flooding, without inappropriately restricting development;
- ◆ the Committee's recommended strategy was to be consistent with existing legislation and the merits approach of the State Government's Flood Policy and should provide a regional basis for the preparation of local floodplain management plans and policies by local Councils; and
- ◆ a report was to be provided by end of November, 1997, in a format suitable for public release. [Such release is now anticipated in December, 1997, in view of the Ministers' advice that it may be appropriate to obtain public comment shortly after their receipt of this Report.]

The Committee defined the principal study area as that part of the Hawkesbury-Nepean valley downstream of Warragamba Dam, including the creek and river catchments which are potentially affected by mainstream Hawkesbury-Nepean River flooding (Figure 1.1 and 1.2). The downstream limit of the study area is Spencer. The Committee's assessment of issues, conclusions and recommendations otherwise generally relate to the six local government areas represented on the Committee.

The Committee's program for undertaking the above tasks included seven meetings between May and November, 1997. These were held in the premises of Baulkham Hills Shire Council, Blacktown City Council, Hawkesbury City Council, Penrith City Council, Hawkesbury-Nepean Catchment Management Trust and Penrith Lakes Development Corporation.

1.4 MEMBERSHIP OF THE COMMITTEE

The following persons were appointed by the State Government as members of the Committee:

Mr Graham Andrews, FRAPI, MRTPI	Chairman (part time)
Mr Frank Braybrooks	Community Representative (Cattai)
Ms Kerri Foulds	Community Representative (Richmond)
Mr Malcolm McEwan	Community Representative (Windsor)
Cr Kevin Cramer	Mayor, Penrith City Council *
Cr Meagan Lawson	Hawkesbury City Council *
Cr Alan Pendleton	Blacktown City Council *
Cr Les Sheather	Hawkesbury City Council *
Cr Les Shore	Baulkham Hills Shire Council *
Cr Robert Bell	Gosford City Council
Cr Margaret McMurray (until September, 1997)	Hornsby Shire Council

* Nominee of Western Sydney Region Organisation of Councils (WSROC)

Mr Peter McGhee	Trustee, Hawkesbury-Nepean Catchment Management Trust
Mr Ian Campbell	Assistant Director General, Department of Urban Affairs and Planning
Mr Mike Geary (from October, 1997)	Acting Executive Director, Sustainable Land and Coastal Management, Department of Land and Water Conservation
Dr Chas Keys	Deputy Director General, State Emergency Service
Mr David Papps (until September, 1997)	Acting Deputy Director General, Natural Resource Management, Department of Land and Water Conservation
Mr Ed Sanchez	Manager, Sydney Development Services, Roads and Traffic Authority
Mr Alan Dodds (Observer)	Manager, Strategic Resources Planning, Sydney Water Corporation

When addressing the Committee, Mr Yeadon said further that:

".....the Government sought nominations from major stakeholders and the community at large. The selection of representatives was regarded as a very important part of the process.

The representation on the Committee provides an opportunity for strong interaction and pooling of resources and experience to achieve floodplain management goals with very positive outcomes for the valley."

1.5 THE PROJECT TEAM SECRETARIAT

The Project Team Secretariat was established to assist the Committee and manage its comprehensive work program. The Secretariat comprised a team of specialist personnel drawn from the Department of Land and Water Conservation, the Department of Urban Affairs and Planning, the State Emergency Service, and the Department of Public Works and Services.

1.6 BACKGROUND DOCUMENTS

Whilst the Project Team Secretariat arranged for consultants to undertake a series of technical studies and investigations, as explained next in Section 1.7 and as discussed further in Chapter 5 of this Report, the Secretariat also provided the Committee with background briefing papers and supplementary study reports to clarify the context of the Committee's work program, as follows:

- ◆ **Background Discussion Paper:** This paper provided a brief outline of the early development of the valley; discussed the evolution of floodplain management in NSW from the 1817 declaration of the five "Macquarie Towns" to the adoption of the NSW Government's Flood Policy based on the "Merits Approach", as set out in the Floodplain Development Manual 1986; highlighted the central flood management issues for the Hawkesbury-Nepean valley and the State Government's progressive strategies for their resolution.

- ◆ **Review of the Floodplain Development Manual:** The Committee was informed about the current review of the Manual which is expected to lead to a revised document provisionally entitled the "Draft Floodplain Management Manual", relevant extracts from which were also provided for the Committee's guidance.
- ◆ **Regional Planning Studies:** This paper informed the Committee about the evolution of regional metropolitan strategy planning in the Sydney region with particular reference to planning in the Hawkesbury-Nepean valley and its implications for the strategy to be developed by the Committee.
- ◆ **Flood Emergency Plans:** This paper informed the Committee about the current management arrangements for flood response operations for floods of all possible severities in the Hawkesbury-Nepean valley below Warragamba Dam. It briefly outlined key responsibilities and actions under the plans and noted that the plans are scheduled for review beginning in late 1997.
- ◆ **Role of the Bureau of Meteorology NSW Hydrology Section:** The Bureau of Meteorology provided a brief document describing the NSW Hydrology Section; its role in the provision of flood forecasts; and the types of flood forecasts provided to the State Emergency Service.
- ◆ **Summary of Completed Flood Studies in the Valley:** This paper outlined the history of flood studies undertaken by Sydney Water and the Department of Land and Water Conservation and was presented to inform the Committee about the contemporary state of technical understanding of flood behaviour in the valley.
- ◆ **"Proposed Warragamba Flood Mitigation Dam Environmental Impact Statement" and "Proposed Warragamba Dam Auxiliary Spillway Environmental Impact Statement":** Complete sets of both of the EIS documents were provided to interested members of the Committee.
- ◆ **Overview of submissions made to Sydney Water relating to the Warragamba Dam Auxiliary Spillway EIS:** This paper informed the Committee about the key issues raised in responses to the EIS documents as a means of gauging public views on flooding.
- ◆ **Warragamba Dam Gate Operations:** This paper informed the Committee about gate operations and the results of investigations into their use for flood mitigation purposes. It summarised the findings of a 1996 report on gate operations prepared by SMEC Australia Pty Ltd which indicated that alternative gate operations may be beneficial in reducing downstream flood levels and that options will be further investigated. However, the paper also suggested that any reduction in peak flood levels obtained is likely to result in reduced evacuation time.
- ◆ **A Review of Public Awareness of Flooding in the Hawkesbury-Nepean Rivers' Catchment:** This paper informed the Committee about contemporary actions on behalf of the State Government to create public awareness of flooding in the valley. The paper briefly discussed dam safety issues relating to Warragamba Dam; the State Government's preferred option for ensuring dam security; the history of flooding in the valley; the potential scale of flooding in the event of dam failure; the effectiveness of the proposed auxiliary spillway in reducing flood damages by preventing dam failure; and the various programs of public consultation and awareness which have been undertaken in the valley to date, including those of the inter-agency Hawkesbury-Nepean Valley Flood Awareness Committee.

The paper also identified steps for public consultation by Committee members during September and October, 1997, followed by the recommended public exhibition of the Committee's report (*after its receipt by the Government in November, 1997*) and a supplementary report on public submissions in early 1998. The Committee resolved to so advise the Ministers, who later responded that public comment may be sought shortly after their receipt of the Report.

- ◆ **Application of Risk Management to the Hawkesbury-Nepean Floodplains:** This paper discussed hazards associated with floodplains; the quantification of flood hazards; the difference between hazard and risk; quantification of foreseeable flood risks; available responses to risk; communicating risks; and community expectations. It outlined a risk management approach to floodplain management so as to achieve outcomes acceptable to the community.
- ◆ **Flood Insurance for Residential Properties:** This paper (*by Mr G. C. Jones FAII, FAIM, FAICD*) informed the Committee about the current status of flood insurance for residential properties. It discussed the nature of flooding and damages caused on a national scale; the public attitude to flooding and insurance; the insurance industry definition of flood; the criteria for insurability; the availability of flood data and damage reduction measures; and relief payments. The paper concluded that whilst flood insurance for residential properties generally is not currently generally available, there is scope for its provision if property holders, governments and the insurance industry all appropriately fulfil their responsibilities. Residential flood insurance is however not expected to become universally available in the foreseeable future.
- ◆ **Urban Flood Damage Under Greenhouse Conditions: What Does It Mean For Policy?:** Mr D. I Smith (*Senior Fellow, ANU*) provided copies of his paper, presented to the Climate Change and Water Resources Asia - Pacific 97 Conference, for the Committee's information. The paper briefly outlines research to date and discusses three case studies including the Hawkesbury-Nepean valley. The methodology used to estimate flood behaviour and damage is outlined and results for various scenarios are presented.

1.7 CONSULTANTS' STUDIES

Consultants were commissioned to undertake the following specialist technical studies to assist the Committee in preparing its Hawkesbury-Nepean Flood Management Strategy:

- ◆ "Impacts of Flooding on Communities and Infrastructure" undertaken by Molino Stewart Environmental Services
- ◆ "Engineering Studies to Modify Flood Behaviour" undertaken by Webb McKeown and Associates Pty Ltd
- ◆ "Land Use Planning and Development Control Measures" undertaken by Don Fox Planning and Bewsher Consulting
- ◆ "Emergency Response Planning and Traffic Infrastructure" undertaken by Danielson and Associates Inc., Colorado USA in association with Patterson Britton & Partners Pty Ltd and Masson & Wilson Pty Ltd

The Committee drew upon the data and detailed findings presented in the above studies when preparing this Report. Copies of the summaries and/or recommendations of each of the above Consultant's Reports are contained respectively in **Appendices A to D**.

1.8 STRUCTURE OF THIS REPORT

The principal theme of this Report is that the present foundation of State flood and metropolitan planning policies, complemented by the procedures of the State Government's Floodplain Development Manual, now require strategic application to the Hawkesbury-Nepean valley's full range of flood risks.

The Report summarises the relevant policy background in **Chapter 2** and discusses recent management directions relating to Warragamba Dam and its proposed spillway in **Section 3**. A succinct explanation of the unique flood hazards existing in the Hawkesbury-Nepean valley and the significant consequences of flooding are presented in **Chapter 4**, thereby identifying the need for and the practical role of a regional floodplain management strategy for the valley.

The substantial background of earlier expert studies was complemented by a range of additional studies undertaken by consultants of international and national standing, commissioned to assist the Committee, as described in the previous **Section 1.7**. The scope and key points of the findings of the latter studies are summarised in **Chapter 5**.

The components of the resultant Hawkesbury-Nepean Floodplain Management Strategy prepared by the Committee are then described in **Chapter 6**.

The Committee's conclusions and recommendations, incorporating the Hawkesbury-Nepean Floodplain Management Strategy, are presented in **Chapter 7**. They address the identification and estimation of costs of evacuation infrastructure works; the options for managing the tasks to complete the Regional Floodplain Management Study and monitor the implementation of the Strategy; the upgrading of flood emergency plans and flood forecasting; and the promotion of pertinent, co-ordinated local floodplain management plans and policies for the valley, including flood warning, public awareness and future flood evacuation.

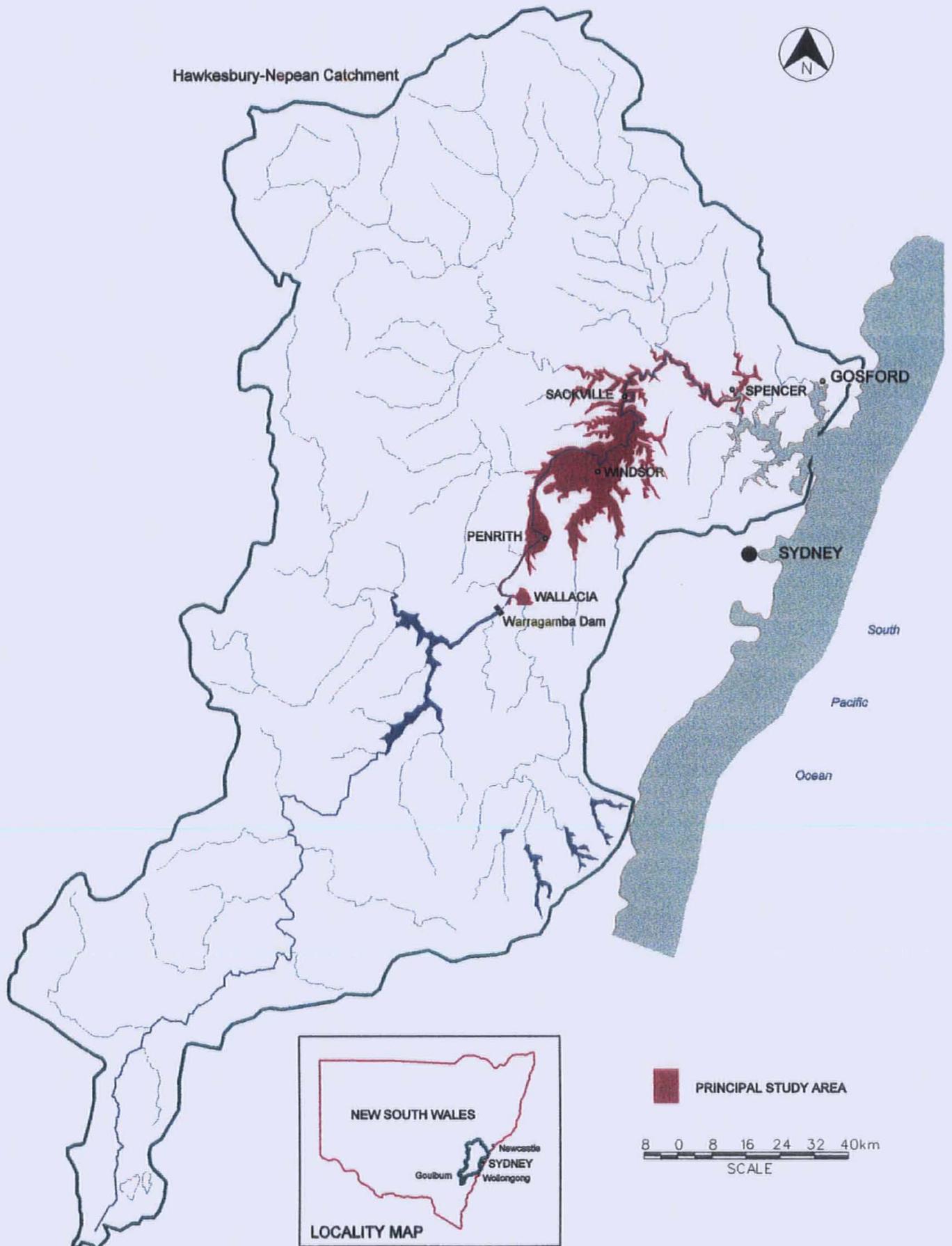
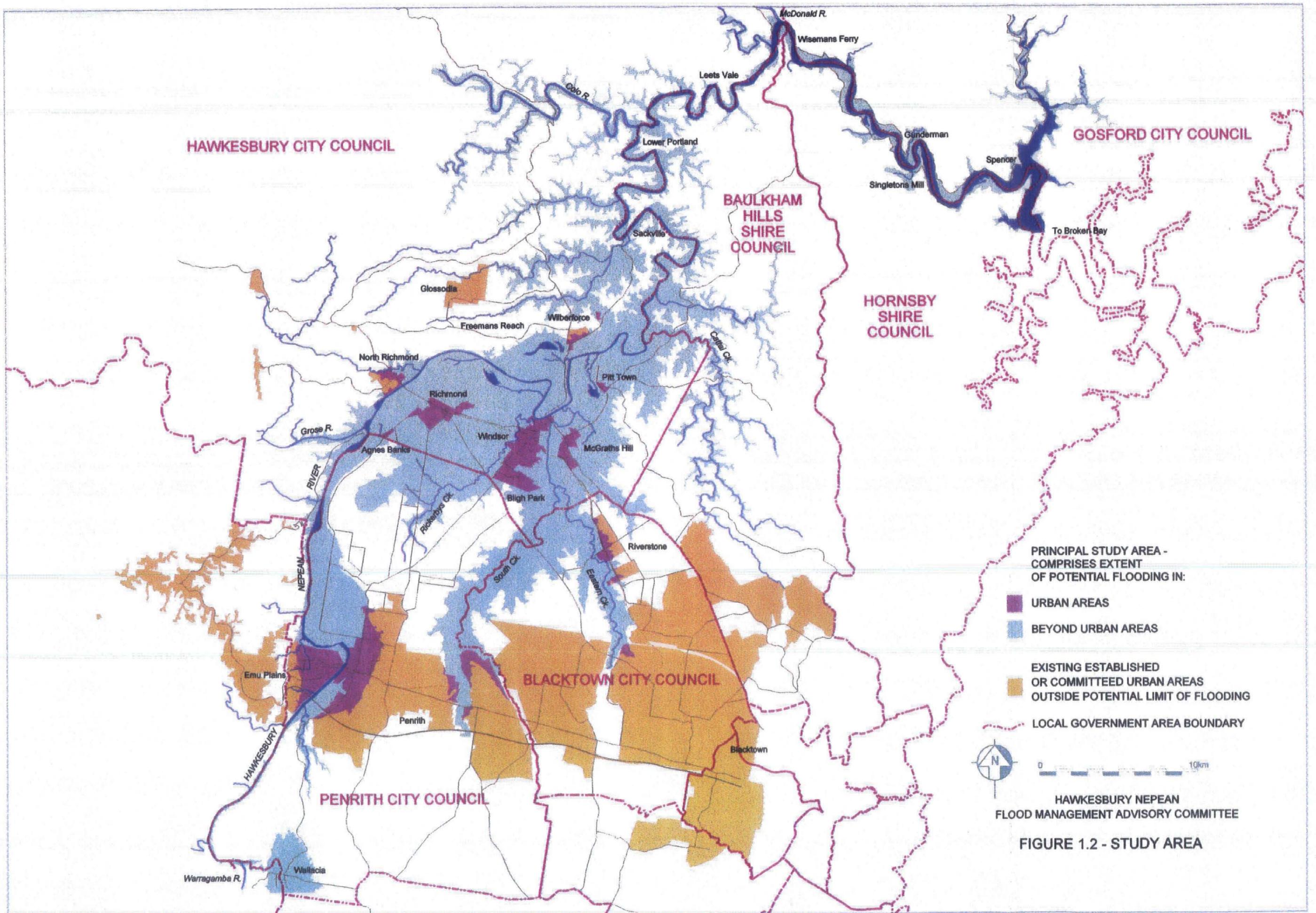


Figure 1.1 Location Plan
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Chapter 2 POLICY CONTEXT

This Chapter provides a brief chronology of major landuse planning studies and government policies which have had a bearing on development in the Hawkesbury-Nepean valley and floodplain. This is extremely important for understanding the current policy environment in which a Floodplain Management Strategy and Regional Floodplain Management Study may be implemented.

A brief overview of the current NSW Government's Flood Policy is given in terms of its objectives and application. The role and responsibilities of the State Emergency Service is described in the light of its important involvement in the implementation of the Flood Policy. The recent establishment and potential role of the Ministry of Urban Infrastructure Management is also noted in relation to the Committee's Strategy.

2.1 PLANNING HISTORY

The following chronology outlines the major planning studies and government policies which are relevant to the Hawkesbury-Nepean valley.

- 1817 Governor Macquarie proclaimed the "Macquarie Towns", Windsor, Richmond, Wilberforce, Ebernezzer and Pitt Town be located on high ground.
- 1900's Directive not heeded - development proceeded within the floodplain.
- 1945 *The NSW Local Government Act 1919* amended giving local councils certain powers to control land use, including floodplains.
- 1951 *The County of Cumberland Planning Scheme* - first statutory land use plan for Sydney region which incorporated broad land use zones.
- 1958 After severe flooding the Government issued a brief *policy statement* aimed at achieving responsible floodplain development planning through local government initiatives.
- 1968 *Sydney Region 1970-2000 AD Outline Plan* set guidelines and broad strategy for Sydney's expansion and recognised 'flood liable land' as a constraint to future urban development.
- 1977 *Government Circular* issued promoting the removal of urban development from land within the 1:100 year flood where practical and appropriate.
- 1980 *Review of the Sydney Region Outline Plan* pointed the way for future planning of the Sydney region.
- 1986 *Floodplain Development Manual* implementing the NSW Government's Flood Policy, provided guidance for floodplain management based on a merits approach for environmental planning and development control (*currently under review, see below*).
- 1987 *Sydney Regional Environmental Plan No 11 - Penrith Lakes Scheme* provided the framework for implementation of future urban development and recreation uses adjacent to the Nepean River, together with the extraction of sand and gravel.
- 1987 *Sydney Regional Environmental Plan No 13 - Mulgoa Valley* set a framework for future development recognising the Valley's rural and scenic landscape and items of heritage significance.
- 1988 *Sydney Into Its Third Century: Metropolitan Strategy for the Sydney Region* established a planning and development strategy for Sydney as it approached the 21st Century.
- 1989 *Sydney Regional Environmental Plan No 19 - Rouse Hill Development Area* provided a framework to manage the growth of the area in a co-ordinated planning manner.

- 1989 *Sydney Regional Environmental Plan No 20 - Hawkesbury Nepean River* - provided a framework for detailed planning for a large part of the river catchment below Sydney's main water supply dams (*currently under review, see below*).
- 1993 *Sydney's Future* provided a new strategy for managing the Greater Metropolitan area citing the Urban Development Program as the tool for providing co-ordinated urban planning.
- 1995 *Cities for the 21st Century*, a revised Greater Metropolitan Strategy, embodied a 'whole of government approach' to integrated urban management.
- 1997 *Greater Metropolitan Growth Strategy*, established a growth plan for every local government area in Sydney, the Hunter, the Illawarra and the Central Coast.

Awaiting release

- ◆ amended *Sydney Regional Environmental Plan No 20 - Hawkesbury-Nepean River* and accompanying *Environmental Planning Strategy for the Hawkesbury-Nepean* will promote integrating catchment management principles into the planning process.
- ◆ revised Floodplain Development Manual to be entitled *Draft Floodplain Management Manual*.

2.2 NSW STATE GOVERNMENT'S FLOOD POLICY

Floodplain management is the application of strategies and measures to protect communities and assets against the undesirable consequences of flooding. It has evolved over recent decades, responding to flood experience and changes in land use as well as meeting the needs and expectations of the community. Past approaches attempted to rely initially on engineered flood mitigation works to control flood behaviour and later on, the utilisation of severe State-wide prescriptive planning policies to restrict all development on land below the 1 in 100 chance per year flood, with little consideration of the consequences of rarer floods.

This evolution has culminated in the NSW Government's Flood Policy (*the Policy*) as described in the 1986 'Floodplain Development Manual'. Underpinning the Policy is the merits based approach, which involves a process aimed at generating a strategic land use plan that is socially responsible, equitable from the community's view point and sustainable in the long term, while also ensuring public safety. These objectives are achieved by consideration of the merits of proposed development options for individual areas based on a wide range of factors, rather than through the application of standardised rules.

The Policy enables a flexible risk management approach to be applied to planning for existing and future use of flood risk areas by balancing social, economic and ecological considerations against all of the consequences of flooding, with a view to both minimising the potential for property damage and the risk to life. Minimising the potential for loss of life is paramount. The Floodplain Development Manual notes importantly that bigger floods will occur and that there is potential for significantly increased risks.

A central plank of the Flood Policy is that whilst development on floodplains should be controlled, development should not be prohibited:-

"..... floodplains should not be unnecessarily sterilised and development should not be unreasonably restricted

... .. NSW Floodplain Development Manual 1986

It is not unusual for towns and cities, world-wide, to be sited on floodplains. The challenge is to manage the flood hazard fairly and equitably for the overall benefit of the flood affected community. This is a particularly difficult challenge in the Hawkesbury-Nepean valley because of the unusual nature of severe floods ie. the ability of flood waters to rise to great depths.

The application of the Flood Policy, to date, has not fully addressed the unique magnitude and potential consequences of severe floods in the valley as discussed further in Section 4.2.1. There are a number of floodplain management issues which need to be addressed on a regional basis to improve application of the Policy and ensure public safety as discussed further in Section 4.3.

2.3 STATE EMERGENCY SERVICE (SES) AND RELATED RESPONSIBILITIES

Integral with the Flood Policy is the flood planning component of floodplain management undertaken by the SES.

The SES is the agency having statutory responsibility under the State Emergency Service Act 1989 for dealing with floods (*including the establishment of flood warning systems and the co-ordination of the evacuation and welfare of affected communities*). Accordingly, the SES has the responsibility to develop and maintain plans which address the preparation for, response to and initial recovery from the effects of floods. These plans require the co-ordination and integration of many organisations involving various levels of government.

The New South Wales State Emergency Management Committee is the principal committee established under the provisions of the State Emergency and Rescue Management Act, 1989 for the purposes of emergency management throughout the State and, in particular, is responsible for emergency planning at State level. Its responsibilities include the establishment and review of appropriate emergency management structures at all levels and the provision of advice and assistance to the Minister for Emergency Services in the preparation and review of the State Disaster Plan (Displan).

The object of Displan is to ensure the co-ordinated response to emergencies by all agencies having responsibilities and functions in emergencies. In particular Displan:

- ◆ Identifies, in relation to each different form of emergency, the combat agency primarily responsible for responding to the emergency;
- ◆ Provides for the co-ordination of the activities of other agencies in support of the combat agency in the event of an emergency;
- ◆ Specifies the tasks to be performed by all agencies in the event of an emergency; and
- ◆ Specifies the responsibilities of the Minister, and State, District and Local Emergency Operations Controllers.

State level flood plans prepared by the SES are submitted for endorsement by the State Emergency Management Committee as Sub-Plans for the Displan, to ensure co-ordination with the overall emergency management arrangements.

Additionally, the Office for Emergency Services provides strategic co-ordination, support and independent advice to the Minister for Emergency Services and portfolio agencies which include the New South Wales Fire Brigades, Rural Fire Service and the State Emergency Service.

2.4 MINISTRY OF URBAN INFRASTRUCTURE MANAGEMENT

The first Urban Infrastructure Management Plan was developed by the Ministry of Urban Infrastructure Management prior to the completion of the Hawkesbury-Nepean Floodplain Management Strategy. The Plan, which has a five year outlook and is the beginning of an annual series, encourages integrated infrastructure planning and delivery within the Greater Metropolitan Region.

The Plan identifies a small number of the most important issues, strategies and projects which are likely to dominate the infrastructure debate in the medium term and which have the potential, if implemented, to deliver better urban outcomes such as health, safety and liveability. While some initiatives can be expected to appear for more than one year, the content of future Plans will vary in recognition of new issues that gain priority. Major infrastructure initiatives identified in the Hawkesbury-Nepean Floodplain Management Strategy may be considered for inclusion in the next annual Plan if the Strategy is broadly agreed to have high priority within Government.

Chapter 3 FLOOD MANAGEMENT IMPLICATIONS OF WARRAGAMBA DAM

The safety of Warragamba Dam and its operation are matters of public interest relating to the overall flood management of the Hawkesbury-Nepean valley.

This Chapter overviews recent studies related to the safety of the Dam, its gate operations and the proposal to construct an auxiliary spillway beside the Dam.

3.1 VALLEY-WIDE ASSESSMENT OF FLOOD IMPACTS

The valley-wide social and economic consequences of floods over the full range of potential flooding has only been considered in earnest since the safety of Warragamba Dam became an issue in the 1980s.

To address this issue, comprehensive rainfall runoff and streamflow computer models of the entire catchment, and much of the river system, were developed over several years. These provided knowledge, for the first time, about the full extent of flooding in the valley including areas of inundation. The computer studies extended to the Probable Maximum Flood (PMF), being the largest flood likely to occur, having an estimated 1 in 100,000 chance of occurrence in any one year.

A Flood Damage Model was also developed, based on extensive field survey work, using a system developed by the Centre for Resource and Environmental Studies at the Australian National University. The linking of the rainfall-runoff, streamflow and flood damage models brought into sharp focus, for the first time, the enormity of the latent flood damages and the potential for loss of life that has developed in the Hawkesbury-Nepean valley.

The State Government, on 17 October 1989, established the Warragamba Dam Inter-Departmental Committee (IDC) to consider and report on a range of issues related to the Warragamba Dam Flood Protection Program. The IDC investigated a range of options for mitigating flood levels in the valley downstream of the dam, as well as valley-wide hazards, flood effects and environmental consequences.

In 1993 the State Government proposed raising the dam height by 23 metres to address both dam safety and the potential for flood mitigation storage. After considering an Environmental Impact Statement (EIS) completed by Sydney Water in 1995 the State Government decided not to proceed with the scheme to raise the dam height. The State Government subsequently decided that Sydney Water should proceed with an EIS for an auxiliary spillway to address dam safety.

In 1994 the Hawkesbury-Nepean Valley Flood Awareness Committee informed the public that it was likely that the upgraded dam would reduce frequent flooding but would not contain all flooding. Therefore, flood emergency plans to guide warning and evacuation remain important to minimise potential loss of life in significant floods.

3.2 FLOOD MANAGEMENT IMPLICATIONS OF THE AUXILIARY SPILLWAY

Sydney Water is planning to construct an auxiliary spillway as part of its Warragamba Dam Flood Protection Program and to allow the dam to safely pass the full PMF, without failure of the dam itself, as formerly found to be most probable if it was overtopped by such extreme flows. The proposed spillway was the subject of the comprehensive Environmental Impact Statement (EIS) released in late 1996.

Sydney Water has completed its consideration of public submissions on the EIS for the proposed auxiliary spillway and has forwarded its Representations Report to the Minister for Urban Affairs and Planning for a determination.

At the request of the Minister, the Director-General, Department of Urban Affairs and Planning, is now preparing a final assessment report. The Environmental Planning and Assessment Act, 1979, makes provision for the completion of the assessment report within the statutory period of three months.

Concurrent with the latter procedure, the Committee has been preparing this Report, which, as indicated in Section 5.1.1, will provide the State Government with complementary advice on floodplain management downstream of Warragamba Dam.

The beneficial effect of the proposed spillway, assures the safety of the dam. However, the threat of severe floods cannot be easily eliminated because flood behaviour on the floodplain downstream of Warragamba Dam can be influenced to varying degrees by floodwaters flowing from many parts of a relatively large catchment. The Nepean, Warragamba, Grose, Colo and MacDonald Rivers can all individually or collectively contribute to flooding along the Hawkesbury-Nepean River.

Chapter 4, Flood Hazard and its Management, accordingly discusses the consequences of flooding in the Hawkesbury-Nepean valley and the need for a regional floodplain management strategy.

3.3 GATE OPERATIONS

It is widely recognised that the operation of the spillway gates of Warragamba Dam could have some potential influence on downstream flooding, despite the small storage controlled by the gates in comparison to the total volume of large floods.

In December, 1995, "The Working Group for Sydney Water Corporation Flood Operation" commissioned a review of studies on Warragamba Dam spillway gate operation arrangements to determine the practicability of achieving better outcomes in regard to downstream flood management. The review indicated that alternative gate operating procedures could be beneficial in reducing downstream flood levels without compromising dam safety, however it would also result in higher water levels upstream of the dam, increase the duration of downstream flooding and reduce warning times due to early release of stored water.

An agreement is now in place between Sydney Water Corporation and the Department of Land and Water Conservation, to undertake further assessment of an alternative operating procedure, with regard to the likely impacts upstream and downstream of the dam (*eg inundation, warning times, rates of rise*). These investigations are programmed for early 1998.

Chapter 4 FLOOD HAZARD AND ITS MANAGEMENT

Floods have the potential to threaten life and property. The storm and flood behaviour which generates these threats is continually being studied as our scientific knowledge and capability improves. The present knowledge of flood behaviour of the Hawkesbury-Nepean River which is much more extensive than it was 10 years ago, as a result of investigations into the safety of Warragamba Dam, has been used to explore the consequences of severe flooding in the valley by reference to a repeat of the largest flood on record (1867).

The landforms of the Hawkesbury-Nepean valley have created a unique flood setting with the potential for initially isolating towns and then engulfing them completely. Hence it has been extremely difficult to apply the State Government's Flood Policy in the valley. As a consequence, the great majority of those people living in the floodplain are unlikely to understand that a severe flood may inundate their homes.

The unique flood behaviour in the Hawkesbury-Nepean valley necessitates a management approach that must function at both the regional and local level. The need for a Regional Floodplain Management Strategy to fully embrace these two levels is recognised as the only satisfactory means of overcoming the inherent difficulties in applying the State Government's Flood Policy in the valley.

4.1 THE EFFECT OF A SEVERE FLOOD TODAY

In June 1867, the Hawkesbury Nepean valley experienced its largest recorded flood, causing water to rise 19 metres above normal river level, 12 metres above the Windsor Road Bridge and 3.7 metres above the present day level for urban development control at Windsor (*the flood planning level, FPL*).

"The volume of water has astoundingly increased since Thursday. On Friday many buildings in the town were in jeopardy and on Saturday the whole township, excepting the two or three patches already named, was overwhelmed. The water rose very rapidly, and the inhabitants were in dread of being swamped altogether. Most of them thought that they would have to betake themselves to the Terrace, the nearest and most accessible town in the Blue Mountains. The water continued to rise slowly during the night, but at 5 o'clock yesterday

(Sunday) morning it was at a standstill..... Some portions of George Street, the main thoroughfare in Windsor, must be fifteen or sixteen feet deep, and in several places about the township the telegraph posts and wires were not visible. Mr Ascough's house is under water, so also are the Royal, The Australian, and Houlding's Hotel. Another six feet, or ten at the most, would not have left an inch of ground in Windsor unwashed by the flood."

"The gloomiest forebodings as to probable loss of life are prevalent. It is

reported that William and George Eather, farmers living at Cornwallis, placed their wives and children on the roofs of their houses and there clung with them awaiting help until the rising waters washed them off. The two wives and their ten children were overwhelmed in the flood and the husbands saved themselves and one little boy by swimming to a willow tree from which they were shortly afterwards rescued and taken in a boat to Richmond."

... .. The Sydney Morning Herald, Monday, June 24th, 1867.

A repeat of the Flood of Record (1867) (*about a 1 in 250 chance per year occurrence*) would create an "inland sea" up to 11 metres deep and 200 square kilometres in area causing inundation within the towns of Richmond, Windsor, McGraths Hill, Bligh Park, Pitt Town, Wilberforce, Emu Plains and parts of Penrith. Some 40,000 people would need to be evacuated to safety.

The limited warning time and inadequate evacuation capacity of the present road network, which could be totally cut by local flooding before mainstream flooding occurred, would mean that notwithstanding the existing Flood Emergency Plans, many of the inhabitants of the floodplain could not be evacuated to safety. Under current circumstances there would be considerable loss of life.

After a flood of the same magnitude as that of 1867, the loss of houses would mean that as many as 6,000 people could need alternative accommodation for up to 12 months. Residential buildings and essential services would require months to be restored.

Some 50,000 people would be without power for two to five weeks. It would take three to six months to restore domestic gas services. Untreated sewage would flow into the Hawkesbury River for many weeks while the sewerage system was restored.

The stress of being flooded, perhaps having the family home destroyed, of being evacuated, of worrying about post flood recovery and the future, may affect general community health in a dramatic way. The effect would be severe because the present valley's communities have had no experience of such a flood for which they would be completely unprepared. It would be a traumatic event and it has been estimated that some 4,500 residents may need medical treatment.

A recurrence of such severe flooding would constitute the largest natural disaster in Australia's history, eclipsing the human suffering and damage wrought by Cyclone Tracy and the Ash Wednesday fires combined. The resultant flood damage would be in the order of \$1.4 billion.

It is important to note that flooding which is more severe than that of 1867 is possible. The most extreme event that can be determined analytically, that is, the Probable Maximum Flood (PMF), would see the depth of inundation increase up to 18 metres above the river flats. It would directly affect over 16,000 dwellings, 3,500 commercial and industrial buildings and some 60,000 people would need to be evacuated. Many more people would be affected indirectly through disruption to essential services to a much wider area than the floodplain.

4.2 CONSEQUENCES OF FLOODING

The flood hazard in the Hawkesbury-Nepean valley is like no other in NSW and the impacts and consequences of flooding in the valley are extremely high compared to other NSW floodplains. This is due to:

- unique flood behaviour;
- the potential isolation of towns; and
- lack of flood experience.

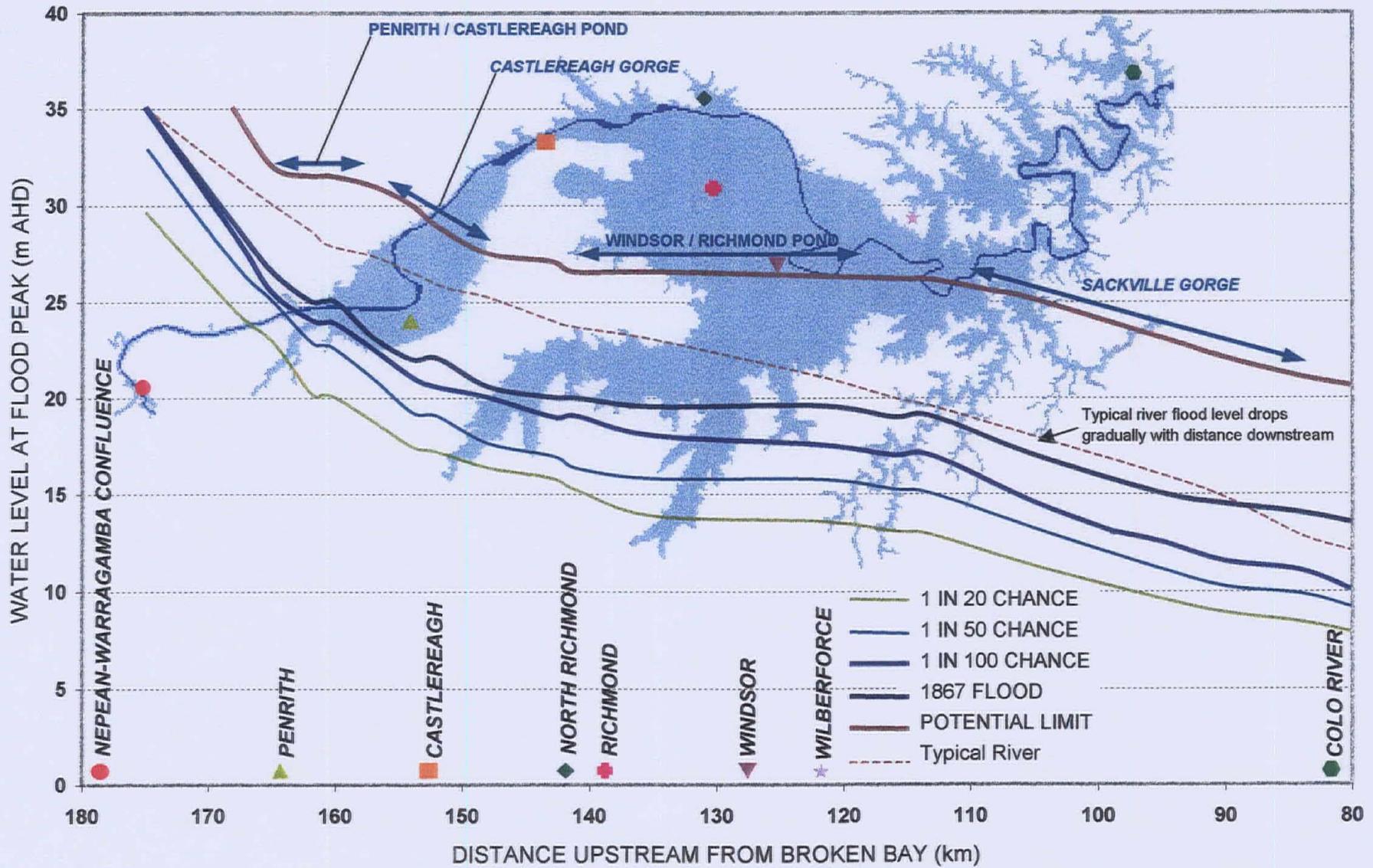


Figure 4.1 Gorges and Ponds in the Hawkesbury-Nepean Floodplain

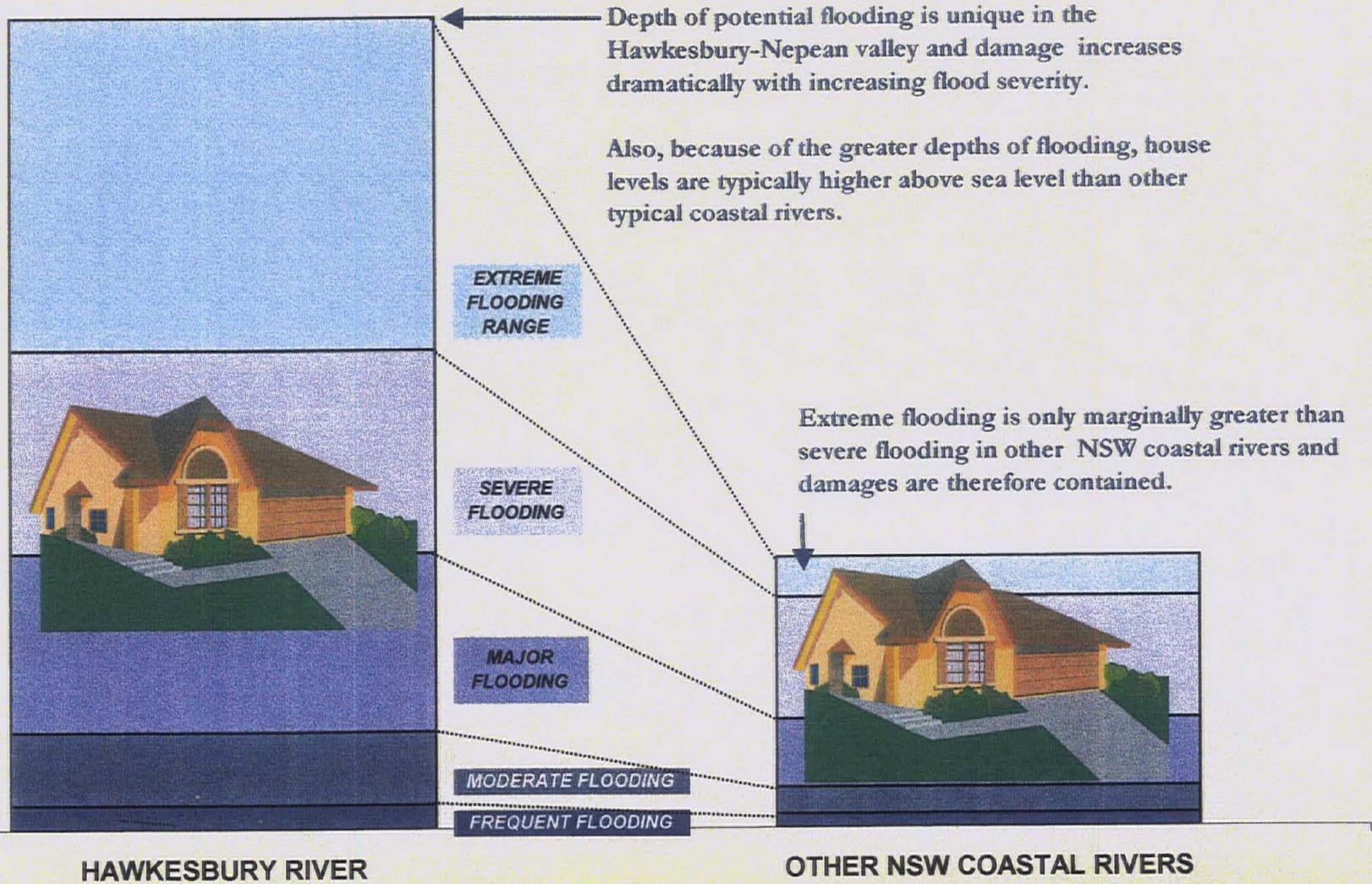


Figure 4.2 Unique Flooding Behaviour in the Hawkesbury-Nepean Valley

4.2.1 Unique Flood Behaviour

The landforms of the valley have created a unique flood setting.

Downstream of Wallacia, the Warragamba River enters the Nepean River prior to the widening of the valley to form the floodplain between Penrith and Castlereagh and similarly, the major low level floodplain between North Richmond and Wilberforce. A narrowing of the valley at Castlereagh controls the discharge of floodwaters between these two floodplains while downstream of Wilberforce a final gorge, 120 km long, constrains outflow to the outer estuary and Broken Bay.

For significant flood events, the inflow from the Hawkesbury River and its tributaries exceeds the outflow through the final gorge causing the valley to fill, creating a huge pond (Figure 4.1). The towns affected by flooding are Penrith and Emu Plains in the upper floodplain, Richmond, North Richmond, Windsor, McGraths Hill, Bligh Park, Pitt Town and Wilberforce in the lower floodplain, and a number of small communities throughout the gorge country down to Spencer.

As shown in Figure 4.2, flooding can be of great depth by comparison with other NSW rivers. Moreover, the difference in depths between major and extreme floods is much greater than occurs elsewhere.

Flood levels on the Hawkesbury-Nepean floodplain can typically rise at a rate of half a metre an hour for several hours. Peak rates of rise of over a metre per hour can occur for shorter periods. At this rate a house on the lower areas of the floodplain could be submerged in some six hours.

4.2.2 Potential Isolation of Towns

Whilst the built environment of the Hawkesbury-Nepean valley has been developed for some 200 years, only recently has the urbanisation of Sydney expanded westwards to Rouse Hill, Penrith and the lower Blue Mountains. Most of the urban development of the floodplain is centred upon the early Macquarie Towns of Richmond, Windsor, Pitt Town and Wilberforce. As a notable example of colonial floodplain management, these towns were sited on high land in the floodplain.

It has been only in the last decade or so that the *full* extent of potential flooding has become known. That is, that the highest lands of these towns, which become isolated islands in the early stages of a flood, can be submerged up to six metres deep. It is therefore the growth, based upon a colonial legacy, that has caused the need for the present day communities to be evacuated early to avoid loss of life in a severe flood.

The urban road network has not evolved or been designed for the purpose of evacuating the floodplain's communities. Studies carried out for this Report have shown that even local flooding is likely to render the network unsuitable for the task because of low-lying road alignments. Much of the population would be unable to be evacuated to safety.

Londonderry Road, a principal route for evacuation of Richmond, for example, has been found to be inadequate for this purpose because it is prone to frequent closures by local flooding. In 1996, the State Government recognised the need to undertake urgent works to upgrade low spots along Londonderry Road to alleviate this problem. Detailed plans for these works have been completed recently and it is expected that construction will commence in the 1997/98 financial year.

Thus the combination of a substantial population, which in a short time can be trapped and ultimately submerged by rapidly rising flood water, together with the limited flood warning time available, and the lack of reliable evacuation routes, makes the existing urbanised floodplain in the Hawkesbury-Nepean particularly hazardous.

4.2.3 Lack of Flood Experience

The present valley's urban and rural population has had no experience of severe flooding, having only suffered events up to approximately a 1 in 40 chance per year flood since 1867 (Figure 4.3). This lack of awareness will make evacuation all the more difficult and could increase the trauma that may be experienced by the floodplain communities in the event of a severe flood.

The floods of living memory have caused limited flooding of properties, minor structural damage to houses, and sadly, some accidental loss of life.

In the case of floods much larger than that of living memory, many houses would be inundated. The movement and great depth of water involved would push some houses off their foundations and cause so much structural damage that they may be uninhabitable after the flood. Studies have shown that a repeat of the 1867 flood would inundate almost 7,000 houses throughout the valley and may destroy up to 2,000 of them. In a more extreme flood, of the order of a PMF, up to 16,000 houses would be flooded and as many as 12,000 may be destroyed.

Because the community is unaware of the potential for such profound damage on a large scale, the trauma created by these severe floods would be all the more intense and long lasting.

The extent to which the community generally perceives and/or accepts the flood risk may be explained by reference to the present community's experience as illustrated in Figure 4.3. It may be seen that most of the potentially flood affected houses are situated above recently experienced levels of flooding.

4.3 APPLICATION OF THE GOVERNMENT'S FLOOD POLICY IN THE HAWKESBURY-NEPEAN VALLEY

Floodplain management has evolved over a number of years, as described in Sections 2.1 and 2.2, resulting in the State Government's Flood Policy the "Floodplain Development Manual" 1986. The key thrust of the Policy is that floodplain management should be on a merits basis across the full range of flood risk. In this approach, flood planning levels are based on social, economic and ecological, as well as flooding, considerations. Where rarer floods may occur above the flood planning levels, attention still has to be paid to risks to human life.

This Policy has been well applied throughout NSW to curb the growth of inappropriate floodplain development and it has generally worked to create flood awareness and preparedness in floodplain communities. Whilst the Government's merits based Flood Policy, which is regarded as one of the most advanced in the world, provides an excellent basis for addressing flood risks through greater flexibility and opportunities, its application in the Hawkesbury-Nepean situation has been difficult, for a number of reasons. Notwithstanding its strengths, application of the Policy in the Hawkesbury-Nepean valley has not paid sufficient attention to the extreme depths that are associated with rarer floods.

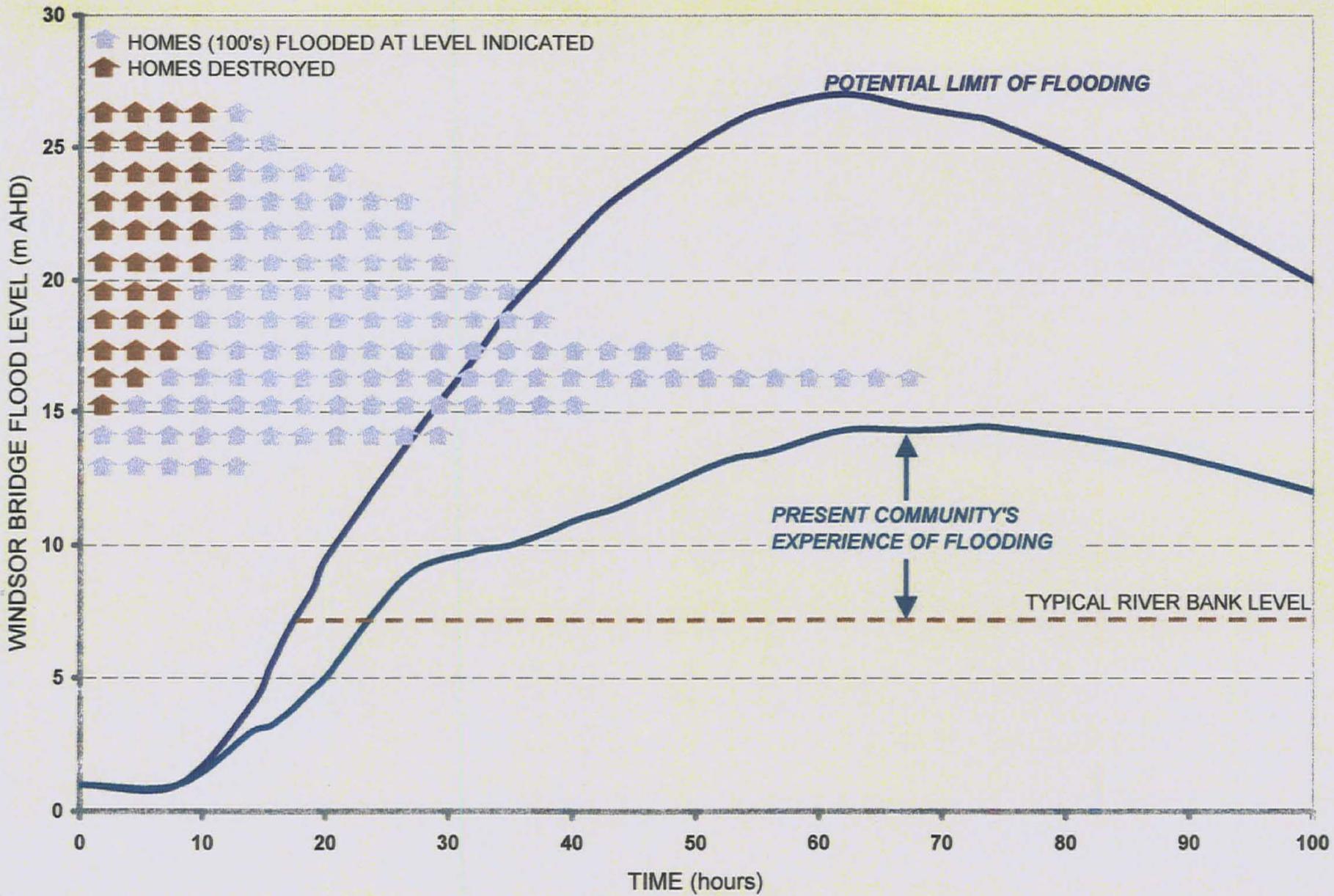


Figure 4.3 Flooding Experience in the Hawkesbury-Nepean Valley

In practice, local authorities have generally adopted a Flood Planning Level (*FPL*) such that typically, certain classes of development should not occur below the 1 in 100 chance per year flood level. Urban land releases have been similarly based on this level. This has contributed to the common community perception that land above the *FPL* is not subject to flood risk.

Apart from the Hawkesbury-Nepean valley, this lack of appreciation of the hazards associated with severe floods above the 1 in 100 chance per year flood has not led to potentially disastrous situations because the range in flood levels above the 1 in 100 chance per year level is small. As shown in **Figure 4.2**, a severe flood on a typical NSW coastal river increases flood levels but not enough to cause significant destruction of dwellings. In the Hawkesbury-Nepean valley, however, the much greater depth of flooding is sufficient to cause their widespread destruction.

Thus a particular difficulty in applying the Policy in the Hawkesbury-Nepean valley, as indicated above, is the lack of experience of significant flooding. There is no living memory of the immense proportions of severe floods because the last such event occurred in 1867. Consequently, there has been no consciousness and certainly no urgency or priority, in the collective minds of previous governments and administrators, both State and local, to consider the consequences of the full range of flood hazards and plan for them.

Hence it has been extremely difficult to apply the State Government's Flood Policy in the Hawkesbury-Nepean valley, in order to address the unique and potentially devastating impact of the full range of floods. As a consequence, the great majority of those people living in the floodplain are unlikely to understand that a severe flood may inundate their homes.

It has also not been recognised generally by the community in the valley that the different types of flood risks require a range of different measures in which to manage each type of risk. Co-ordinated and integrated regional, local and emergency planning, employing a combination of these measures, is the key means by which the whole range of flood risks can be effectively managed. Significantly, there has been a lack of co-ordination from a floodplain management perspective across six local government areas and the many Federal and State authorities and agencies which provide infrastructure and services to the valley. With no single co-ordinating authority, the risks to life and the economic consequences of severe floods, which need to be tackled from a regional or valley-wide perspective, have only now become the subject of a prospective floodplain management strategy.

4.4 NO ROOM FOR COMPLACENCY

As scientific methods and knowledge grow, our appreciation of the flood hazards in the valley improves. It would seem that such understanding invariably points to an under-estimated hazard. For instance, the present flood planning level at Windsor-Richmond, which when it was established had a 1 in 100 chance per year of occurrence, is now thought to have a more frequent 1 in 70 chance per year of occurrence. Such revisions are not uncommon. They are occurring on an international scale as more meteorological data is amassed and better analytical modelling techniques are developed.

Similarly with the long term implications of the Enhanced Greenhouse Effect, the most recent research indicates that the bigger floods in the valley may be more likely to happen as that effect builds up in the next century.

An international expert, Mr D. I. Smith, has found that:

"..... the worst case [for the most wet scenario] suggests that annual flood damage (in south eastern Australia) could increase within the range of 2.5 to 10 [times], this contrasts the most dry scenario that indicates little change"

..... Paper presented to Climate Change and Water Resources, Asia-Pacific 97 Conference

Hence the risk of flooding is likely to increase rather than stabilise or decrease, leaving no room for complacency.

4.5 THE NEED FOR A REGIONAL FLOODPLAIN MANAGEMENT STRATEGY

As discussed in Section 4.3, it has been difficult to apply the State Government's Flood Policy in the Hawkesbury-Nepean valley. There is currently a very real threat to the lives of those living in the floodplain in the event of a significant flood.

Roads, generally, are not designed for the abnormal requirements of emergency flood evacuation. The current inadequacy of evacuation routes to effect an evacuation of some 60,000 people, in the limited time likely to be available, is an example of a crucial issue which has not been fully appreciated because of the lack of a regional flood management perspective.

The fact that flood events like an 1867 type of flood have a low probability of occurring in any one year (*about 1 in 250 chance per year*) is no justification to avoid putting the necessary works and measures in place to curb the risk to life and minimise the growth in damage which will face future generations.

A Regional Floodplain Management Strategy is required which would:

- ◆ identify the means to reduce the risk to life for the present residents of the valley and which would afflict future generations, in times of severe flooding;
- ◆ identify the regional works and measures necessary to secure an effective evacuation plan;
- ◆ identify opportunities for State Government agencies responsible for providing infrastructure and services to the valley to reduce the impact of flooding on existing and future communities from the perspective of a valley-wide appreciation of the hazards posed by flooding; and
- ◆ undertake a comprehensive Regional Floodplain Management Study to provide the much needed basis for Councils to prepare/amend local planning instruments. By maintaining consistency with the regional framework, local floodplain management will achieve a high degree of co-ordination across the valley.

When completed to an adequate level of detail, the Regional Floodplain Management Study will eliminate the need for the separate preparation of local floodplain management studies by the Councils. Each Council will then be able to rely upon the Regional Floodplain Management Study to prepare local floodplain management plans in accordance with the procedural guidance expressed in the Floodplain Development Manual 1986.

The components of the resultant Strategy and Study therefore are discussed further in Chapter 6, after the summary of the Consultants' studies has been presented in Chapter 5.

Chapter 5 CONSULTANTS' STUDIES

As outlined in the Introduction, a set of specialist technical studies was undertaken by consultants, commissioned to assist the Committee. Each study is summarised below whilst extracts are provided respectively in Appendices A to D.

5.1 IMPACTS OF FLOODING ON COMMUNITIES AND INFRASTRUCTURE

5.1.1 Scope

This investigation was carried out to identify and evaluate the impacts and consequences of flooding on communities and infrastructure within the study area and propose measures by which those impacts could be mitigated. Specifically the investigation was to:

- examine the extent and state of urban/rural development and key public/private infrastructure in the floodplain;
- define and quantify the impacts and consequences of flooding on infrastructure;
- estimate the tangible and intangible damages (*both direct and indirect*) for urban assets and infrastructure; and
- formulate and assess options to reduce impacts on infrastructure.

Files and databases from Sydney Water's investigations into Warragamba Dam were compiled, reviewed and updated, and discussions held with all relevant utility organisations to ascertain current floodplain development levels. Flood impacts and consequences were then described and damage estimates prepared for a range of floods up to the PMF. Particular attention was paid to assessing both the importance of utility services to emergency response, flood clean-up and long term recovery, and intangible social impacts caused by evacuation, loss of utility services and long-term relocation.

5.1.2 Flood Damages

Floods up to a 1 in 20 chance per year of occurrence remain in bank at Penrith but overflow the banks in the Richmond and Windsor areas. They can cause total damages of between \$20 million to \$90 million and create temporary disruption to roads, rail and some electricity services. Some low lying rural properties are evacuated in these floods and some homes are flooded.

Floods in the range of a 1 in 20 to a 1 in 200 chance per year of occurrence can cause damages in a single flood of between \$90 million and \$1.4 billion. At the upper end of this range, they can flood urban areas throughout the valley, damaging thousands of houses and businesses and causing hundreds of building failures. They will involve evacuation of tens of thousands of people, loss of electricity supplies for days to weeks in both flooded and non-flooded areas and the discharge of hundreds of megalitres of untreated sewage over many months. A 1 in 200 chance per year flood may cause some 40,000 people to be evacuated and more than 6,000 people would be without homes. Many fatalities and flood induced illnesses can be expected.

Floods bigger than those with a 1 in 200 chance per year of occurrence would result in widespread destruction of entire communities on the floodplain and long term disruption to surrounding areas which could be without electricity supplies for months.

Rural damages dominate in floods up to the 1 in 10 chance per year event (Figure 5.1). Urban and commercial and industrial damages begin to become significant in the 1 in 50 chance per year event and then dominate the damages in larger events. This reflects the historical minimum planning levels for urban development which generally have between a 1 in 50 and 1 in 100 chance of being exceeded in any year. In extreme floods, the Richmond RAAF Base's damages would be substantial.

The impacts and damages above the FPL become extremely high because of flood depth and the fact that few measures have been taken to minimise impacts for the rarer events. The main reasons for this are:

- the small knowledge base of severe floods;
- poor flood awareness within the community and decision makers; and
- the fact that decisions are based mainly on flood probabilities with minimal consideration of consequences.

It should be recognised that damages to urban development (*residential, commercial/industrial*) contribute nearly 50% to average annual damages, and increase dramatically when a flood exceeds the FPL.

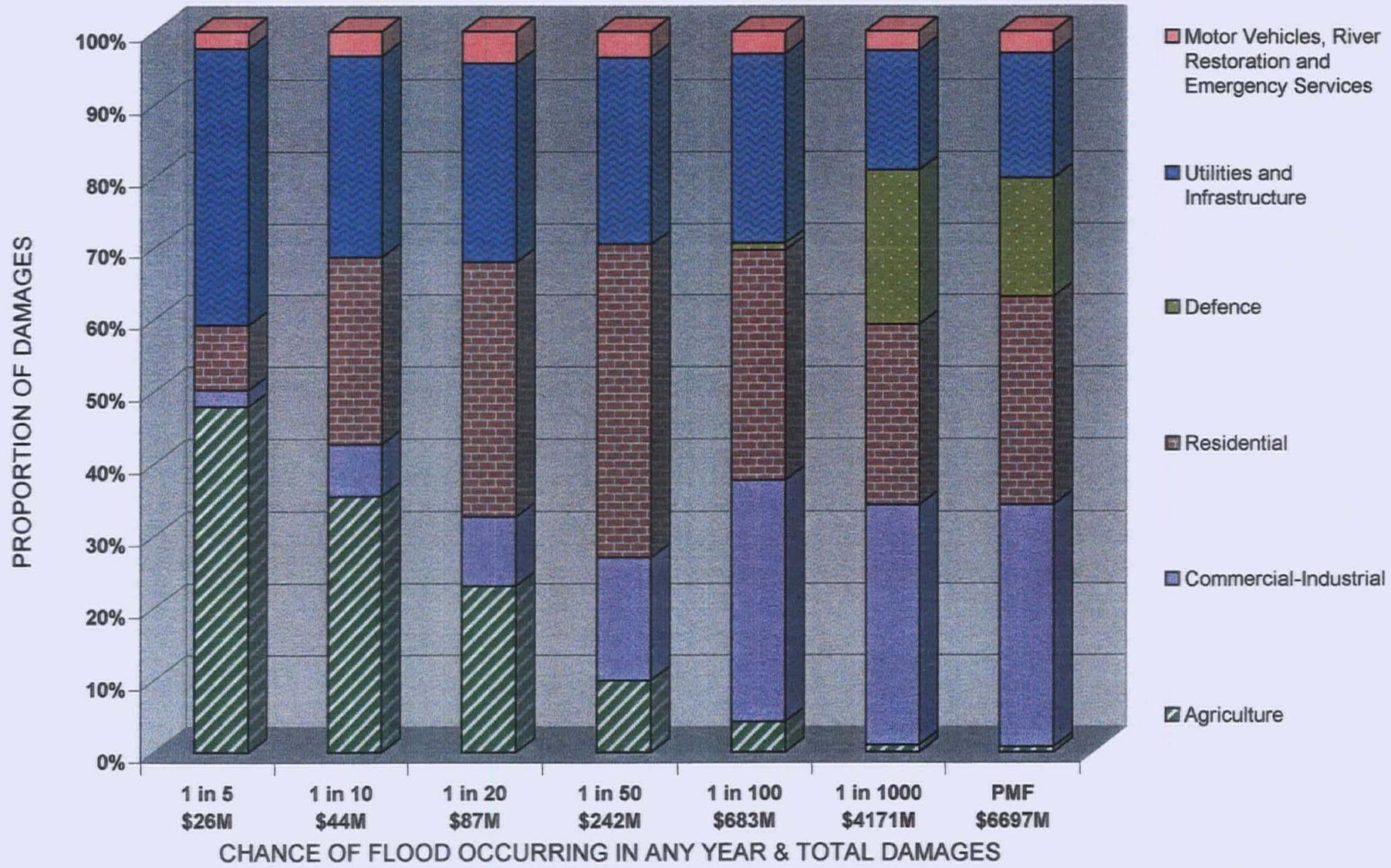
5.1.3 Infrastructure Impacts

Investigations highlighted the crippling impact of floods on infrastructure. Transport links, including bridges, together with utilities, such as electricity and water are extremely important to the local community in terms of long term public recovery. The indirect effects of such impact include community isolation.

The following schedules indicate the range of impacts on infrastructure which would occur at different levels (RL) by reference to the Australian Height Datum (AHD) (*approximately mean sea level*):

Windsor District (Figure 5.2)

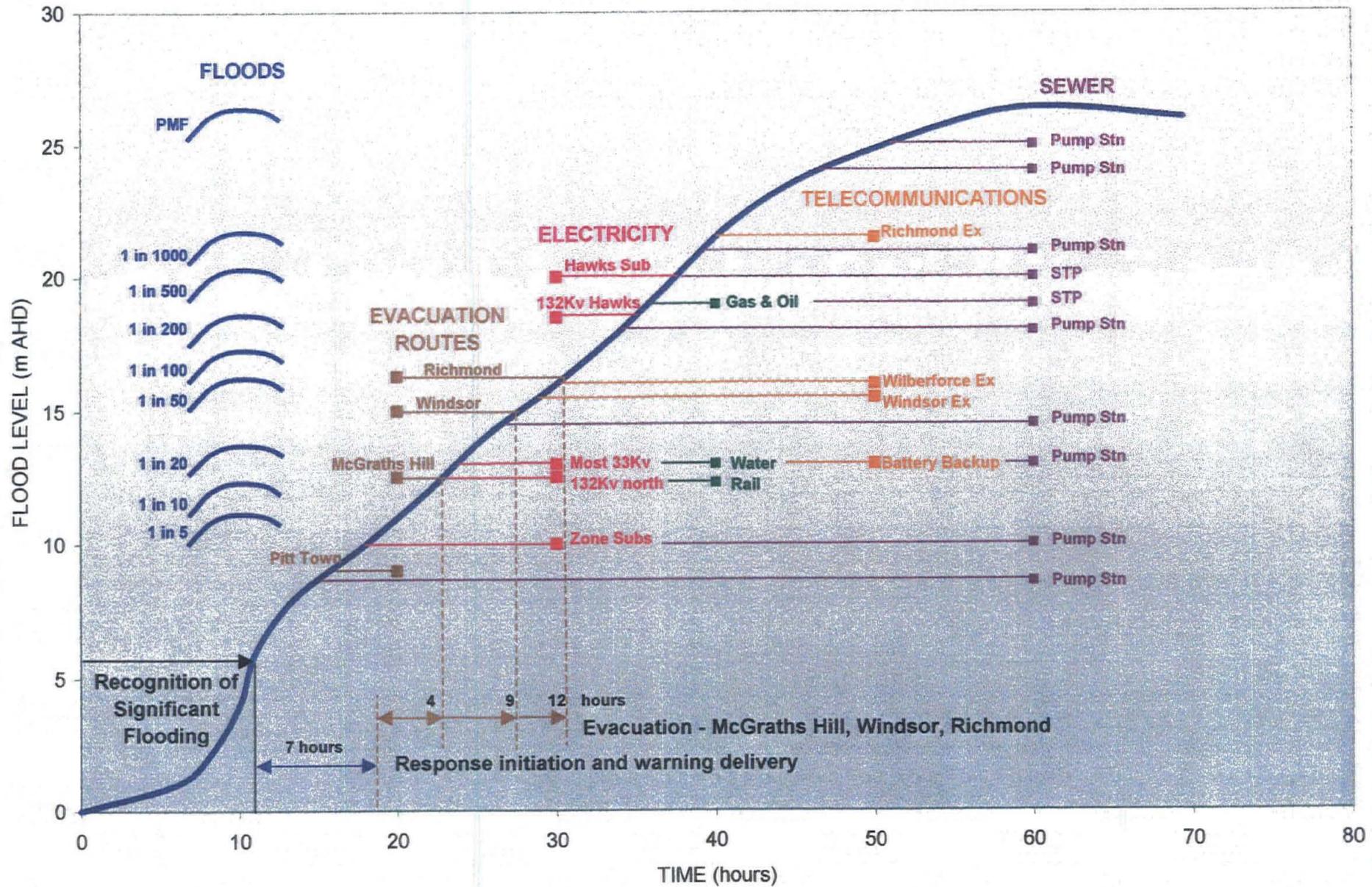
<i>Power</i>	floods RL 13.0 m to RL16.5 m: North Richmond, Richmond and Windsor without power, 2 days to 1 week floods RL 16.5 m to 20 m: up to 80,000 people without power 2 to 5 weeks floods greater than RL 20 m: 160,000 people without power up to 6 months
<i>Telecommunications</i>	RL 15.5 m: system failures occur floods greater than RL 21.5 m: 70,000 customers no service 2 to 6 weeks
<i>Gas</i>	floods greater than RL 16.5 m: no gas for 3 to 6 months and supply to Newcastle and Central Coast possibly cut for up to 5 months.
<i>Sewerage</i>	floods less than RL 20 m: some treatment plants fail, 2 to 3 weeks to restore floods RL 20-25 m: most treatment plants fail, raw sewage into river for up to 3 months



Adapted from 'Impacts of Flooding on Communities and Infrastructure', Molino-Stewart

Figure 5.1 Hawkesbury-Nepean Valley Flood Damage Summary

Figure 5.2 Windsor District Infrastructure Impacts



Adapted from 'Impacts of Flooding on Communities and Infrastructure'. Molino-Stewart

Penrith District (Figure 5.3)

<i>Power</i>	RL 24 m: Emu Plains to Cranebrook, no power 2 days to 1 week floods between RL 24 to 27 m, 80,000 people without power 2 to 5 months floods greater than RL 27 m: power down for up to 5 months
<i>Telecommunications</i>	RL 26 m: system on battery back-up RL 30 m: 50,000 customers without service up to 6 weeks
<i>Gas</i>	floods below RL 26 m: 2 to 3 weeks to restore supply floods between RL 26 m and RL 27 m: no gas for up to 3 months floods above RL 27 m: no gas for up to 6 months
<i>Sewerage</i>	up to RL 26 m: minor damage, 1 to 2 weeks to restore above RL 28 m: treatment plants fail, raw sewage into river for up to 3 to 6 months

5.1.4 The Social Effect of Residential Flood Damages

The social effect of residential damages is summarised in Figure 5.4. It shows how the floodplain population has no experience of significant floods and the great impact they will have. In living memory, the number of properties flooded has been only in the hundreds and there has been relatively minor community trauma. Severe floods, however, would flood thousands of houses, destroying many of them.

In summary, the consequences of a severe flood on the community and its assets would be catastrophic in nature and magnitude. The traditional approach to reducing consequences has relied on modifying floods with little recognition of modifying development. As a result there is now a high level of exposure which will be perpetuated in future development if nothing is done to change the character of that development. However, it must be recognised that different assets can have different levels of protection depending on how critical they are.

The Committee has noted that otherwise, in a complementary manner, road infrastructure improvements for evacuation, as detailed later in Section 5.4, offer the most effective means of reducing flood risk to the existing occupants of such development.

The Committee has also noted that, in Australia, the vast majority of residential flood damages cannot be covered by insurance. It is understood that the inland floodplain is often considerably cheaper than other higher land and is therefore attractive to lower-income earners, who consequently are less able to recover from the damages caused by flooding.

5.1.5 Opportunities for Reducing Consequences for Infrastructure

The study concluded that there are many opportunities both in the short and long term to reduce the vulnerability of the valley infrastructure to flood damage, including the following:

Short Term Opportunities:

- all utilities could develop comprehensive flood recovery plans to minimise impacts during major floods;
- co-ordination between all utilities is required because of interdependencies eg. power outages;
- the Defence Department could be advised of the current understanding of flood hazards in the valley;

- AGL be supplied with latest river flow data so that the vulnerability of the Plumpton to Newcastle gas and oil pipeline crossing could be reviewed.

Long Term Opportunities for Further Consideration:

- relocation and/or flood resistant design for future refurbishment/rebuilding of power grid components;
- incorporating flood resistant designs in the future upgrading/replacement of sewage treatment plants;
- relocation or more flood resistant designs in the future replacement/upgrading of Penrith and Richmond telephone switching centres;
- location of future public and private hospitals; and
- relocation of hazardous industries out of the floodplain.

Further information about this investigation is provided in Appendix A.

5.2 ENGINEERING STUDIES TO MODIFY FLOOD BEHAVIOUR

5.2.1 Scope

This investigation was undertaken to identify and evaluate various streamflow engineering works for the river system and floodplain as part of an overall strategy to mitigate flood hazards. The study involved:

- defining basic flood behaviour and assessing flood hazard over the floodplain;
- developing and examining a range of structural works (*eg detention basins, levees, diversion channels, dredging*) to mitigate hazards; and
- briefly considering property modification measures and viable non-structural options (*eg education programs, voluntary purchase, flood warning, gate operations*).

This study used the rainfall runoff and streamflow computer models to investigate the variability of flood hazards within the valley, across the full range of floods. A number of possible flood mitigation options were simulated in the models to quantify the extent to which they would modify flood behaviour.

5.2.2 Findings

The modelling results highlighted the high hazard potential throughout the valley, due to the substantial water depths that may occur. Generally, local flood behaviour varies across the floodplain depending upon the magnitude of the flood and ground elevation. Areas of Penrith, Emu Plains and the Lower Hawkesbury have additional hazards due to the way floods breakout over natural levees causing significant velocities across the local floodplain. Penrith/Emu Plains have a shorter warning time because they are further upstream. Furthermore, the lower Hawkesbury, below Sackville, contains numerous scattered communities which are difficult to access.

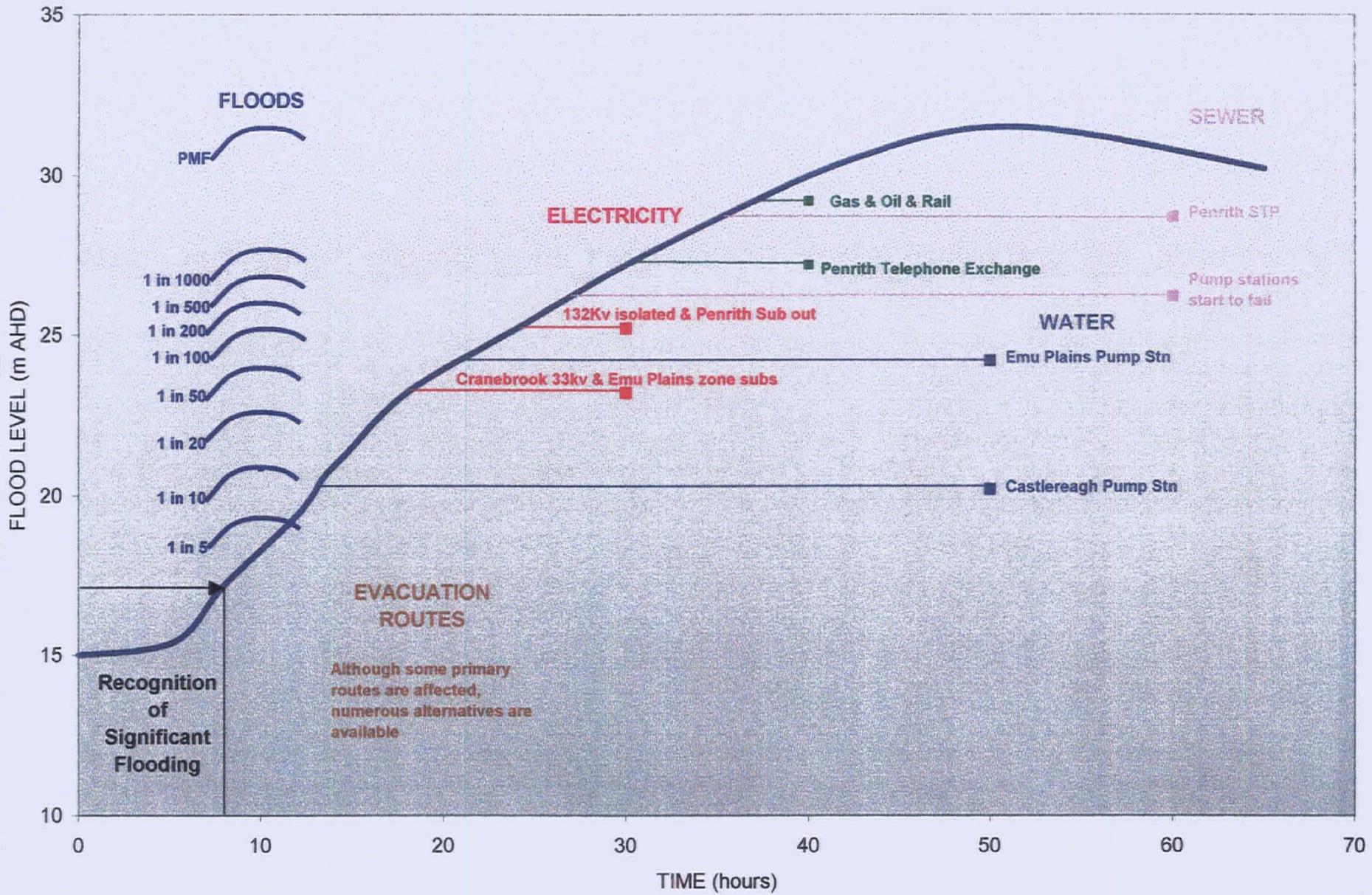
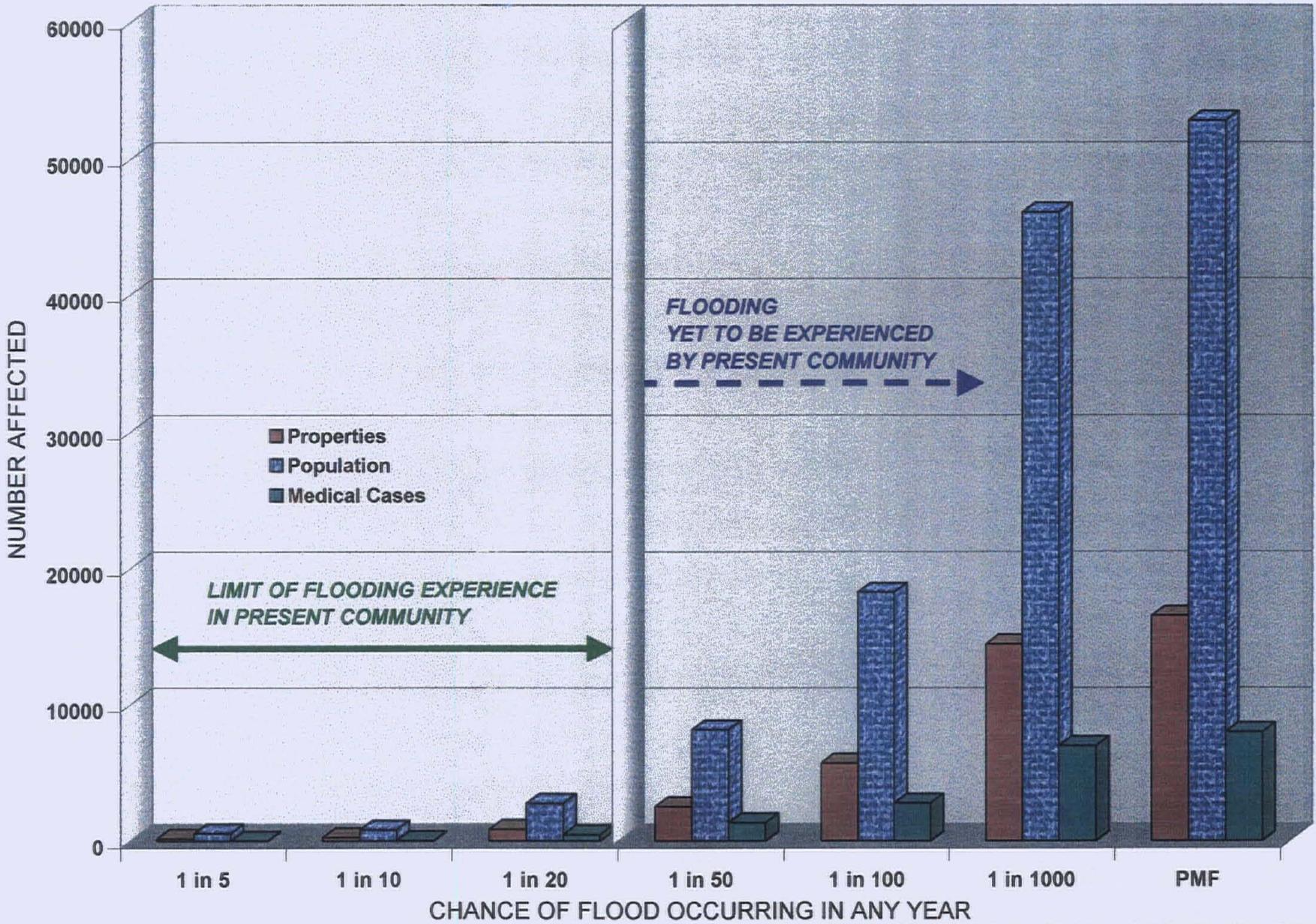


Figure 5.3 Penrith District Infrastructure Impacts

Adapted from 'Impacts of Flooding on Communities and Infrastructure'. Molino-Stewart

Figure 5.4 Social Effects of Residential Flood Damages



Adapted from 'Impacts of Flooding on Communities and Infrastructure', Molino-Stewart

Flood modification measures were considered on both a regional (*valley-wide*) basis, including upstream and downstream of Warragamba Dam, and on a local basis (*eg for individual townships*). Options were formulated based on discussions with various stakeholders. Consideration was given primarily to measures to reduce the flood hazard for floods in the range of the 1 in 100 to 1 in 500 chance per year floods where most damage reduction can be realised.

5.2.3 Valley-wide Options

Possible major flood mitigation dams and major bypass channels, at critical points of the river, were examined. It was considered that the high economic and environmental costs involved with the mitigation dams would render them inappropriate.

Of the bypass channels, a channel linking the river near Wilberforce to Currency Creek was found to have the potential to lower flood levels upstream by up to 1.0 metres but at the expense of increased flood levels downstream, of up to 0.7 metres, for the range of floods referred to above in Section 5.2.2. Further, it would require significant excavation and bank protection works with associated environmental and social impacts including some property resumption.

The Committee has noted that investigation of this channel option would be required in the local flood planning activity including detailed assessment of any further flood damages arising from the changes in flood behaviour.

Flood warning and voluntary purchase of high risk properties are the other options that have merit and could be pursued further. Modification to Warragamba Dam gate operations can provide a measure of flood level reduction but possibly at the expense of warning time. This option is currently being examined by the Sydney Water Corporation and the Department of Land and Water Conservation as explained in both Sections 1.6 and 3.3.

5.2.4 Local Options

Options for site-specific flood behaviour modification were considered for communities at Wallacia, Penrith/Emu Plains, Windsor/Richmond and downstream of Sackville, including levees, retarding basins, flow deflectors, emergency access, bank protection and channel improvements. Most however, were considered impractical for economic, social and environmental reasons. Those which were deemed worthy of further consideration are listed below by individual areas:

Wallacia

- raise Park Road to provide high level access and flood mitigation along Jerrys Creek.

Penrith/Emu Plains:

- possible levees along various parts of the river, the most promising being on the Penrith side upstream of the M4 Motorway;
- deflection walls near Jamison Road and Captains Road to reduce overbank velocities;
- emergency access to the M4 at Regentville; and
- bank protection between Regentville Bridge and Victoria Bridge;

Windsor/Richmond:

- a series of levees at McGraths Hill, Riverstone, Windsor, Bligh Park, Mulgrave, Pitt Town and Wilberforce. These works could provide protection up to the 1 in 50 chance flood level but would present significant social problems. The local community would need to be enthusiastic about the works for these to be pursued further;
- raising of various roads to provide high level evacuation routes; and
- a refuge mound at McGraths Hill.

Downstream of Sackville:

- a possible levee at Wisemans Ferry;
- possible velocity protection at Spencer;
- a series of escape roads and helicopter pads to service the small communities strung along the valley; and
- improved flood warning and dissemination of such information in a timely and effective way to the affected communities.

The above options were considered to have some merit and possibly worthy of further consideration by each Council, as part of the preparation of their local Floodplain Management Plans. Such consideration would need to include a detailed benefit/cost analysis including the implications of the particular option to flood emergency planning.

5.2.5 Conclusions of the Investigation

This investigation concluded that the number of potentially viable structural engineering options is very limited due to the nature of the valley, the widespread urban development and the magnitude of the flood hazard. More detailed investigations (including a cost-benefit analysis) would be necessary and the local community consulted before any implementation.

The need to consider the above options not as stand-alone works, but in conjunction with measures recommended in other parallel studies, is stressed. Improvements to the flood forecasting and warning system, community flood awareness and evacuation routes are measures that clearly must be instituted as a minimum to reduce flood risks.

Further information about this investigation is provided in Appendix B.

5.3 LAND USE PLANNING AND DEVELOPMENT CONTROL MEASURES**5.3.1 Scope**

This study was carried out to:

- review current floodplain planning practice within the valley;
- formulate and assess various land use planning options; and
- identify appropriate regional planning measures, policies and guidelines, to assist local floodplain management.

The Study recognised that decision makers and the community did not fully understand the real flood hazard and consequently the flood risks that exist in the valley. It is commonly perceived that the flood hazard only exists on land below the flood planning level, that is, within the area over which where restrictions are placed on development (*generally the 1 in 100 chance per year of occurrence*). Floods can occur well above this level (*Webb McKeown 1997*). The rarest flood that could occur may have the potential to inundate the valley and pose a threat to life and property. For example, in parts of the study area, the level of this rarest flood could be up to nine metres above the 1 in 100 chance per year flood.

In recognising that the flood hazard varies across the floodplain, the study aimed to balance the likelihood and consequences of flood events by considering land use planning options which distribute land uses within the floodplain and control development to minimise flood consequences. Relevant existing and potential urban development areas for such consideration are illustrated in **Figure 5.5**.

To achieve this, a range of development options was evaluated using several criteria (*eg flood damages, evacuation, orderly/efficient urban development*). **This approach found that a matrix of development controls, based on the flood hazard and the land use, can balance the risk exposure across the floodplain, as well as substantially reduce economic losses (Table 13.1, Appendix C).**

5.3.2 Strategic Role of Environmental Planning

Planning measures provide the greatest opportunity to control future increases in risk. Floodplain management deals with occupying the floodplain and optimising its use in a manner which is compatible with the flood hazard and at a level of risk acceptable by the community. Substantial reductions in damages and risks to life can be easily achieved by distributing land uses within the floodplain in a manner which recognises their differing vulnerability to flood risks. Effective regional and local land use planning and emergency planning is the key mechanism by which the flood risks can be managed. To achieve sound flood management through land use planning the Study recommended the following activities:

Metropolitan Planning

- recognise the full range of flood risks up to the PMF in metropolitan planning strategies, including definition of unacceptable flood hazardous areas for development;
- establish a sub-committee of the Metropolitan Strategy Committee to consider flood emergency response when planning for urban development; and
- fully utilise the Environmental Planning and Assessment Act to support graduated planning controls across the full flood risk, such as directives and planning instruments.

Local Planning

These activities would be outcomes from the proposed Regional Floodplain Management Strategy:

- establish appropriate floodplain management methodology, by way of best practice planning guidelines, to assist local councils in the preparation of relevant planning instruments (*eg LEP/DCP/LAP*); and

- provide assistance to councils by means of best practice guidelines for subdivision and building design in flood risk areas.

The Study also found that continued development of the floodplain is acceptable provided that the implications of flooding, across the full range of flood risks, and compatibility with flood emergency plans, are fully taken into account.

The Study therefore recommended the promotion of comprehensive floodplain management plans and the use of flood policies by Councils, rather than continuing to rely upon a singular flood planning level (FPL), such as that commonly related to the 1:100 chance per year flood.

This may be achieved if land uses are compatible with the local flood hazard. For example:

- road infrastructure serving new development areas must be orientated and located to support evacuation of all residents, as part of flood emergency plans;
- land uses to be appropriately distributed across the floodplain recognising the full range of flood risk;
- floor level controls and flood proofing should be required of new development so as to reduce structural damage;
- land uses such as parks, recreation areas, agriculture and certain industries which are relatively less affected by flooding, should be encouraged on the lower areas of the floodplain; and
- conversely, developments such as hospitals and nursing homes should be located on high areas, towards the edge of floodplain or preferably beyond the floodplain.

5.3.3 Social Effects

To ascertain the study area's social characteristics, an assessment of census data over the last 10 years was undertaken. This found that there has been continual and substantial growth in the number of dwellings and population in the area. It concluded that the social and economic implications of flood losses (*personal and property*) may be severe, particularly in the newer release areas, where property owners are usually first time buyers of relatively low income and generally comprise young families. The importance of these factors needs to be recognised and considered when planning future urban areas within the floodplain, particularly as these young families are less able to cope financially and may need to be reliant upon charitable or government relief if they experience flood losses.

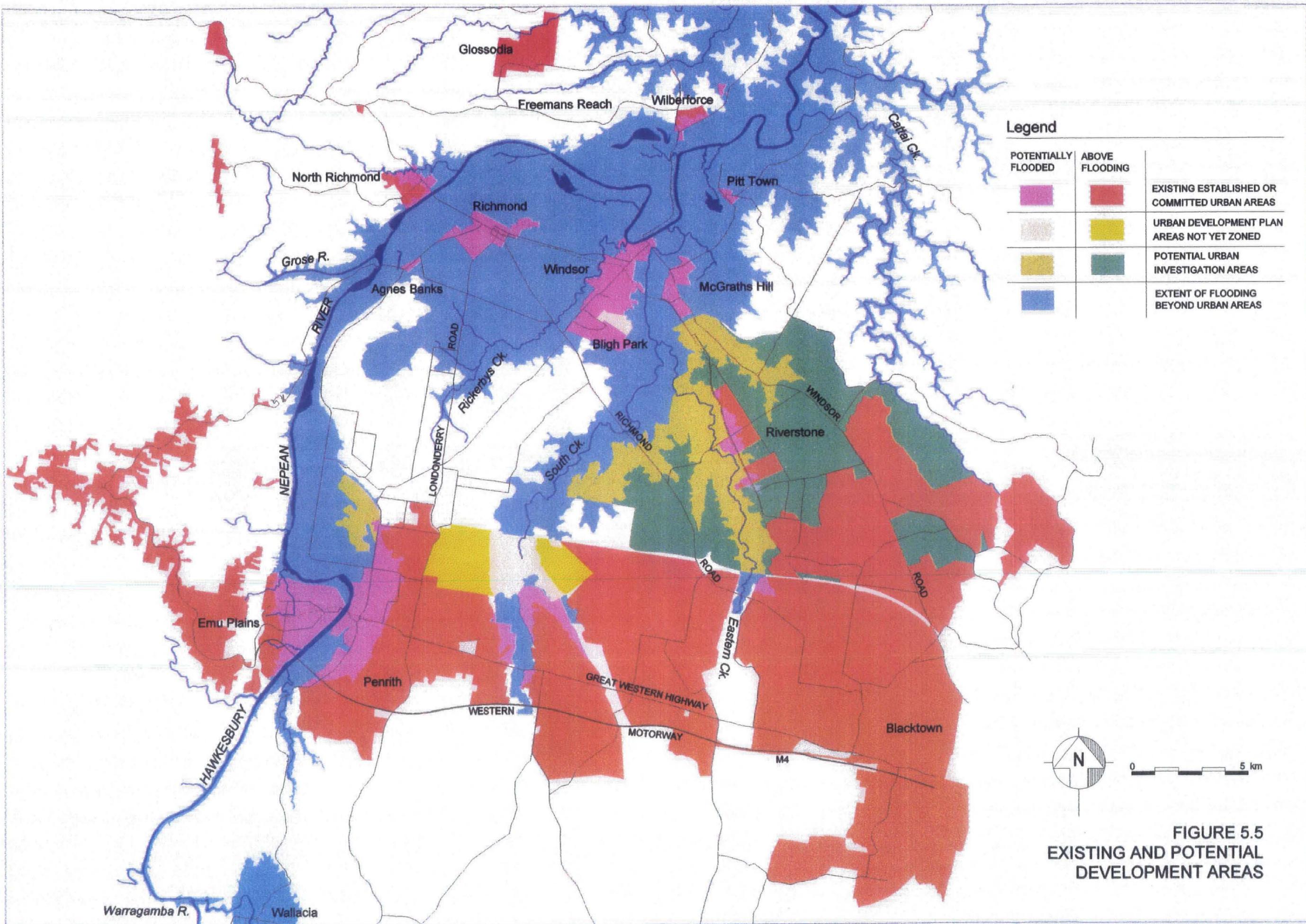


FIGURE 5.5
EXISTING AND POTENTIAL
DEVELOPMENT AREAS

5.3.4 Communicating Real Flood Risk to the Community

The study highlighted the need for:

- ◆ a flood awareness program that is co-ordinated at a regional level. The program could include such educational measures as flood warning poles, evacuation signs, flood displays, training of key personnel and media liaison.
- ◆ an informed Section 149 Certificate, consistent across the six local Government Councils, which would clarify, and require Councils to notify the whole of the potential flood hazard (*ie up to the PMF*); and
- ◆ Councils to regularly (*every three years*) issue a flood certificate to all property owners and residents in the floodplain identifying the flood hazard.

Further information about this study is provided in Appendix C.

5.4 EMERGENCY RESPONSE PLANNING AND TRAFFIC INFRASTRUCTURE

5.4.1 Scope

This study involved a review of the current flood emergency plans and the regional urban road network and its capacity to handle evacuation traffic. Communications, flood forecasting and flood warning systems and interdependencies with utilities and relevant community support services in the valley were also reviewed.

In carrying out the work, discussions were held with:

- State Emergency Service;
- Bureau of Meteorology;
- Department of Land and Water Conservation;
- Sydney Water Corporation;
- Roads and Traffic Authority; and
- Penrith and Hawkesbury City Councils.

5.4.2 Flood Forecasting

It is apparent that the Bureau of Meteorology flood forecasts, which will be crucial in initiating evacuations when significant floods are a threat to the valley, may not provide sufficient lead time to ensure successful completion of the task before local mainstream flooding cuts evacuation routes. Better data and computer links with Sydney Water are required, as are state-of-the art radar tools. These will help ensure that river height predictions are both more timely and more accurate than in the past and will allow evacuation decisions to be made with greater confidence.

5.4.3 Flood Warning

The availability of the most accurate and timely flood forecast is of no avail if a warning system that is effective, timely, and understood by the affected population is not in place. Current plans rely on some utilisation of the broadcast media, both radio and television, with heavy reliance upon a

"doorknocker" system utilising as many as 600 volunteers who must be inserted into the evacuation area and then evacuated themselves. The present plan does not have the redundancy necessary nor does it utilise techniques that have been proven to be effective in other flooding situations.

Consideration should be given to the adoption of early warning techniques such as development of an emergency warning broadcast system for both radio and television, and installation of a warning siren network that supplement those warning actions presently relied upon. Validation of existing warning systems should be performed.

5.4.4 Local Flooding and Evacuation

The study found that local flooding could cut the currently available evacuation routes at about 100 locations. Preliminary assessments of the runoff characteristics of the local catchments indicated that at some of these low spots, local flooding could cut the roads for up to 20 hours. The majority of the durations of local flooding were in the range 1 to 12 hours. Given the very short time available to effect an evacuation (*eg. 14 hours in the Windsor area*) it was concluded that local flooding of the current road network could completely frustrate the existing evacuation plans.

Preliminary assessments and costings were carried out of the work necessary to upgrade each low point on the evacuation routes, so that the risk of local flooding would be eliminated.

5.4.5 Traffic Assessments

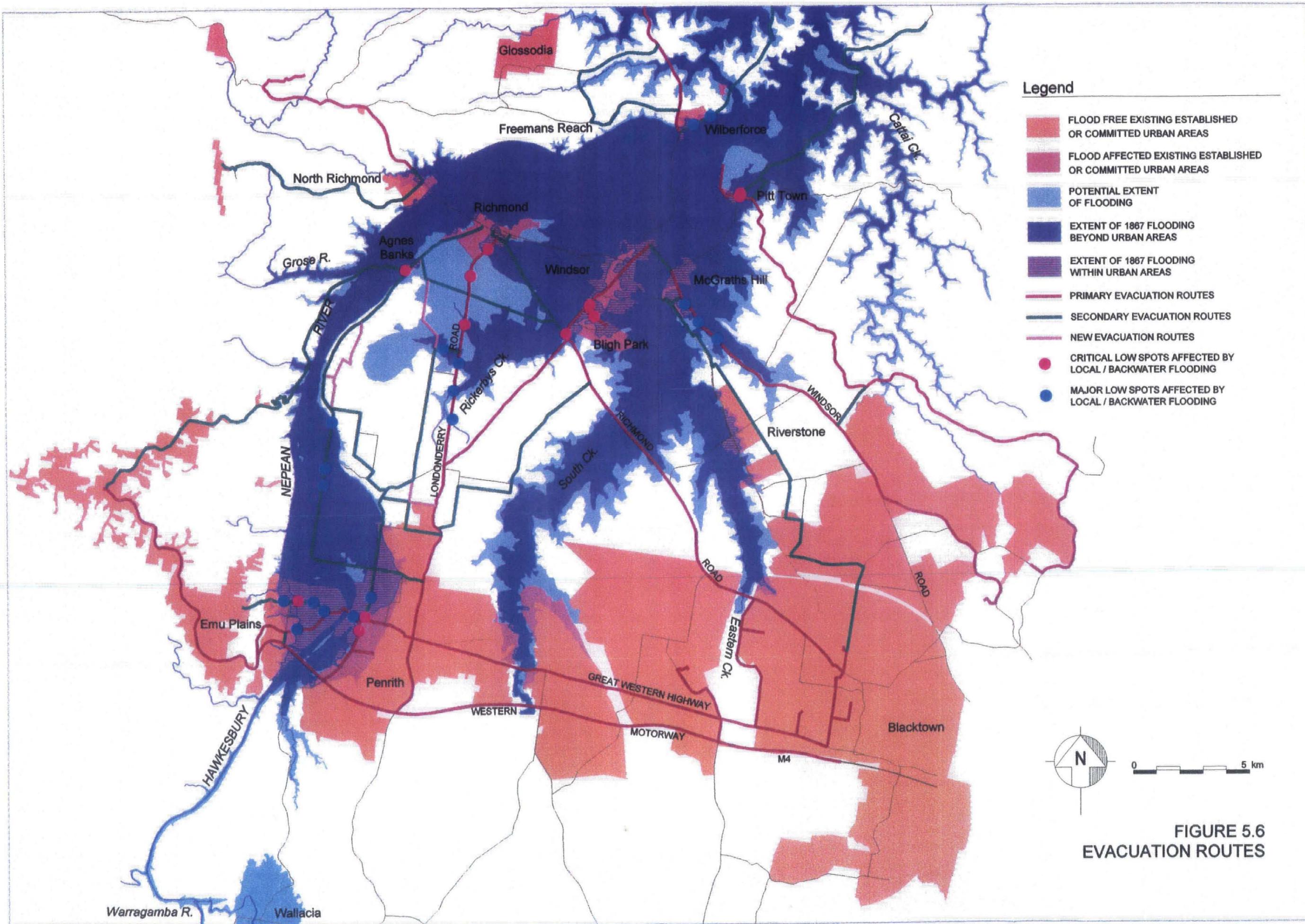
The condition of the existing road system was assessed by field surveys and then used to assess traffic capacities. Areas of potential local flooding were assumed to have been upgraded. The traffic dynamics of the evacuation process was examined across all suitable roads i.e. not just the evacuation routes nominated in the emergency response plans. Minor improvements, to provide a general improvement in safety and to preserve the traffic capacity of the system, were identified, Figure 5.6. There may be further improvements following the investigations listed in Section 5.4.7.

The study found that if no action is taken to upgrade the existing evacuation routes from their present condition and local flooding occurs, the majority of the flood prone population (*some 60,000*) will be isolated with potential for loss of life if severe flooding (*ie. In excess of the 1 in 250 chance per year*) occurs. Even if the threat of local flooding is mitigated by appropriate works, the study found that the road system cannot cope with the present evacuation task and 15,000 persons can be expected to remain un-evacuated and potentially drowned if severe flooding occurs, that is in excess of about the 1 in 250 chance per year flood. There is no possibility that a majority of these people could be evacuated by other transportation means such as boats and helicopters, or by rail.

5.4.6 Upgrading of Evacuation Routes

A preliminary program of road improvements was developed which allowed for the viability of evacuation routes to be phased in across the valley, to increase their effectiveness. The works represent a mix of low spot rectification, minor road raisings and increased traffic lanes.

The preliminary estimate of the Evacuation Infrastructure Program (*roads*) is \$46 million. This is the minimum amount required to provide the road infrastructure needed to evacuate the existing population at risk in the event of a severe flood, plus allowances for development of currently zoned land within the floodplain. This minimum amount should not be confused with the individual phases of the Program which merely reflect a logical implementation of the works across the valley.



5.4.7 Further Investigations

Studies to date have focussed on quantifying the capacity of evacuation routes to deal with vehicle movements along arterial roads out of the floodplain to evacuation centres. No quantitative assessment has been possible in the time available of the full logistics of mobilising an evacuation on the massive scale required in a very severe flood on the Hawkesbury-Nepean River.

Additional research must be carried out to verify that evacuation operations can be successfully completed in the time available. This will require investigation of:

- ◆ the time required to mobilise evacuees (*measured from the point at which it becomes apparent that evacuation will be necessary*);
- ◆ the accessibility of evacuation routes from suburban streets under conditions of local flooding and with traffic congestion likely;
- ◆ multiple access from within discrete urban development areas, such as Bligh Park, to arterial evacuation routes;
- ◆ availability of busses in sufficient numbers as indicated in the flood emergency plans;
- ◆ availability of rail assets for shuttle operations;
- ◆ availability of appropriate aircraft and sites from which to operate them; and
- ◆ the suitability of existing nominated evacuation centres and the identification of alternatives if necessary.

5.4.8 Cost Estimates for the Study's Recommended Evacuation Infrastructure

~~Cost estimates for recommended evacuation route upgrades are summarised as follows~~

Specific details and priorities for construction can be found in the supporting reports prepared by Patterson Britton & Partners Pty Ltd and Masson and Wilson Pty Ltd.

Existing Population (60,000)

~~Road works to allow current Flood Emergency Plan to be fully implemented~~ These works exclude \$800,000 for current expenditure in the 1997/98 financial year to planned improvements for Londonderry Road. They would enable evacuees to reach evacuation centres, and would provide a level of essential reserve capacity ie. increase security of evacuation by providing tolerance for incidents such as traffic accidents, fallen trees and cables across roads.

Roadworks - Existing Population - Subtotal	\$37,300,000
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Future Growth

Upon completion of the above road works, the Richmond area evacuation infrastructure may have the ability to absorb a further 7,500 people, but at the expense of reserve capacity. This is because Windsor shares part of Richmond's evacuation routes. Richmond then would have no capacity to absorb urban growth unless further infrastructure upgrading to re-establish reserve capacity was constructed.

Additional road works to cater for additional evacuees from future development of currently zoned residential areas, and prospective Urban Development Program Areas, to ensure no loss of essential evacuation route redundancy (\$8,000,000 nominal amount).

Roadworks – Future Growth – Subtotal	\$8,000,000
Roadworks – TOTAL COST	\$45,300,000

The Committee expressed interest in the need for the full program to be assessed in relation to the relative degree of flooding which may otherwise cut off the use of the evacuation routes. The Consultant's report demonstrates that at present, the lowest point of the most elevated evacuation route for the Richmond/Windsor area, for example, would be cut by approximately a 1 in 50 chance per year flood from the Hawkesbury River.

Upon completion of the proposed roadworks to ensure the evacuation of the affected community, the lowest point of the most elevated evacuation route would then be affected until a rarer flood of approximately 1 in 200 chance per year occurrence from the river.

Therefore, this demonstrates that irrespective of the severity of flooding, for example within the range of the 1 in 200 chance per year occurrence up to the potential limit of flooding, there is no sensitivity relative to the cost of the roadworks for the purpose of evacuation.

5.4.9 Flood Emergency Planning Issues

The study identified many opportunities to improve the effectiveness of flood emergency plans in the valley. Some of the more significant opportunities could be achieved by:

- immediately upgrading the evacuation routes as previously described;
- enabling the Bureau of Meteorology to utilise the latest technology for flood forecasting and early flood warning capability;
- altering the present Flood Emergency Plans so that control of flood operations at all levels of flooding is retained by the SES;
- preparing flood evacuation plans for areas between Wilberforce and Spencer;
- establishing full time Division Controllers for the SES to improve flood combat capability and provide resources for a concerted public awareness program;
- establishing an effective/proven flood warning system based on the use of several warning methods;
- implementing a comprehensive public awareness program;
- planning and development of new urban release areas so as to ensure the safe evacuation of existing residents;
- planning all future road improvements where appropriate, to facilitate the evacuation process; and
- completing a regional floodplain management study to provide a regional focus for the preparation of local floodplain management plans by each Council in the valley.

Further information about this study is provided in **Appendix D**.

Chapter 6 HAWKESBURY-NEPEAN FLOODPLAIN MANAGEMENT STRATEGY

6.1 A REGIONAL FLOODPLAIN MANAGEMENT STRATEGY FOR THE VALLEY

The primary objective of the Committee was to prepare a comprehensive strategy for floodplain management in the Hawkesbury-Nepean valley. In doing so, the Committee considered many matters relating to the Terms of Reference. The basis for consideration of some of these matters were the findings of existing studies as discussed in Section 1.6 of this Report. Technical studies were also commissioned as discussed in Section 1.7 and Chapter 5 of this Report to round out the range of matters considered so as to enable the Committee to examine all of the components of such a comprehensive Strategy.

The Committee recognised that the majority of the Strategy's components could be assessed to a final level of detail. It was also recognised that there would be some components, such as evacuation infrastructure and planning, which could be addressed only to the level of detail to enable the estimation of the order of costs attributable to essential works, subject to later design detail and appropriate environmental impact assessment.

The Committee concluded that the resultant Hawkesbury-Nepean Floodplain Management Strategy should deliver a comprehensive Regional Floodplain Management Study from which the local Councils can prepare their own Floodplain Management Plans and Policies consistent with the merits approach of the Floodplain Development Manual. The Strategy should also deliver a program for implementation, management and monitoring as proposed in Chapter 7.

In preparing its Strategy, with many components completed to a sufficient level of detail the Committee has effectively completed a substantial portion of the Regional Floodplain Management Study.

6.2 COMPONENTS OF THE HAWKESBURY-NEPEAN FLOODPLAIN MANAGEMENT STRATEGY

The Committee has carefully considered all available background information and the reports by commissioned Consultants. The overall components and proposed outcomes of the Committee's resultant Hawkesbury-Nepean Floodplain Management Strategy are shown in Figure 6.1.

It was recognised that the majority of the Strategy's components could be assessed to a final level of detail, and in so doing, also provide a substantial portion of a Regional Floodplain Management Study. The proposed Strategy also delivers a work program with budgetary and action responsibility for its implementation. The range of Strategy components, therefore, is discussed in the following items:

6.2.1 Existing Development

- *Flood Evacuation*

In a severe flood, evacuation will be necessary to ensure the safety of the floodplain community. A major constraint to the SES is the lack of reliable evacuation routes which have adequate traffic handling capacity to move large numbers of vehicles under extremely difficult conditions and in a very short time.

The existing road network is cut frequently by flooding from local drainage at about 100 locations. This has the potential to completely frustrate any effort in evacuation. The majority of the population at risk (*some 60,000 people*) would also be isolated by floodwater from the Hawkesbury River at very low levels and potentially lost in severe flooding, if the evacuation routes are not upgraded.

A substantial road improvement program, including rectification of low spots, minor road raisings and increased traffic lanes, is recommended. The program of upgrades would also provide immediate benefits for the whole region in terms of normal road use, by increasing capacity and road safety and by minimising the impacts from local storms which can be extremely hazardous and highly disruptive on frequent occasions. Further investigation into the accessibility of evacuation routes from local neighbourhoods, and the assessment of evacuation by rail, air and bus are also recommended.

- *Public Awareness*

Heightened public awareness is essential to generating the best public response to evacuation. Studies have shown that such public awareness reduces evacuation time, reduces actual flood damages (*particularly commercial and industrial*) and helps to reduce the post-flood trauma of the affected population. Broad education activities to engender improved public awareness (*both passive and active measures*) need to be examined at the regional and local levels.

Public awareness is currently limited to relatively frequent flood events (*less than a 1 in 40 chance per year*), which have so far, only predominantly affected the rural communities. A desirable consistency in local government Section 149 certificates relating to flood policies, and tailored public awareness programs, are important measures that need to be co-ordinated at the regional level.

- *Flood Behaviour Modification*

Computer flood models of the flood behaviour in the valley are available to define the magnitude of the flood hazard. Opportunities for flood mitigation works to reduce the flood hazard, were examined on both a valley-wide basis and on a local area basis (*eg. for specific townships*) and included upper catchment dams, various levees, detention basins and modifications to the main river channel.

The majority of valley-wide options have low viability because of their high capital, environmental and social costs. However, opportunities for flood behaviour modification at the regional level needed to be examined to a preliminary level of detail, to identify options which may be worthy of detailed evaluation by local government as a component of local floodplain management plans. These works need to be complemented by other measures such as public awareness and any warning/evacuation requirements.

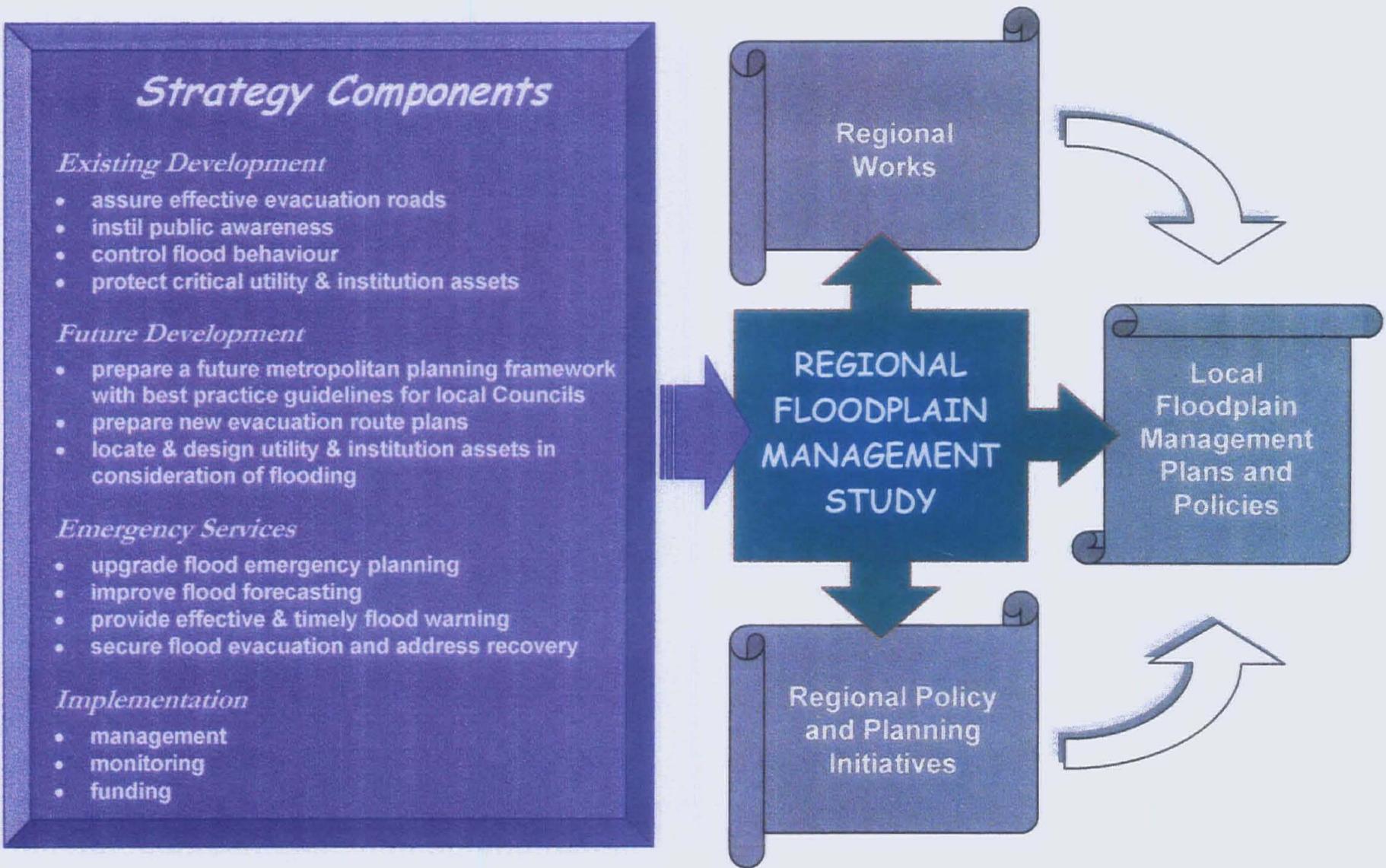


Figure 6.1 Structure of the Hawkesbury Nepean Regional Floodplain Management Strategy

- *Utilities and Institution Assets*

Key utilities and institutions operating within the valley (eg. power, gas, water, sewerage, transport, telecommunications and hospitals), are prone to substantial flood damage to varying degrees. Some utilities such as power and telecommunications will fail early in a flood, thereby making emergency response more difficult. Significant flooding would cause the loss of essential services for months and prolong recovery.

Short and long term opportunities to reduce the vulnerability of essential services should be encouraged by the State Government. Most important is the development and/or review of flood recovery plans for both public and private utilities and institutions. In the longer term, consideration should be given to the relocation and/or flood resistant design of various infrastructure assets currently in the floodplain, and to promoting better co-operation and co-ordination between all utilities because of their inter-dependence (eg. power and telecommunications).

The improved security can provide increased benefits for communities outside the floodplain, by minimising disruption from loss of services.

6.2.2 Future Development

- *Future Metropolitan Planning Framework*

Land use planning measures provide the greatest opportunity to control future increases in flood risk and to bring about changes within planning timeframes. Flood sympathetic development can offset higher risks and bring about a substantial reduction in economic losses. This is important given that insurance for residential flood losses is not available, and that a large proportion of flood damages are likely to be borne by first-time home buyers with relatively lower incomes. This group, which generally comprise young families, is less able to cope financially with the impacts of flooding.

A comprehensive regional framework of policies and guidelines, supported at the metropolitan planning level, is needed to ensure that future development is wholly consistent with the full range of flood risks and facilitates the evacuation of existing and future communities. These would introduce the distribution of land use type, building form and densities over the floodplain and graduated planning controls (rather than a singular FPD), whereby future development reflects the variation in flood risks throughout the full range of flooding and across the whole floodplain. This approach would be consistent with the State Government's Flood Policy and Floodplain Development Manual.

At a local level, there is need to prepare a methodology for incorporating variable flood risk into local floodplain management plans and planning controls (ie. LEPs, DCPs and LAPs). Councils can be assisted in this way by the State Government initiating best practice guidelines for planning to address flood risks, flood compatible subdivision design and building design. The primary aim of these measures is to optimise use of the floodplain while simultaneously managing development to ensure public safety and to minimise flood consequences.

6.2.3 Emergency Services

- *Flood Emergency Planning*

The principal aim of flood emergency planning is to save the lives of those exposed to the threat of severe floods. The appropriateness and viability of current SES Flood Plans detailing actions in a flood event for the study area, need review in light of the more recent findings of the Committee relating to flood evacuation.

The review will need to address the logistical and technical support requirements of the SES to improve flood combat efficiency and allow regular exercising of the Flood Plans. Opportunities to improve the effectiveness of the Plans include the implementation of a computerised flood intelligence system, the testing of inter-agency communication systems and the establishment of real-time flood data linkages between key agencies. Specific Flood Plans will also need to be developed for isolated and remote communities in the lower reaches of the Hawkesbury River.

- *Flood Forecasting*

Accurate prediction of river levels based on forecast rainfall, very early in a potential flood event, is crucial to emergency response in the valley, however rainfall and flood forecasting, which is the responsibility of the Bureau of Meteorology, is a very complex and difficult scientific area. Flood forecasts may not provide sufficient lead time to ensure a complete evacuation before evacuation routes are cut.

Opportunities to improve the accuracy of flood forecasting were identified with the Bureau of Meteorology and Sydney Water. These included the enhancement of data acquisition and transfer with state-of-the-art systems, expanding the rainfall and river gauge network and the direct linkage of computers with Sydney Water.

The benefits of improved flood forecasting can be enjoyed throughout the valley and is not restricted to gains in flood evacuation and the flood affected community. In particular, the recommended weather radar system has been demonstrated elsewhere to be highly cost effective and would benefit the whole of Sydney.

- *Flood Warning*

Flood warning is concerned with ensuring that the affected population is made aware of the emergency situation and prepares for possible evacuation. Current plans rely heavily on a door-knock system and to a lesser extent on utilisation of the broadcast media which were found not to have the necessary redundancy to deliver effective and timely warnings.

A review is needed of early warning systems and procedures, which have proven effective overseas. These include the establishment of a formal public broadcast system using radio and television, and the installation of warning sirens.

- *Post Flood Recovery*

A small but vital part of emergency response planning is the recovery of affected communities after the flood event. For a significant flood, the recovery operation will be a substantial exercise because many people may need alternative accommodation, medical treatment, trauma counselling and welfare assistance for many months.

The extent to which the magnitude of the problem has been recognised and planned for by the State's welfare network needs to be examined. It was found that post-flood recovery plans needed review in light of the current understanding of the magnitude of flood impacts on the community.

Therefore, recovery plans of community welfare agencies needs to be reviewed.

6.2.4 Regional Floodplain Management Study

The culmination of the Hawkesbury-Nepean Floodplain Management Strategy will be a Regional Floodplain Management Study (RFMS) which will provide a detailed assessment of regional flood policy and regional floodplain management issues. The RFMS will provide the regional focus needed by each Council to determine the most appropriate local flood policy and prepare an effective local floodplain management plan, for its local government area, in accordance with the Floodplain Development Manual. In preparing the Strategy, with many components completed to a sufficient level of detail, the Committee has effectively completed a substantial portion of the RFMS.

6.2.5 Implementation of the Strategy

- *Management*

The Regional Floodplain Management Study embraces a range of complex issues spread across numerous Federal, State and local government authorities. Co-ordinated and dedicated project management will be required to complete the Study within a short but realistic timeframe. In the Committee's view, this can be achieved by reconstituting the existing Committee as the Hawkesbury-Nepean Floodplain Management Steering Committee, reporting directly to Cabinet.

- *Monitoring*

To ensure that the objectives of the Strategy are met, there is a need to monitor the progress and priorities of the recommended activities through a single project management authority. The existing Committee, reconstituted as a Steering Committee, would be in the best position to monitor implementation of the Study compared to other options, as it is already fully conversant with the range of issues and has developed a strong working relationship between all stakeholders.

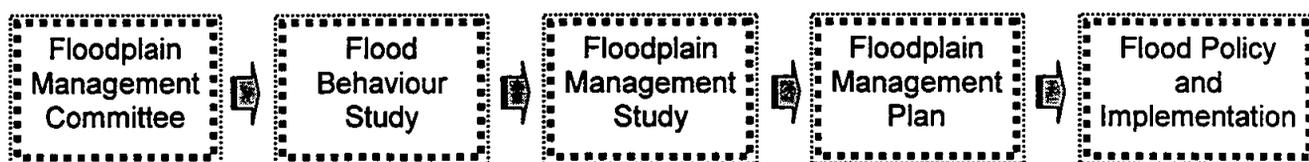
- *Funding*

The completion and implementation of the Strategy will require the co-ordinated provision of funds. Hence the recommended sources and amounts of funds needed have been identified across all the Strategy components as described in the Conclusions of the Report.

6.3 REGIONAL FLOODPLAIN MANAGEMENT STUDY

Local Government has a responsibility to prepare local floodplain management plans in accordance with the Floodplain Development Manual. These plans identify the measures which have been adopted by each Council to manage the flood hazard which occurs throughout its local government area. The measures may be structural or non-structural and they must be implemented in a co-ordinated fashion across the floodplain to ensure effectiveness.

The following diagram illustrates the usual process for achieving local floodplain management.



A floodplain management committee is formed by a council. A flood behaviour study enables that committee to identify stages of flood flow, depth, velocity, inundation extent and related hazards. The committee is then ready to undertake a floodplain management study which identifies and assesses relevant socio-economic, environmental and land use issues related to flood mitigation works, flood damages, flood emergency response and contingency planning.

Then follows the preparation of a floodplain management plan that provides measures to manage the existing, future and residual flood damage and flood hazard problems, and minimises the exposure of the community to flooding. Finalisation of such a plan requires complementary local environmental planning policies and development controls. The council is then able to adopt and implement local flood policies which can be publicised and formally advised in such documents as Section 149 Certificates under the Environmental Planning and Assessment Act 1979.

Thus when the floodplain lies in a single local government area, co-ordination across the floodplain is achieved through consistent application of the particular Council's flood policy and floodplain management measures. The Hawkesbury-Nepean floodplain, however, has no less than six local government areas and many state government agencies which are responsible for providing infrastructure in the valley. It is almost impossible for each Council, operating independently, to carry out local floodplain management studies in such a way that they interlock to provide the regional floodplain management perspective and co-ordination which is essential for the preparation of effective, local floodplain management plans. A regional perspective is made all the more difficult to achieve because of the unique and potentially devastating character of flooding in the valley. Put simply, what has worked in other valleys, and the experience of other Councils and flood affected communities, has limited application to the Hawkesbury-Nepean valley.

The State Government has recognised this unique floodplain management difficulty in the setting up of this Committee, Section 1. **The culmination of the Hawkesbury-Nepean Floodplain Management Strategy will be a Regional Floodplain Management Study (RFMS) which will provide a detailed assessment of regional flood policy and regional floodplain management issues.** The RFMS will provide the regional focus needed by each Council to determine the most appropriate local flood policy and prepare effective floodplain management plans, for each local government area, in accordance with the Floodplain Development Manual.

The Committee has noted that guidance is also provided in the Manual on the adoption of an interim local flood policy as a temporary means of directing development decisions until such time as a local floodplain management plan is prepared and implemented.

When completed, the RFMS will deliver an assessment of the works and measures to be implemented by State Government agencies as well as detailed guidelines and crucial information to assist Councils to prepare their local floodplain management plans. The RFMS will contain the following items, many of which have been completed already.

Item	Cost to Complete
1. Flood Emergency Planning	Completed
<ul style="list-style-type: none"> • Identify opportunities to improve flood intelligence and flood combat efficiency; 	Completed
<ul style="list-style-type: none"> • Develop specification for computerised flood intelligence system. 	\$50,000
2. Flood Forecasting	Completed
Identify opportunities for enhancing flood and rainfall data acquisition with state-of-the-art systems to improve accuracy of flood forecasting.	Completed
3. Flood Warning	Completed
Identify opportunities to improve early warning system with emphasis on systems and procedures which have proven effective overseas in similar circumstances.	Completed
4. Flood Evacuation	Completed
Identify road infrastructure improvements to ensure adequate evacuation traffic handling capacity and security against road closures by local catchment flooding:	Completed
<ul style="list-style-type: none"> • Carry out preliminary appraisal re: existing population; 	Completed
<ul style="list-style-type: none"> • Prepare detailed infrastructure (<i>roads</i>) program to allow 5 year phased plan to be implemented for existing population and future urban growth on zoned land; 	\$200,000
<ul style="list-style-type: none"> • Prepare evacuation infrastructure (<i>roads</i>) plan for future urban development areas. 	\$100,000
5. Public Awareness	Completed
<ul style="list-style-type: none"> • Identify opportunities for engendering public awareness; 	Completed
<ul style="list-style-type: none"> • Establish concepts for preparation of a tailored regional public awareness program. 	\$50,000
6. Metropolitan Planning Framework	Completed
<ul style="list-style-type: none"> • Review current floodplain planning practice in the valley; 	Completed
<ul style="list-style-type: none"> • Identify opportunities for introducing regional planning measures, policies and guidelines to assist local government to prepare local floodplain management plans; 	Completed
<ul style="list-style-type: none"> • Prepare best practice floodplain management methodology for Hawkesbury-Nepean valley to allow Councils to develop local floodplain management plans which reflect the full flood hazard in the valley; 	\$300,000
<ul style="list-style-type: none"> • Prepare best practice subdivision guidelines; 	\$200,000
<ul style="list-style-type: none"> • Prepare best practice building guidelines. 	\$200,000
7. Flood Behaviour Modification	Completed
Examine opportunities for flood behaviour modification at the regional level and the local level.	Completed

8.	Critical Utility and Institutions Assets Prepare briefing documents for utility providers, agencies and institutions to prepare flood recovery plans.	\$50,000
9.	Funding Prepare costings and identify sources and amounts of funds needed and five year budget programme.	Completed
10.	Committee Administration and Community Consultation To allow co-ordination of RFMS, monitoring of the implementation of the Strategy and continued community consultation.	\$600,000
11.	Printing of RFMS	\$100,000
12.	Miscellaneous	\$150,000
Total Estimated Cost		\$2,000,000

The Study items remaining to be completed are further referred to in Section 7.4.

Chapter 7 RECOMMENDATIONS TO IMPLEMENT THE STRATEGY

Whilst Chapter 6 described the Committee's assessment of the Strategy's components including a substantial portion of the Regional Floodplain Management Study, this concluding Chapter recommends a means by which the State Government can implement the Strategy.

The four principal outcomes to be achieved by the implementation of the Committee's Hawkesbury-Nepean Floodplain Management Strategy are summarised as follows:

- ◆ works and plans to improve evacuation routes, nominated in Sections 7.1 and 7.3;
- ◆ government policy initiatives relating to co-ordinated flood emergency planning, flood forecasting, flood warning and public awareness, nominated in Sections 7.2 and 7.3;
- ◆ best practice floodplain management and planning policies, nominated in Sections 7.2 and 7.3; and
- ◆ completion of the comprehensive Regional Floodplain Management Study, based upon which local Councils can prepare their own floodplain management plans and policies consistent with the merits approach of the Floodplain Development Manual, nominated in Sections 7.1 and 7.4.

The costs of promised elements of the Strategy have been estimated to a preliminary level of detail and where appropriate, the responsible government agencies have been nominated. Inter-agency collaboration will be required to achieve the desired implementation. The Committee's recommendations relating to the Strategy commence with Section 7.4.

Accordingly, the Committee has prepared detailed advice and recommendations for implementation and funding of the Strategy in Sections 7.5, 7.6 and 7.7.

The relevant abbreviations for the agencies, plans and programs referred to in those sections are as follows:

BoM	Bureau of Meteorology
DCP	Development Control Plan
DLWC	Department of Land and Water Conservation
DUAP	Department of Urban Affairs and Planning
EP&A	Environmental Planning and Assessment Act 1979
LAP	Local Approvals Policy
LEP	Local Environmental Plan
LG	Local Government
MUDP	Metropolitan Urban Development Program
RTA	Roads and Traffic Authority
SEMC	State Emergency Management Committee
SES	State Emergency Service
SW	Sydney Water Corporation
UDP	Urban Development Programs

The lead agency for action responsibility is underlined in each case.

7.1 STRATEGY COMPONENTS - IMMEDIATE PRIORITY

7.1.1 Evacuation Routes

(reference Sections 5.4.6, 5.4.8 and 6.2.1)

Implement the essential program of road improvements to the existing road system serving the Study area:

Cost: \$37.3 million

Action Responsibility: RTA and LG

7.1.2 Complete Strategy Components and Regional Floodplain Management Study

(reference Sections 5.4.9, 6.2 and 6.3)

Complete the Strategy components for which preliminary work was undertaken when developing the Strategy and carry out necessary detail assessments to **complete the Regional Floodplain Management Study** to serve as a basis for councils to complete their local floodplain management plans:

Cost: \$2 million

Action Responsibility: DLWC, DUAP, LG, SES and RTA

7.2 STRATEGY COMPONENTS - HIGH PRIORITY

7.2.1 Flood Emergency Planning

(reference Section 5.4.7, 5.4.9 and 6.2.3)

Provide necessary resources for SES to urgently review/rewrite and validate the Hawkesbury-Nepean Flood Emergency Plans and conduct annual exercises and updates. The scope of reviews and resourcing of SES should incorporate:

- augmentation of Flood Emergency Plans for the area downstream of Wilberforce;
- establishment of two full-time Division Controllers for plan reviews, emergency operations, flood preparedness activities and advice to Councils;
- verification of feasibility of buses for early evacuation;
- investigation of feasibility of trains and other systems for early evacuation;
- review and testing of voice communications systems including backup and agency interconnections;
- regular exercise of flood emergency plans;
- establishment of free flow of flood intelligence between major agencies (*ie. establish computer data linkages between SES, BoM, SW, Police*); and
- establishment of a computerised flood intelligence system for use by all flood agencies and to allow "what if" scenarios to be run to enhance emergency response planning.

Cost: \$700,000 + \$500,000 per year

Action Responsibility: SES

7.2.2 Flood Forecasting

(reference Sections 5.4.2 and 6.2.3)

Establish direct computer link between BoM and SW to speed up data transfer and reduce forecast times by one hour:

Cost: present resources

Action Responsibility: SW and BoM (in train)

Install redundancy or backup for field gauge communications to provide data security for those stations critical to the forecasting process:

Cost: \$200,000

Action Responsibility: BoM and DLWC

Expand the gauge network of rainfall and river gauges to improve accuracy of forecasts and provide essential data in downstream catchments of Colo and McDonald Rivers:

Cost: \$600,000 (see note Section 7.7 re Federal Funding)

Action Responsibility: BoM and DLWC

Encourage BoM to establish continuous working interface between meteorologists and river modellers to get best possible early rainfall forecasts and river level predictions:

Cost: present resources

Action Responsibility: BoM and DLWC

Establish fully operational weather radar acquisition system to provide state-of-the-art flood forecasting and flash flood warning system. Would benefit whole of Sydney:

Cost: \$16 million (see note Section 7.7 re Federal Funding)

Action Responsibility: BoM and DLWC

7.2.3 Flood Warning

(reference Sections 5.4.3 and 6.2.3)

Promote preparation or amendment of Federal legislation to establish public broadcast emergency warning system utilising both radio and television, based on proven overseas procedures:

Cost: present resources

Action Responsibility: SES

Install flood warning sirens for the main towns that have the potential to become isolated:

Cost: \$3 million

Action Responsibility: SES and LG

Verify feasibility/effectiveness of doorknock method of flood warning including mobilisation of necessary resources:

Cost: present resources

Action Responsibility: SES

7.2.4 Public Awareness

(reference Sections 5.3.4, 5.4.9 and 6.2.1)

Prepare and implement specifically tailored regional public awareness program in co-operation with local government, including use of radio, television and print media:

Cost: up to \$1 million per year

Action Responsibility: SES, LG and DLWC

Develop public education at local level through activities such as instructional packets for use by owners/householders, and in schools, Council newsletters, spot announcements on media and flood awareness booths at local events:

Cost: in item directly above

Action Responsibility: SES and LG

Implement evacuation route signage and traffic control markers including marking of flood levels on poles:

Cost: \$200,000

Action Responsibility: SES, LG, RTA and DLWC

Develop procedures to ensure evacuees register with evacuation centres so as to facilitate family reunification and reduce overall community anxiety in times of flood evacuation:

Cost: present resources

Action Responsibility: SEMC

Under co-ordination of a regional flood awareness program, **increase flood awareness through the provision of flood Policy notations on Section 149 Certificates:**

Cost: to be assessed

Action Responsibility: LG, SES

7.2.5 Regional Floodplain Management

(reference Sections 5.3.2, 6.2.2 and 6.3)

Establish best practice floodplain management methodology for the Hawkesbury-Nepean valley, based on the Floodplain Development Manual and full use of directives and planning instruments under the EP&A Act. Best practice should incorporate:

- Preparation and promotion of **guidelines for graduated planning controls across full range of flood risk** so that future changes of land use will be compatible with that flood risk;
- **specific State policy and strategy initiatives** which provide a comprehensive planning framework from which Councils can prepare local floodplain management plans;
- **review/amendment of UDP/MUDP strategy to ensure compatibility with full flood risks of the Hawkesbury-Nepean valley**, recognising that substantial reductions in flood damage growth and risk to life will stem from flood compatible distribution of land use;
- consideration be given to the **establishment of a sub-committee of the Metropolitan Strategy Committee**, (Department of Urban Affairs and Planning), **to advise on flood emergency response** relating to future urban development areas;
- **review of S149 notifications to include flood policies;**
- **preparation of best practice building guidelines** to encourage use of flood compatible building materials and practices;
- **preparation of best practice subdivision guidelines** to encourage development of subdivisions which minimise flood damages and facilitate evacuation and safety of residents; and
- encouragement of Councils to assist with the **establishment of additional SES centres** in areas of new urban growth:

Cost: incl in RFMS

Action Responsibility: DLWC, DUAP, LG, SES and Solicitor General (S149 notifications)

7.3 STRATEGY COMPONENTS - LOWER PRIORITY

7.3.1 Flood Emergency Planning

(reference Section 5.4.7)

Consider the effects of flooding of the Upper Nepean River on emergency response:

Cost: present resources

Action Responsibility: SES

7.3.2 Flood Evacuation Infrastructure (Roads)

(reference Sections 5.4.6, 5.4.8 and 5.4.9)

Implement detailed infrastructure (roads) plans:

- to ensure that presently zoned, undeveloped areas will have sufficient evacuation road capability as they are developed; and
- to ensure future UDP development areas will have sufficient road capability without affecting the existing floodprone population:

Sources of funding of roadworks to be determined.

Cost: \$8 M (nominal)

Action Responsibility: DUAP, LG, DLWC, RTA and SES

7.3.3 Post Flood Recovery

(reference Sections 5.1.5, 6.2.1 and 6.2.3)

Review post-flood recovery for evacuees in the light of the current understanding of the magnitude of human trauma which will be caused by major flooding:

Cost: present resources

Action Responsibility: SEMC

Initiate State Government directive to relevant state utility service providers and agencies including Integral Energy, Sydney Water, State Rail, RTA, Hospitals, to prepare flood recovery plans for their assets and infrastructure:

Cost: present resources

Action Responsibility: whole of government

Encourage relevant private utilities including nursing homes, Telstra, Optus, Vodafone, AGU to prepare flood recovery plans for their assets and infrastructure:

Cost : present resources

Action Responsibility: various

7.3.4 Local Planning

(reference Sections 5.3.2 and 6.3)

Promote the preparation of local floodplain management plans by Councils consistent with the Regional Floodplain Management Study, incorporating:

- application of graduated development controls;

- LEP, DCP and LAP consistent with regional methodology including, where appropriate, referral of rezoning and major development proposals to the SES for consultation;
- flood policies on S149 Certificates; and
- investigation of local flood behaviour works such as levees and/or diversion channels.

Cost: as per Government Policy

Responsibility: LG, DUAP, DLWC and SES

7.4 COMPLETION OF STRATEGY COMPONENTS AND REGIONAL FLOODPLAIN MANAGEMENT STUDY

RECOMMENDATION NO. 1

Completion of the various regional components of the Strategy which have to be implemented at the State agency level, and completion of the Regional Floodplain Management Study requires the following items to be addressed:

• prepare detailed evacuation infrastructure (<i>Roads</i>) program to allow 5 year phased plan to be implemented	\$200,000
• prepare best practice floodplain management methodology for the Hawkesbury-Nepean valley. Centre piece will be a practical framework for interpreting flood risk for land use categories across full range of flooding	\$300,000
• prepare best practice subdivision guidelines	\$200,000
• prepare best practice building guidelines	\$200,000
• establish concepts for preparation of a tailored regional public awareness program	\$50,000
• prepare evacuation infrastructure (<i>roads</i>) plan for future development in existing zoned areas and future urban development areas	\$100,000
• prepare briefing documents for utility service providers and agencies to prepare flood recovery plans	\$50,000
• develop specification for computerised flood intelligence system	\$50,000
• Committee administration and community consultation	\$600,000
• printing costs	\$100,000
• miscellaneous	\$150,000
Total Estimated Cost	\$2,000,000

Recommendation No. 1:
 After carefully considering all of the relevant matters relating to the Committee's Terms of Reference, the Committee recommends that the State Government adopt the Hawkesbury-Nepean Floodplain Management Strategy, as described above in Sections 7.1 to 7.4

7.5 IMPLEMENTATION OF THE STRATEGY

RECOMMENDATION NO. 2

Completion of the Regional Floodplain Management Study will require substantial co-ordination across various State Government agencies and the local Councils. The issues involved are complex and will require a dedicated project management focus to complete the Study within the timeframe of two years. Also, those components of the Strategy which are complete and can be implemented by the relevant responsible agency, subject to funding, will need to be monitored by a single dedicated project management entity, to ensure that progress and priorities meet the objectives of the Strategy.

The options for co-ordinating and managing the Study and monitoring the implementation of the Strategy have been considered as follows:

- ◆ reconstitute the existing Committee to become the Hawkesbury-Nepean Floodplain Management Steering Committee, reporting to Cabinet. The existing Committee is already conversant with the issues and having prepared the Strategy, would have the dedicated focus to monitor completion of the Regional Floodplain Management Study and related works and measures completed with the urgency the matter deserves; or
- ◆ an inter-departmental committee (IDC) could oversee the completion of the study. However, a new IDC would lack local government and community input, as a result of which there may be lack of acceptance of the final product by the public, or
- ◆ a single government authority could be given the overall responsibility to project manage the completion of the Regional Floodplain Management Study. Interdepartmental coordination would be difficult and the authority would lack local input as noted above.

Recommendation No. 2:

The Committee recommends that the State Government reconstitute the present Committee as the Hawkesbury-Nepean Flood Management Steering Committee with Terms of Reference being extended to co-ordinate and monitor the implementation of the recommended Strategy, including completion of the Regional Floodplain Management Study, thereby continuing close partnership between the Councils and community representatives of the valley, as well as relevant State Government agencies.

7.6 CO-ORDINATION OF LOCAL FLOODPLAIN MANAGEMENT PLANS

RECOMMENDATION NO. 3

The Regional Floodplain Management Study will provide a regional basis for local Councils of the valley to prepare local floodplain management plans in accordance with the Floodplain Development Manual. These local plans will include appropriate amendments to planning and development controls to give full effect to the regional framework, particularly with respect to flood emergency planning, infrastructure and public awareness.

Whilst the preparation of local floodplain management plans is the responsibility of local government, subsidised funding is available under the Government's Floodplain Management Program to assist each Council to prepare these local plans.

Recommendation No. 3:
 The Committee recommends that if a Steering Committee is established under to recommendation No. 2 above, its Terms of Reference further include an advisory regional co-ordination role during the period of preparation of local floodplain management plans by each local Council in the valley.

7.7 FUNDING OF THE STRATEGY

RECOMMENDATION NO. 4

The Committee has estimated that some \$57 million would need to be provided by special allocation in State Budgets over the next five years, commencing in the 1998/99 financial year, and that funding continue at \$1 million per year after the five years. These funds are proposed for the following purposes:

- ◆ implementing the vital works and measures nominated in Sections 7.1 and 7.3 of the Report; and
- ◆ completing the Regional Floodplain Management Study nominated in Section 7.4 of the Report.

Additional funding of \$0.5 million is required in the present 1997/98 financial year to facilitate completion of the Strategy components including part of the Regional Floodplain Management Study nominated in Section 7.4.

This will allow the Government to achieve its objective of providing better protection for the region's community.

Recommendation No. 4:
 The Committee accordingly recommends that the State Government endorse funding of the Hawkesbury-Nepean Floodplain Management Strategy in three stages:

• Stage 1:	Continuing work on the Regional Floodplain Management Study during the current 1997/98 financial year	\$0.5 million
• Stage 2:	Completion of the Regional Floodplain Management Study and implementation of the Hawkesbury-Nepean Floodplain Management Strategy during the 1998/99 to 2002/03 financial years as summarised in Table A below.	\$56.7 million
• Stage 3:	Continuation of Flood Emergency Planning and Public Awareness Program beyond 2002/03.	\$1.0 million per year

Table A : Summary of the Committee's estimates of prospective State Budget allocations over the next five years for the Hawkesbury-Nepean Floodplain Management Strategy

Strategy Components	1998/1999	1999/2000	2000/2001	2001/2002	2002/2003	Total
Evacuation Routes ☆	\$5.00 M	\$16.00 M	\$16.30 M	\$4.00 M	\$4.00 M	\$45.30 M
Completion of Regional Floodplain Management Study	\$1.50 M					\$1.50 M
Flood Emergency Planning ☆☆	\$0.85 M	\$0.85 M	\$0.50 M	\$0.50 M	\$0.50 M	\$3.20 M
Flood Forecasting ☆☆☆	\$0.20 M					\$0.20 M
Flood Warning		\$3.0 M				\$3.00 M
Public Awareness	\$0.50 M	\$0.50 M	\$1.00 M	\$1.00 M	\$0.50 M	\$3.50 M
TOTAL	\$8.05 M	\$20.35 M	\$17.80 M	\$5.50 M	\$5.00 M	\$56.70 M

☆ Total funding has been distributed to reflect a practical implementation.

☆☆ A once-only cost of \$700,000 has been distributed over the first two years. The annual cost of \$500,000 has been included over the full period of 5 years.

☆☆☆ Additional **Federal funding** amounting to \$16.6 million for Flood Forecasting Measures (*Section 7.2.2*) would be required in 1998/1999 to complement the amounts recommended above for inclusion in the State Budget allocations.

APPENDICES

The following four Appendices comprise extracts from the individual technical studies prepared by Consultants, commissioned to provide expert advice and recommendations to the Hawkesbury-Nepean Flood Management Advisory Committee:

Appendix A: <i>Impacts of Flooding on Communities and Infrastructure</i>	Molino Stewart Environmental Services
Appendix B: <i>Engineering Studies to Modify Flood Behaviour</i>	Webb McKeown & Associates
Appendix C: <i>Land Use Planning and Development Control Measures</i>	Bewsher Consulting and Don Fox Planning
Appendix D: <i>Emergency Response and Traffic Infrastructure</i>	Danielson & Associates Inc. USA in association with Patterson Britton & Partners and Masson & Wilson

The Appendices are intended to illustrate the essence of the Consultants' work. A set of the final Consultants' Reports was provided to each Minister's Office and to each Committee member prior to the Committee concluding this Report.

Each Appendix contains, in respect of the above reports, the following:

- a title page identifying the specific study;
- a summary of the main findings;
- recommendations; and
- significant illustrations and figures used in highlighting the main findings/recommendations.

**APPENDIX A
IMPACTS OF FLOODING ON
COMMUNITIES AND INFRASTRUCTURE**

**HAWKESBURY-NEPEAN RIVER
IMPACTS OF FLOODING
ON
COMMUNITIES AND INFRASTRUCTURE**

for

**HAWKESBURY-NEPEAN FLOOD
MANAGEMENT ADVISORY COMMITTEE**

by

**MOLINO STEWART
ACN 067 774 332**

**SEPTEMBER 1997
97005RP1.DOC**

SUMMARY

This report investigates the consequences of flooding for assets and communities in the Hawkesbury-Nepean Valley between Regentville and Spencer. There is particular emphasis on the more highly developed floodplain between Regentville and Sackville which includes Penrith, Richmond and Windsor and other urban centres.

It builds on previous work undertaken for Sydney Water into the effects of Warragamba Dam on flooding in the Hawkesbury Nepean Valley. Data on assets and infrastructure has been updated to reflect 1997 levels of development wherever possible.

The paper evaluates consequences for a range of floods up to the probable maximum flood and identifies the most significant consequences. Consequences are categorised as tangible or intangible and direct or indirect. It evaluates the potential for different strategies to reduce different types of damages in different sized floods. It was assumed for the analysis that Sydney Water would build an auxiliary spillway around Warragamba Dam and the spillway would have less than a 1 in 500 chance of operating in any year.

The topography of the Hawkesbury-Nepean Valley is such that the river can rise by up to 17 metres at Penrith and 26 metres at Windsor. The history of development in the valley is such that many assets and communities would be adversely affected by flooding. There is about a 1 in 3 chance per year that the river will overflow its banks and flood the extensive floodplain around Richmond and Windsor. Floods up to a level with a 1 in 20 chance of being exceeded principally affect this area and damage rural assets and communities. The community is reasonably well prepared for floods of this size.

On average, floods of this size cause about \$8 million in damages per year and individual floods could cost as much as \$190 million. Minor disruption of a few days duration occurs.

Larger floods affect the fringes of urban centres and the flood damage bill would escalate. A flood with a 1 in 50 chance of occurrence would flood the homes of nearly 8,000 people and could leave 1,500 of them homeless. Evacuation of more than 30,000 people would be necessary because evacuation routes would be cut before it was known whether flooding would reach levels which would inundate entire communities. The damage bill is likely to be between \$140 and \$530 million.

Larger floods would overtop the river banks at Penrith and flood extensive urban areas. Power supplies would be disrupted as would telecommunication, water, sewerage and gas systems. More than 30,000 non-flooded properties could be without electricity for several days and gas supplies to the Central Coast and Newcastle could be disrupted for a few months.

The larger the floods, the more extensive the damages. Buildings would fail, particularly in the Penrith and Emu Plains area where velocities are higher, and the disruption to utility services becomes longer. Damage to sewerage systems would result in the discharge of raw sewage to the river for many months. In the more extreme events non-flooded properties could be without electricity for many months.

Floods with a 1 in 20 to 1 in 200 chance of occurring in any year would cause an average of \$15 million in tangible damages annually. A 1 in 200 flood could cause between \$600 and \$2,500 million in tangible damages, flood the homes of 22,000 people, leave more than 6,000 of them homeless and flood hundreds of businesses.

Floods larger than the 1 in 200 event would be very rare but on average would cost a further \$15 million per annum if their damages were averaged over many years. The largest expected flood could have a damage bill of between \$3,500 and \$9,800 million and flood the homes of more than 50,000 people with nearly 40,000 of them left homeless because their houses would fail structurally.

The average annual damages from flooding in the Hawkesbury Nepean Valley is estimated to range between \$21 and \$68 million with the expected cost about \$38 million. Residential dwellings account for about 28 per cent of that total, commercial and industrial damages 20 per cent, agriculture 11 per cent, electricity supply about 10 per cent and the RAAF base at Richmond about 10 per cent. On average about 240 houses would flood each year of which 60 would fail.

Options to reduce the consequences of flooding fall into one of three categories: Those which modify flood behaviour, those which modify flood prone assets and those which modify the response of people to flooding.

Flood behaviour modification options which were investigated included upstream detention storages. These were not recommended for further investigation because of their significant social, economic and biophysical impacts. Likewise, the impacts of the most extensive floodplain levee concepts ruled them out from further consideration. Some levee options, whilst also having significant impacts, were recommended for further careful analysis and discussion with local communities during the development of local floodplain management plans.

Modifying flood behaviour by changing the way in which Warragamba Dam is operated would provide less benefits but would also have less direct impacts. However, changing gate operations could reduce evacuation times and therefore increase flood damages and loss of life.

The only two property modifications which might be practical in the short term and have measurable benefits would be:

- raising the transformers in Penrith and Hawkesbury electricity transmission substations; and
- relocating the RAAF base.

Although the socio-economic impacts of relocating the RAAF base would be significant. It is recommended these options be investigated further by Integral Energy and the Department of Defence respectively.

In the long term, property modification either by relocation or improved design could provide substantial reductions in flood consequences. It is recommended that when utility assets are due for replacement, the probability of flooding up to the PMF, and the direct and indirect consequences of flooding, be considered when selecting locations and designs for key assets.

When key health and emergency service facilities are to be rebuilt consideration should be given to relocating them in areas not prone to flooding and with a low probability of power and telecommunications failure.

Flood response modification is probably the best short term response to the existing flood risks in the Valley. It is recommended that utility and emergency service organisations prepare flood plans or review existing ones to ensure they are based on the most up to date information and are consistent with each other. A Cabinet directive may be necessary to ensure such plans are prepared. It is also recommended that community education about flood risks and response be improved.

It is recommended that means of improving flood evacuation be investigated further.

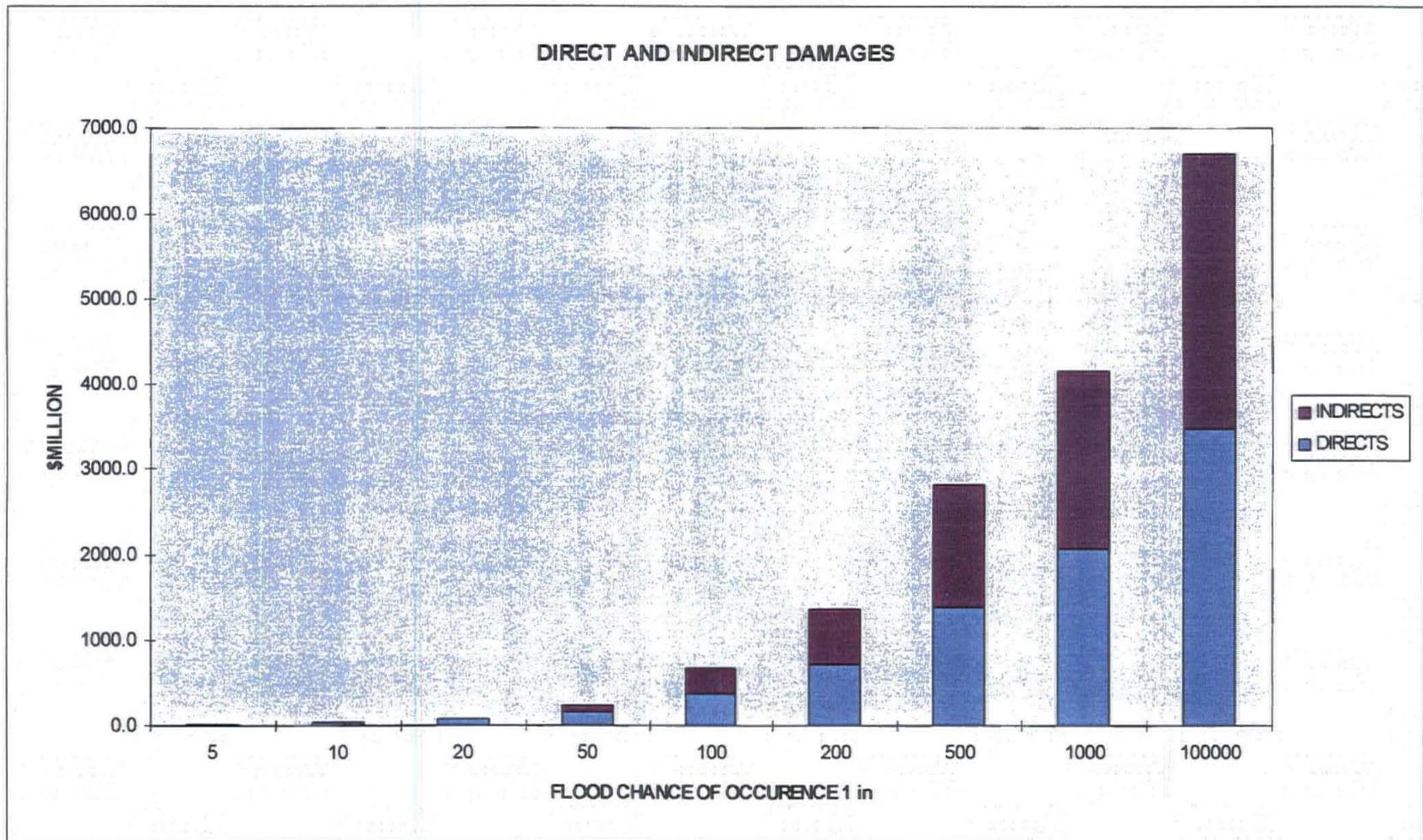
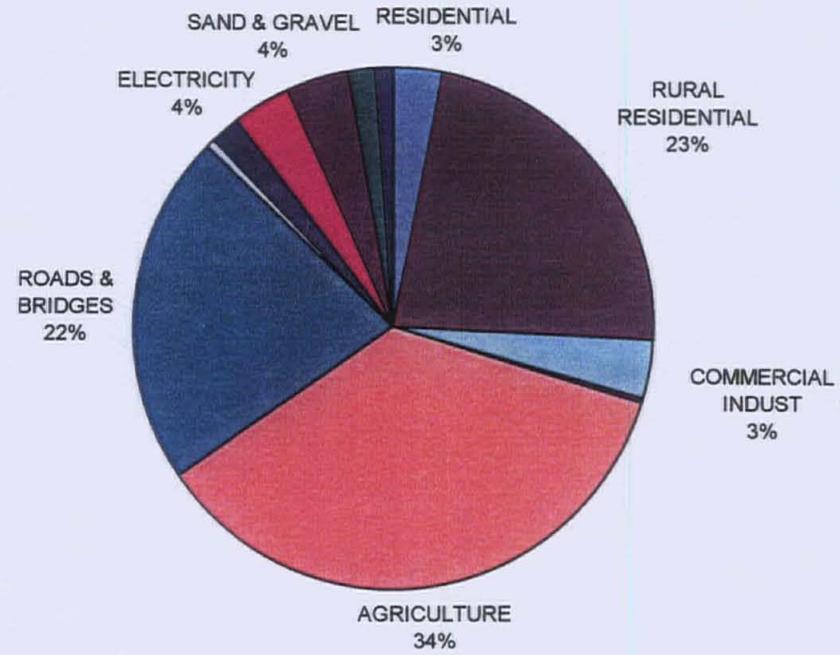


FIGURE 6.1 TANGIBLE DIRECT AND INDIRECT DAMAGES

**DAMAGES BY CATEGORY
1 IN 10 FLOOD
TOTAL TANGIBLE DAMAGE \$44.4M**



**FLOOD DAMAGES BY CATEGORIES
1 IN 200 FLOOD
TOTAL TANGIBLE DAMAGE \$1,360M**

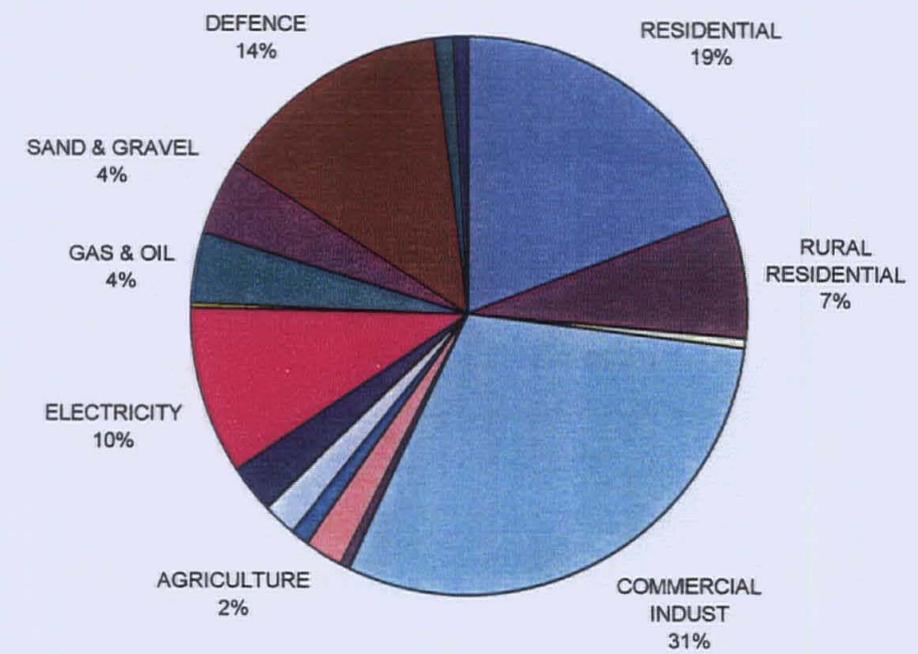


FIGURE 6.2 CONTRIBUTIONS TO DAMAGES BY CATEGORIES

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 THE NATURE OF THE PROBLEM

The history of development in the Valley and the great depths of potential flooding mean that many existing assets and communities are flood prone. The consequences of them being flooded are significant.

Flooding up to a flood with a 1 in 20 chance of occurrence per year costs an average of \$8 million in direct and indirect damages in the Hawkesbury Nepean Valley. It causes temporary disruption to roads, rail and some electricity services. Some low lying rural properties are evacuated in these floods and some homes are flooded. These floods remain in bank at Penrith but overflow the banks in the Richmond and Windsor areas.

Floods with a 1 in 20 to a 1 in 200 chance of occurrence cost an average of \$15 million per year. Individually they flood urban areas throughout the Valley damaging thousands of houses and businesses and causing hundreds of building failures. They involve evacuation of tens of thousands of people, loss of electricity supplies for days to weeks in non-flooded areas and the discharge of hundreds of megalitres of untreated sewage over many months. A 1 in 200 flood could cause somewhere between \$600 and \$2,500 million worth of tangible damages, result in 50,000 evacuations and leave more than 6,000 people without homes. Many fatalities and flood induced illnesses could be expected.

Floods bigger than those with a 1 in 200 chance of occurrence per year would cost an average of \$15 million per year but would very rarely occur. When they did they would result in widespread destruction of entire communities on the floodplain and long term disruption to surrounding areas which could be without electricity supplies for months. In the largest expected flood the damage bill would be between \$3,500 and \$9,800 million, result in 60,000 people being evacuated and leave over 39,000 people homeless.

More than half of the tangible annual average damages would be caused by flooding above the current urban planning levels in the Valley. The magnitude of damages in any one of these floods would place a significant burden upon the local, regional and state economies.

The most significant intangible consequences occur in floods exceeding the flood with a 1 in 200 chance of occurrence. Although the probability of these consequences occurring are low, their magnitude is so great that it is probably beneficial in reducing their probabilities as much as practical.

8.2 STRATEGY ANALYSES

Dedicated flood mitigation dams in the catchment upstream of Penrith might halve the annual average damages caused by flooding in the study area. However, they would have major social, biophysical and economic impacts elsewhere which would probably make them unacceptable to the community at large.

Levees constructed to the level of the PMF would be impractical so they would only exclude floodwaters from urban areas up to the peak flood level for which they were designed. For this analysis it was assumed that they would have a 1 in 200 chance per year of being overtopped. The levees would not reduce the need to evacuate tens of thousands of people because evacuation routes would be cut by flooding before it was known whether or not the levees would be overtopped. They would also have significant social, economic and biophysical impacts for the floodplain which would also make their acceptability to the community questionable.

Changing gate operations or reducing storage levels at Warragamba Dam would marginally reduce tangible and intangible damages in the more frequent floods. Particular care would need to be taken in changing gate operations to ensure warning and evacuation times were not compromised. These strategies would not be effective in larger floods.

Some localised but significant reductions in asset losses would be gained by constructing deflector levees at Penrith and Emu Plains or by relocating the RAAF base. These would be most effective in the most extreme range of floods. The socio-economic costs of these strategies could be significant for local communities. Neither would reduce the number of houses, businesses or people affected by flooding.

Raising transformers at Penrith and Hawkesbury transmission substations might be the most effective way, in the short term, of reducing the risk of long duration electricity disruptions following the more extreme floods. In the long term it may be worth relocating these key assets in less flood prone locations so that the risk of long duration outages is minimised. Reconstructing power lines on higher poles would reduce the risk of short disruptions in smaller floods. These latter two options are only likely to be economical during scheduled reconstruction of these assets.

Similarly there may be some benefits in relocating the Penrith and Richmond telephone switching centres in the long term. This would reduce the risk of extended outages of telephone systems although recovery of these systems would be simpler than for the electricity systems.

It is generally not practical to relocate water and sewage assets but improved design would aid in the recovery of the services following a flood. Sewage

assets are the most critical. Sewage treatment plants could be rebuilt to a more flood resistant design so that they could be operational sooner after a flood. This would be particularly important for Quakers Hill, St Marys and Penrith plants which are large and have significant parts of their catchments which are not flood affected. Major pumping stations on these systems could also be designed to a higher standard than other pumping stations because of the significant amount of raw sewage which would discharge from them when they fail.

The most critical gas and oil supply assets are the main pipelines. Adequate protection of the pipelines where they cross the Hawkesbury River would be beneficial.

There may be benefits in relocating hospitals and nursing homes to areas which have a lower flood risk and a lower risk of long term power outages than they are currently exposed to. This would be most economical when these assets need rebuilding.

There may be benefits in relocating the Penrith Emergency Operations Centre because of the risk of it losing power and communications during a flood.

Local planning controls would be the most appropriate means of controlling future redevelopment in the study area. There could be benefits in including in those planning controls requirements for minimum floor levels, building materials and building designs which would make new buildings less susceptible to flooding. It might also be appropriate to use the controls to exclude particular hazardous materials or industries from the floodplain because of the consequences arising from them being flooded.

Improved flood preparedness will reduce loss of life and stress induced illnesses in all floods and may marginally reduce asset damages. Evacuation routes are a major constraint to realising these benefits and need improvement. It would be beneficial if major utility service providers as well as some major industries prepared their own flood response plans and had them checked by the SES.

8.3 RECOMMENDATIONS

Based on the preceding discussion it is recommended that that flooding be considered in the planning, design and operation of assets in all floods up to the PMF. The probability of a location being flooded and the consequences (direct and indirect) of an asset being flooded should both be taken into consideration when selecting a location and design standard for an asset.

The following specific actions are recommended.

In the Short Term

- The practicality and benefits of raising transformers at Penrith and Hawkesbury transmission substations be investigated in consultation with Integral Energy;
- Integral Energy be encouraged to provide more detail about areas affected and durations of flood induced outages;
- Integral Energy be encouraged to develop flood recovery plans with the view to minimising the duration of outages to non-flooded properties;
- The State Emergency Service's Flood Plan and NSW Health's Draft Disaster Plan be reviewed together with Integrals Energy's Flood Plan to ensure consistency;
- Information on direct flood effects, evacuations and power outages be supplied to the other utility organisations to help them evaluate their need for flood preparedness plans and to plan the location and design of future assets;
- Consideration be given to issuing a Cabinet direction and guidance to agencies and corporatised utility organisations, as a matter of public interest, to prepare flood management plans for their existing facilities and take into consideration in planning new facilities the risks and consequences of flooding up to the PMF.
- The Defence Department be advised of the risks and impacts of flooding on the Richmond RAAF Base;
- AGL be supplied with information on flood velocities at the gas pipeline's Hawkesbury River crossing so that AGL can determine whether improved scour protection is needed;
- Means of improving flood evacuation be investigated further and community education about flooding be improved;
- The social, economic and biophysical impacts of any flood modification strategies be carefully investigated and extensive community consultation be undertaken before proposing any flood modification strategies such as detention storages or levees;
- Careful consideration be given to any proposed changes to Warragamba Dam's gate operations to reduce tangible damages from peak flood heights because they are likely to increase intangible damages, particularly loss of life due to reduced warning times;

In the Long Term

- When Penrith and Hawkesbury electricity transmission substations are to be rebuilt, consider reducing the risk of long term outages by relocating them or incorporating more flood resistant designs;
- Consider rebuilding 132kV and 33kV transmission lines on higher poles when due for reconstruction;
- Consider using more flood resistant designs for key pumping stations and treatment plant components when sewerage assets need replacing. Particularly in Penrith, St Marys and Quakers Hill sewerage systems;
- Consider locating Penrith and Richmond telephone switching centres in less flood prone locations or build them to be more flood resistant when they are due for reconstruction;
- When rebuilding public and private hospitals and nursing homes, consider locating them in areas less prone to flooding or power loss;
- Consider relocating the Penrith Emergency Operations Centre to a location that is less prone to electricity loss and telecommunications failure; and
- Consider relocating hazardous materials and future related industries out of the floodplain.

**APPENDIX B
ENGINEERING STUDIES TO MODIFY
FLOOD BEHAVIOUR**

**HAWKESBURY NEPEAN FLOOD MANAGEMENT
ADVISORY COMMITTEE**

**HAWKESBURY NEPEAN
FLOOD MANAGEMENT STRATEGY**

**ENGINEERING STUDIES
TO MODIFY FLOOD BEHAVIOUR**

FINAL REPORT

SEPTEMBER, 1997

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SUMMARY

The Hawkesbury Nepean Flood Management Advisory Committee has sought a number of separate reports on various components of an integrated floodplain management approach for the Hawkesbury/Nepean Valley. This report presents the findings on Engineering Studies to Modify Flood Behaviour. The primary emphasis is on flood modification measures, but a number of other measures that could also assist in reducing flood damages, are also canvassed.

Although the report is a stand alone appraisal of possible flood modification measures, it must be emphasised that these on their own do not provide a satisfactory answer to the Valley's flood problems. They should be integrated with measures discussed in other similar reports prepared for the Committee to provide an optimal solution.

Flood modification measures were considered under a number of geographical categories: those that would influence the entire Valley and those that would affect specific local areas.

In the first category, valley wide options, consideration was given to major flood mitigation dams and to major bypass channels at critical points of the river. Preliminary model results showed that some mitigation dams could significantly reduce flood levels in the Valley, but the high economic and environmental costs involved would render them inappropriate.

Bypass channels would, in general, have less impact on flood levels, but would still involve high economic and environmental costs. A channel linking the river near Wilberforce to Currency Creek, and hence bypassing Gronos Point and Cattai, was found to be potentially viable but it would be very difficult to justify further development of the option.

Although not directly the responsibility of this report, some consideration was given to the effectiveness of flood warning and modified gate operations at Warragamba Dam. Flood warning is considered to be one of the most important and effective initiatives available, for reducing damages and saving lives in the Valley, while changing gate operations may provide slightly more warning time but will need to be carefully considered and well implemented.

On the local level many options were considered including levees, retarding basins, flow deflectors, emergency access, bank protection and channel improvements. Many of the options were considered not practical on economic, social or environmental grounds. Those which were deemed worthy of further consideration are listed below by area:

Wallacia:

- raise Park Road to provide high level access.

Penrith/Emu Plains:

- possible levee banks along various parts of the river, the most promising being on the Penrith side upstream of the M4 Motorway,
- deflection walls near Jamison Road and Captains Road to reduce overbank velocities,

SUMMARY

- emergency access to the M4 at Regentville,
- bank protection between Regentville Bridge and Victoria Bridge.

Windsor/Richmond:

- a series of levees at McGraths Hill, Riverstone, Windsor, Bligh Park, Mulgrave, Pitt Town and Wilberforce. These works could provide protection up to the 1 in 50 flood level but would present significant social problems. The local community would need to be enthusiastic about the works for these to be pursued further,
- raising of various roads to provide high level evacuation routes,
- a refuge mound at McGraths Hill.

Downstream of Sackville:

- a possible levee at Wisemans Ferry,
- possible velocity protection at Spencer,
- a series of escape roads and helicopter pads to service the small communities strung along the Valley,
- improved flood warning and dissemination of such information in a timely and effective way to the affected communities.

In Floodplain Management Plans combinations of options usually form the optimal solution. Combinations need to consider the full range of floods which occur and the existing and allowable development for each level of flooding. Also, combinations normally consist of both structural and non-structural solutions, and need to take full account of the economic, environmental and social factors. The options listed above therefore need to be seen in this context.

Table 2: Summary of Options

Strategy	Option	Effectiveness	Practicality	Environmental Impacts	Social Impacts	Cost (\$M)
VALLEY WIDE OPTIONS:						
Mitigation Dams	Dam on the Wollondilly River	Lowers level at Penrith by 0.7 m and at Windsor by 0.6 m.	Difficult in National Park.	Significant impact on river environment.	Nil	300 ⁽¹⁾
	Dams on Wollondilly and Coxs Rivers	Lowers levels at Penrith by 1.8 m and at Windsor by 2.3 m.	Both sites in National Park.	Significant impact.	Nil	500 ⁽¹⁾
	Dam on the Nepean River	Lowers level at Penrith by 1.7 m and at Windsor by 1.5 m.	Land resumption required; would affect Camden.	Significant effect on Upper Nepean.	Significant land resumption required.	>290 ⁽¹⁾
	Dam on the Grose River	Lowers level at Windsor by 0.2 m.	National Park and very inaccessible terrain.	Significant	Nil	>290 ⁽¹⁾
	Dam on South Creek	Lowers level at Windsor by 0.3 m.	No suitable location.	Significant	Large land resumption required.	>500
	Dam on the Colo	Lowers level at Windsor by 0.2 m.	National Park.	Significant	Some land resumption required.	>290 ⁽¹⁾
Major Diversions	Currency Creek	1 m benefit at Windsor with 0.7 m increase in level at Sackville.	Huge earthworks required.	Significant	Major land resumption required. Increased levels downstream.	100-200
	Gronos Point	0.1 m lower at Windsor.	Major earthworks required.	Some	Land resumption.	5-15
	Sackville	0.2 m - 0.3 m reduction at Windsor. 0.1 m increase in level at Wisemans Ferry.	Major earthworks required.	Some	Land resumption.	300
	Breakaway	Nil.	Some earthworks.	Some	Some land resumption.	40

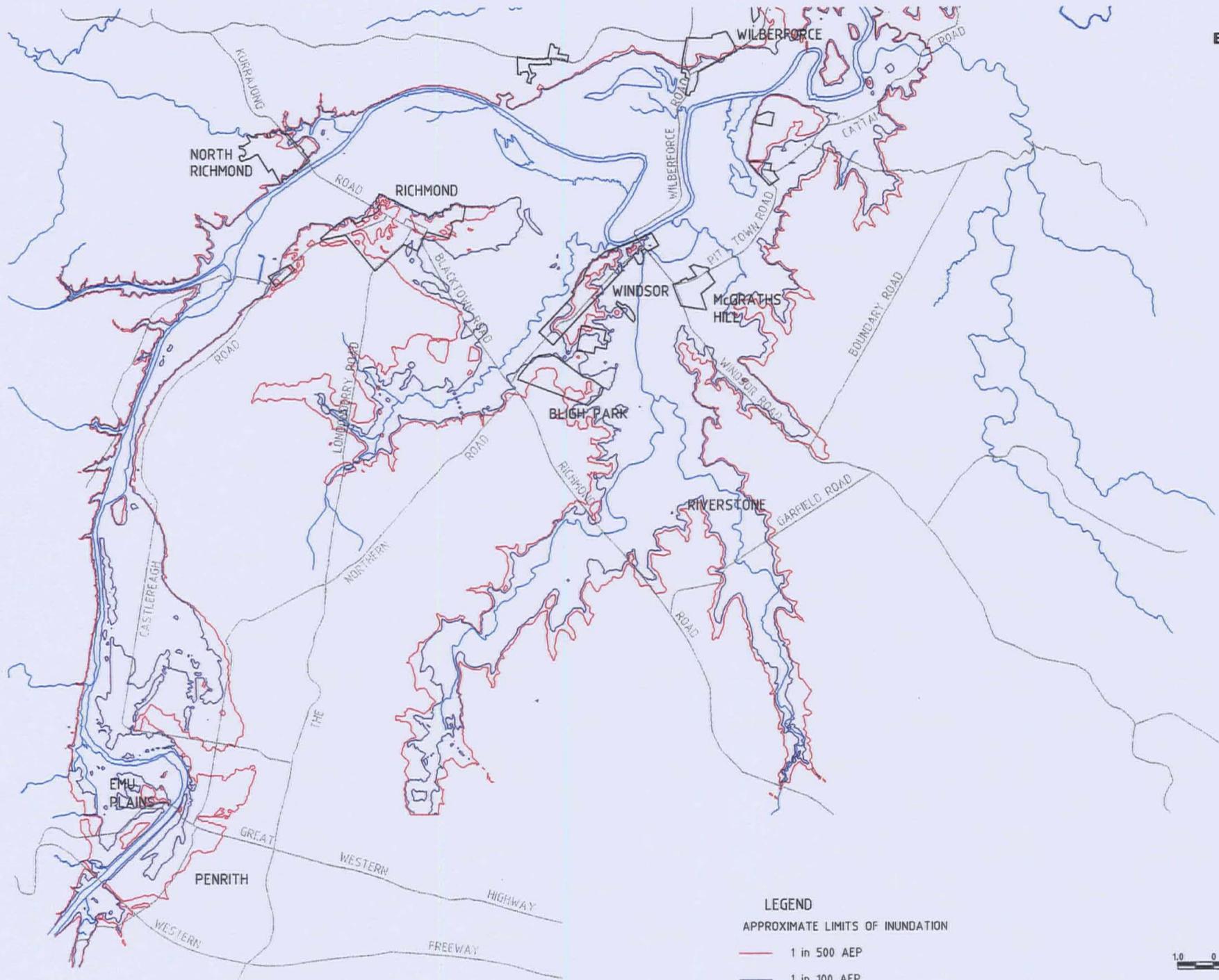
Strategy	Option	Effectiveness	Practicality	Environmental Impacts	Social Impacts	Cost (\$M)
Small Detention Basins	Small Basins on South Creek	0.1 m practical maximum decrease in level at Windsor.	Because of shallow depth the area required is 10% of the catchment.	Some	Enormous land resumption is required.	500
Raise Roads and Bridges		Assist evacuations.	Possible and necessary as part of any scheme.	Minimal	Nil	See other reports
Refuge Mounds		Assist evacuations.	Possible although will need to be quite high.	Some	Some land sterilisation.	Varies
Dredging	Downstream of Sackville	Reduce levels at Windsor by 0.7 m.	High volumes involved.	Significant	Provision of sand.	440 ⁽¹⁾
Flood Warning	Improved Valley Wide Flood Forecasting and Warning System	Very efficient in reducing damages if properly implemented in conjunction with public awareness and evacuation planning.	Requires professional team with access to all data and appropriate training.	Nil	Large social benefits.	<0.5
Gate Operation Improvements	At Warragamba Dam	Some benefit especially on rise of flood.	Could make some floods worse.	Some increase in reservoir levels.	Nil	1.0
Storage Depletion	At Warragamba Dam	Minimal for large floods.	Decrease water supply security and can be difficult to maintain prior to flood.	Less water available for environmental releases and will bring forward the construction of another water supply dam.	Nil	>300 ⁽²⁾
Voluntary Purchase	Purchase High Hazard Properties	Removes worst affected properties.	Subject to owner co-operation.	Nil	Some community disruption.	Approx. 0.2 per property
WALLACIA:						
Road Access		Improve evacuation time.	Achievable.	Some	Nil	1.0
Levees		Protection of low lying properties.	Very high, requires considerable land.	Disturb river bank areas.	Possible false sense of security.	10

Strategy	Option	Effectiveness	Practicality	Environmental Impacts	Social Impacts	Cost (\$M)
PENRITH/EMU PLAINS AREA:						
Levees	Penrith	Minor because of backwater flooding and internal drainage problem.	Would increase levels elsewhere and produce false sense of security.	Disturb river bank areas.	Land resumption, loss of open space and river views, false sense of security.	5
	Emu Plains	Some benefit.	Would increase levels elsewhere and produce false sense of security.	Disturb river bank areas.	Significant land resumption and loss of open space and views, false sense of security.	5-10
Deflection Walls	Penrith and Emu Plains	Would reduce velocity impact on houses.	Minor increase in levels and perhaps localised eddy velocities.	River bank area would be degraded.	Land resumption, some loss of open space and views.	6
Bank Protection	Penrith and Emu Plains	Protect roads and properties.	Achievable.	Protect bank but no longer "natural".	Aesthetics.	0.5 - 2
Removal of Weir	At Penrith	Nil	Would change river environment at Penrith.	Would change river environment at Penrith.	Loss of recreation facility.	1.0
Clearing Weir Pool	At Penrith	Flood level at Penrith could be lowered by up to 0.2 m.	Bank stabilisation would be required.	Minor	Minor	0.5
Clearing and Widening Channel	Downstream of Weir	Flood level at Penrith lowered 0.4 m.	Large scale bank stabilisation would be required.	River bank area would be significantly altered.	Minor	Self Funding
Penrith Lakes Scheme		Only in small floods as fully flooded in large events.	Already under way.			Self Funding
Railway Embankment	Raise Embankment - Minimise Openings	Increase flood levels and lower velocities.	Could cause some minor drainage problems.	Very minor.	Some increases in levels.	40
	Lower Embankment and More Openings	Lower levels and increase velocities.	Nil	Nil	More damage due to high velocities.	10 - 20
Remove Bridges	Victoria and Railway Bridges	Minor reduction in levels.	Removing piers would require new bridge.	Some loss of historical asset.	Major community disruption during construction. Some loss of historical asset.	100

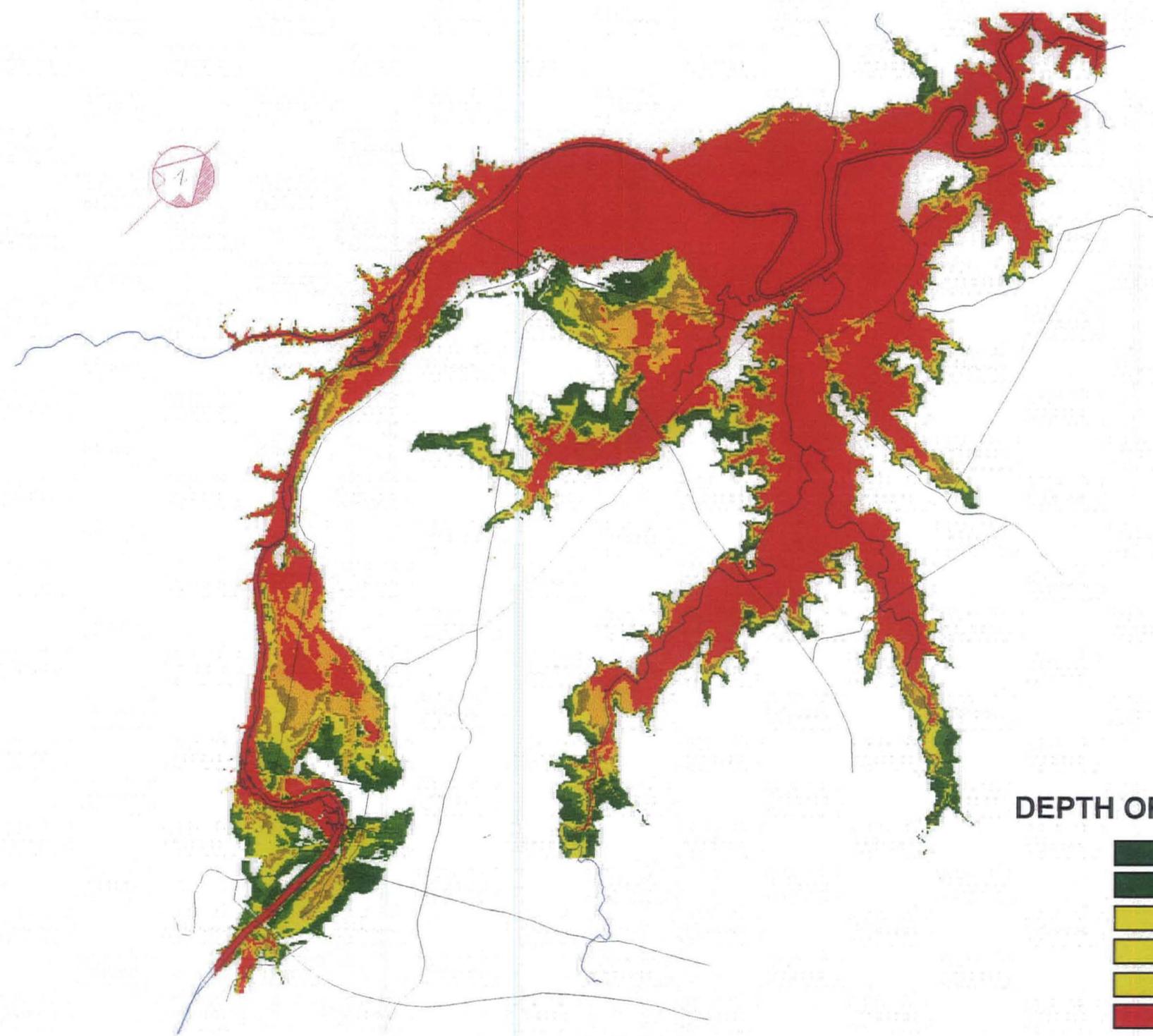
Strategy	Option	Effectiveness	Practicality	Environmental Impacts	Social Impacts	Cost (\$M)
M4 Floodway		No significant change.	Achievable.	Some.	Minimal.	2
WINDSOR-RICHMOND:						
Levees	Windsor, Bligh Park, Mulgrave, Pitt Town, Wilberforce, North Richmond, Riverstone	Reduce flooding up to overtopping level.	Most would be very high.	Visual.	Loss of view, false sense of security.	20 - 40
Detention Basins	Large Basin at Richmond Lowlands	Minor benefits but only in very small floods.	Would increase flooding of agricultural land and require earth and drainage works.	Would affect lagoons.	Significant impact on farms.	Up to 20
	South Creek	SEE VALLEY WIDE OPTIONS				
Macro Levee	Richmond to Windsor	Reduce flooding Windsor and Richmond.	Enormous earthworks and land resumption required and disturbance of historical precinct of Windsor.	Significant visual impacts. Impact on Rickabys Creek.	Major visual impacts; impact on historical precinct.	200
	Richmond to McGraths Hill	Reduce flooding of Windsor, Richmond, Riverstone, Bligh Park, etc.	As above but worse.	As above plus impact on South Creek.	As above.	250
DOWNSTREAM OF WINDSOR:						
Levees	Levees at Various Small Communities.	Prevent flood damages up to overtopping flood.	Possible at Wisemans Ferry	Disturb river banks.	Loss of view; false sense of security.	Varies
Velocity Protection	Diversion Banks at Various Small Communities.	Reduce velocity.	Possible, especially at Spencer. Minor increase in levels.	Disturb river banks.	Small, some visual intrusion.	Varies
House Raising		Will reduce flood damages.	Possible.	Small.	Reduce visual amenity; false sense of security.	30 000-40 000 per house
Escape Areas	For Isolated Communities.	Improve evacuation.	Possible.	Some clearing of land.	Nil.	Varies

NOTES: (1) Costs based on estimate prepared by Sydney Water.
(2) If new water supply storage required.

FIGURE 2
EXTENT OF INUNDATION



DEPTH OF INUNDATION
(1 in 500 AEP)



DEPTH OF INUNDATION

-  1m
-  2m
-  3m
-  4m
-  5m
-  >5m

FIGURE 4
MITIGATION OPTIONS
VALLEY WIDE

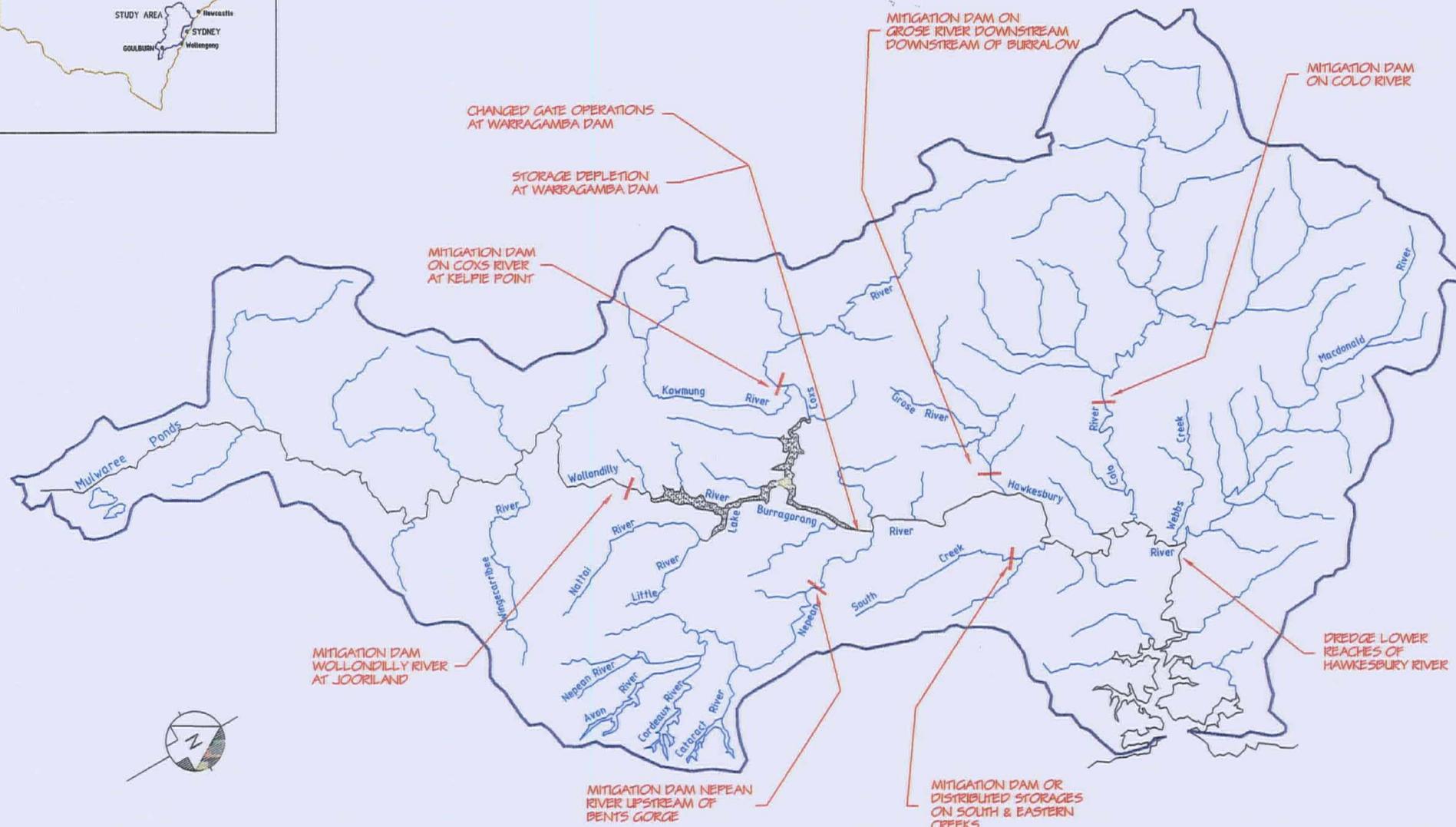
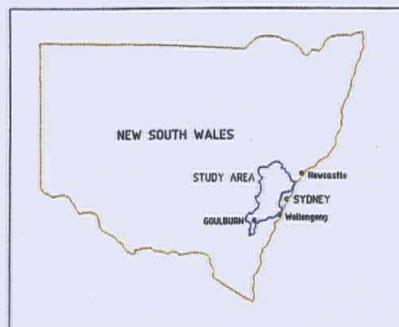


FIGURE 5
MITIGATION OPTIONS
PENRITH EMU PLAINS AREA

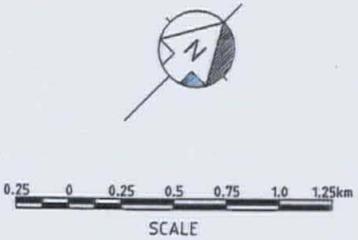
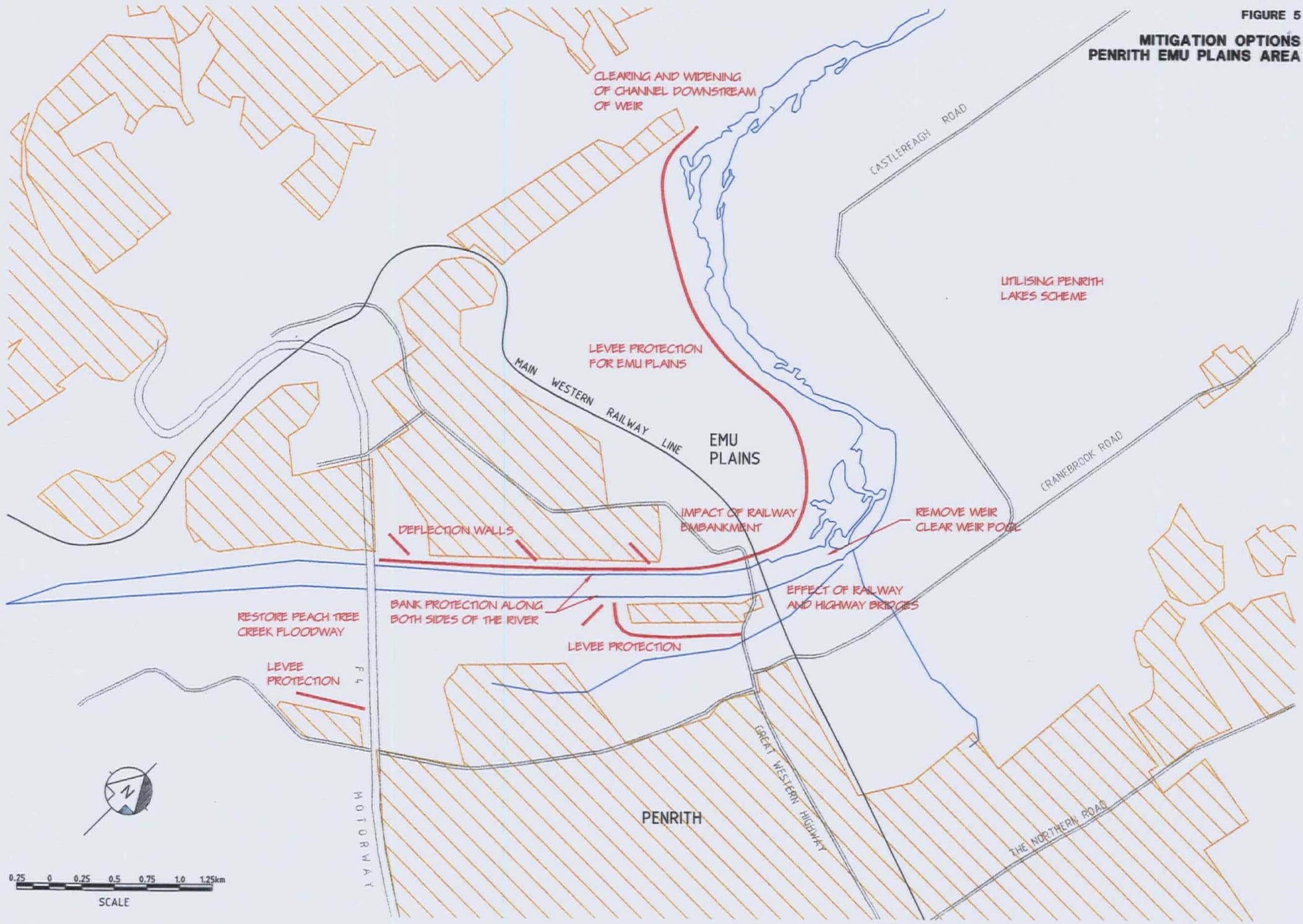
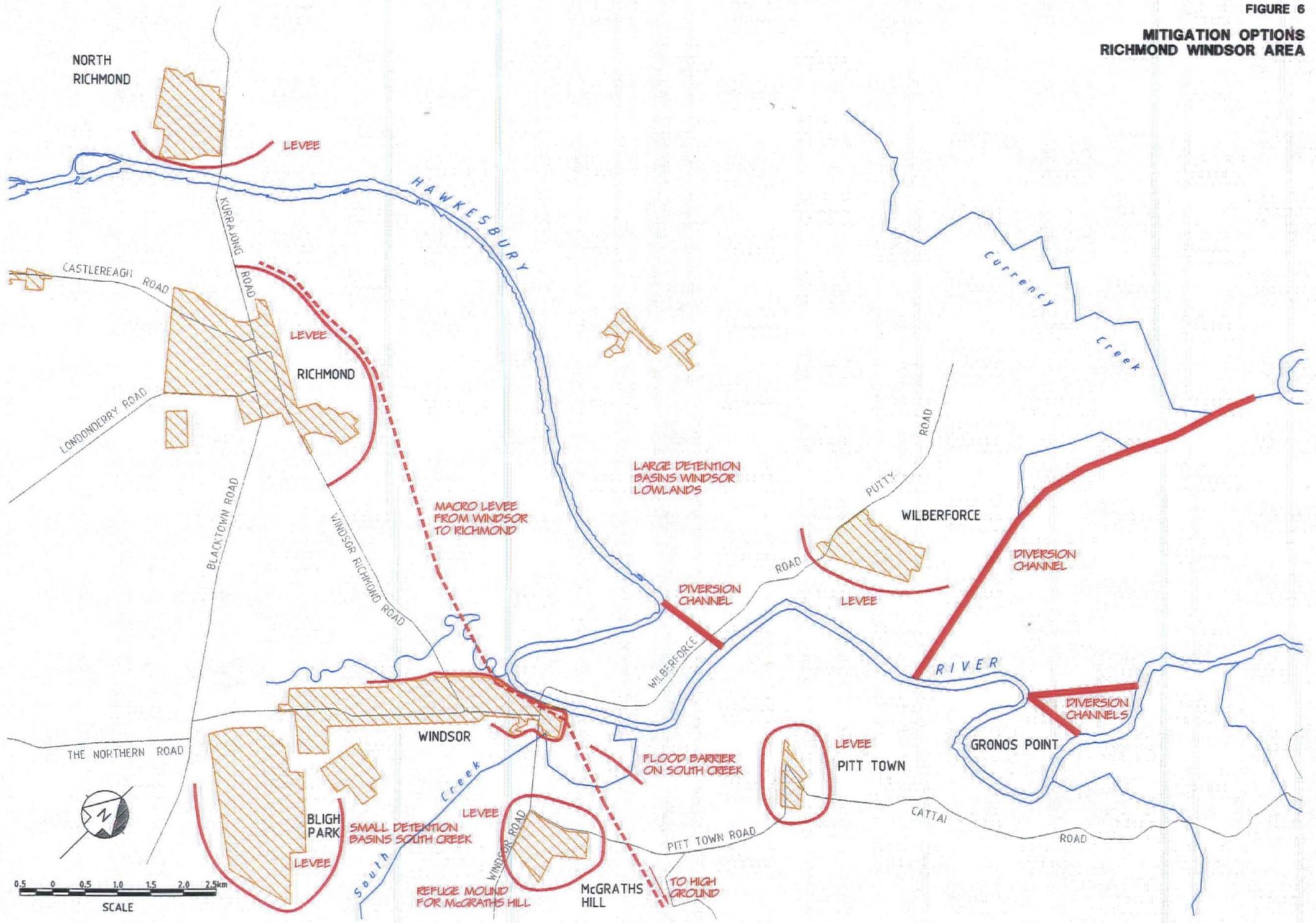
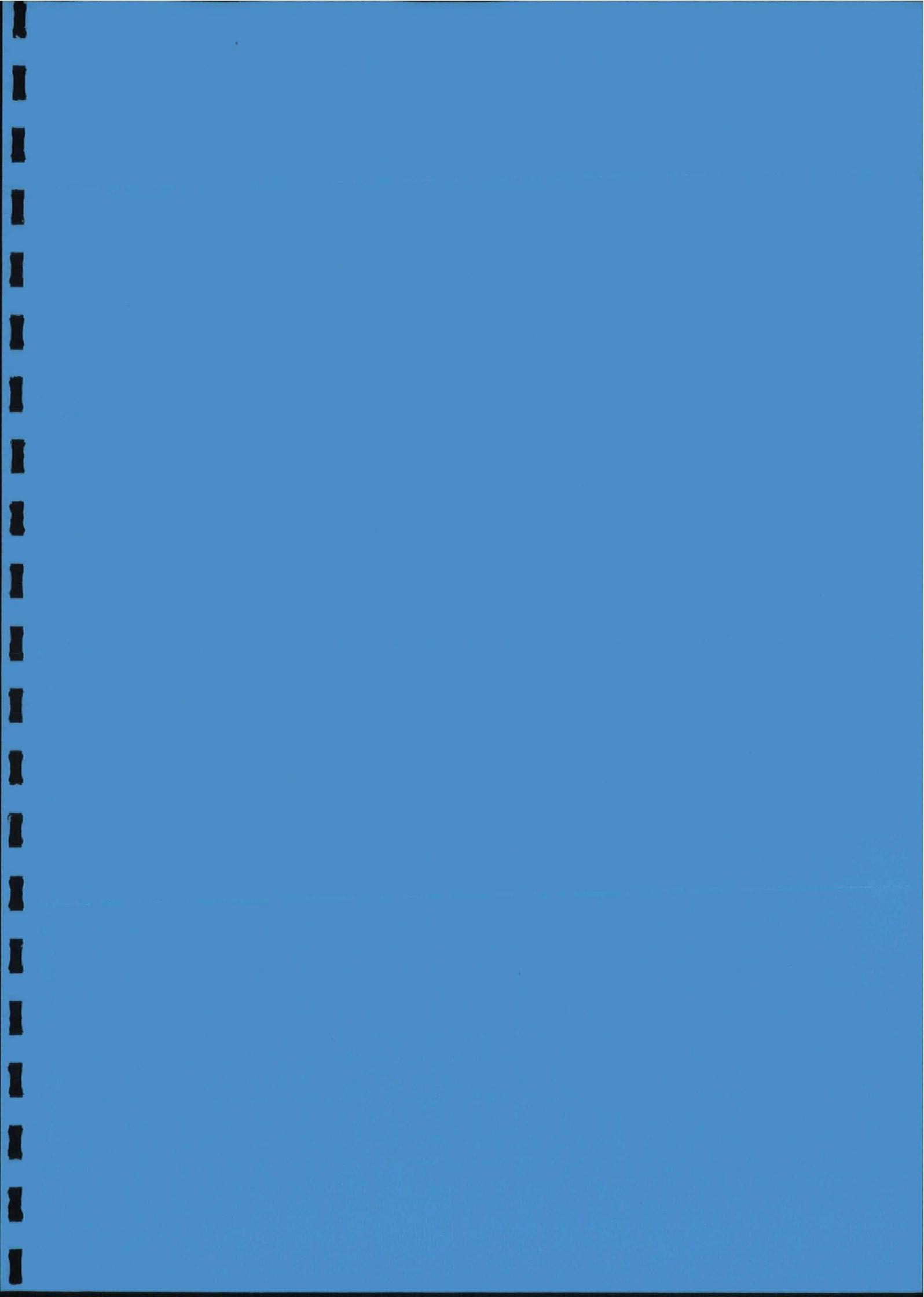


FIGURE 6

MITIGATION OPTIONS
RICHMOND WINDSOR AREA





**APPENDIX C
LAND USE PLANNING AND
DEVELOPMENT CONTROL MEASURES**

Hawkesbury – Nepean Flood Management Strategy

LAND USE PLANNING AND DEVELOPMENT CONTROL MEASURES

Main Report

Prepared for
Hawkesbury – Nepean Flood Management Advisory Committee

Prepared by
Don Fox Planning
and
Bewsher Consulting

DFP Project No: P3748
BC Filename: J721-8.R#

October 1997

TABLE 11.1
 POTENTIAL ADDITIONAL DEVELOPMENT & POPULATION
 HAWKESBURY NEPEAN FLOODPLAIN

AREA	ADDITIONAL DWELLINGS			ADDITIONAL COMM/IND/PUBLIC PROPERTIES			ADDITIONAL POPULATION		
	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	TOTAL	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	TOTAL	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	TOTAL
EXTG RURAL AREAS(EXCL. POT. FUTURE URBAN AREAS)									
BAULKHAM HILLS LGA	200	200	400	200	200	400	600	600	1200
BLACKTOWN LGA	300	300	600	300	200	500	1100	600	1700
HAWKESBURY LGA	600	600	1200	600	300	900	2100	1100	3200
PENRITH LGA	1000	1000	2000	1000	600	1600	3500	2100	5600
SUB TOTAL	2100	2100	4200	2100	1300	3400	7300	4400	11700
EXISTING COMMITTED URBAN AREAS									
ZONED & IMMINENT AREAS	799	349	1148	-	-	0	2237	976	3213
MUDP AREAS	582	118	700	-	-	0	1630	330	1960
OTHER	0	0	0	-	-	0	-	-	0
SUB TOTAL	1381	467	1848				3867	1307	5174
POTENTIAL FUTURE URBAN AREAS(SCENARIO 2)									
NELSON	1900	2200	4200	400	500	900	4800	5600	10400
BLIGH PARK STAGE 2	700	0	700	100	0	100	2000	0	2000
SOUTH CREEK/EASTERN CREEK	5600	6100	11700	1400	1500	2800	15300	16800	32100
ADI SITE	3000	1100	4100	700	300	1000	7200	2600	9800
PENRITH LAKES SCHEME	3700	0	3700	100	0	100	9200	0	9200
SUB TOTAL	14900	9400	24400	2700	2300	4900	38500	25000	63500
TOTAL	18400	12000	30400	4800	3500	8300	49600	30800	80400

NOTES

- 1.REFER TO APPENDICES FOR INFORMATION SOURCES AND ASSUMPTIONS ADOPTED
- 2.THERE MAY BE DISCREPANCIES DUE TO ROUNDING

TABLE 11.2

POTENTIAL ADDITIONAL DWELLINGS
HAWKESBURY NEPEAN FLOODPLAIN

AREAS	SCENARIO 1 NO INCREASES IN DEVELOPMENT POTENTIAL		SCENARIO 2 MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & DISTRIBUTION OF LAND USES TO BE CONSTANT		SCENARIO 3 MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & LAND USES MANAGED TO REDUCE FLOOD RISK		SCENARIO 4 INCREASED DEVELOPMENT POTENTIAL FROM SCENARIO 2 WITHOUT FACTORING FLOOD RISKS	
	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD
	EXISTING RURAL AREAS	2100	2100	2100	2100	2100	2100	2100
COMMITTED URBAN AREAS	1381	467	1381	467	1381	467	1381	467
POTENTIAL FUTURE URBAN AREAS	0	0	14900	9400	16000	11500	18900	13300
TOTAL	3481	2567	18381	11967	19481	14067	22381	15867

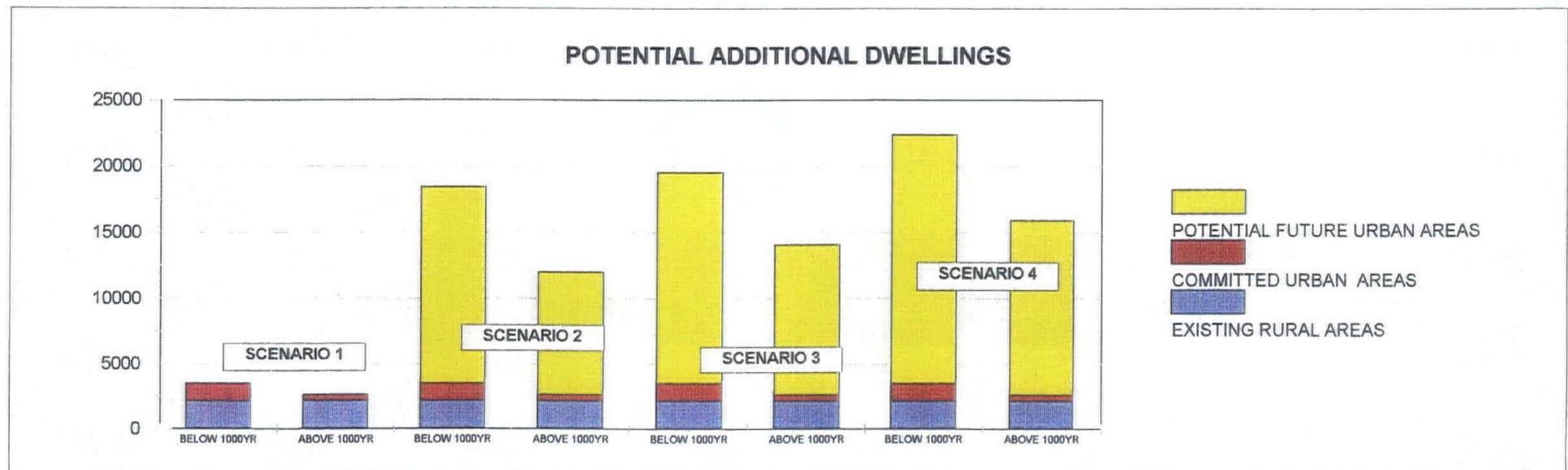


TABLE 11.3

POTENTIAL ADDITIONAL POPULATION
HAWKESBURY NEPEAN FLOODPLAIN

AREAS	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	NO INCREASES IN DEVELOPMENT POTENTIAL		MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & DISTRIBUTION OF LAND USES TO BE CONSTANT		MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & LAND USES MANAGED TO REDUCE FLOOD RISK		INCREASED DEVELOPMENT POTENTIAL FROM SCENARIO 2 WITHOUT FACTORING FLOOD RISKS	
	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD
EXISTING RURAL AREAS	7300	4400	7300	4400	7300	4400	7300	4400
COMMITTED URBAN AREAS	3866	1307	3866	1307	3866	1307	3866	1307
POTENTIAL FUTURE URBAN AREAS	0	0	38500	25000	37000	26500	45400	31600
TOTAL	11166	5707	49666	30707	48166	32207	56566	37307

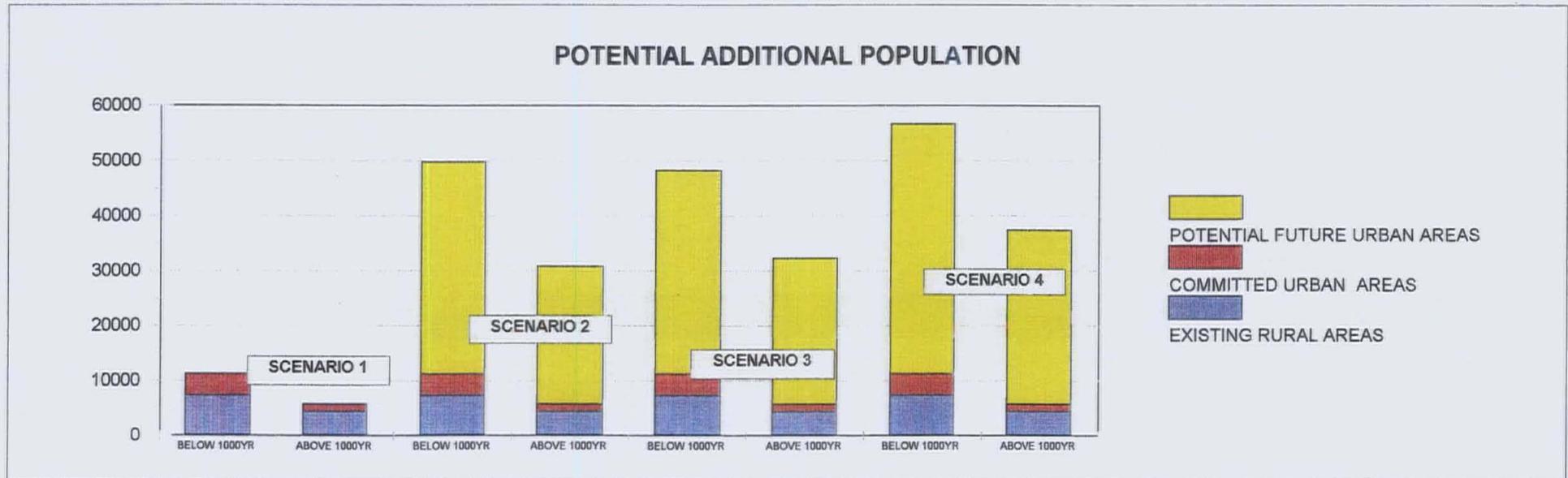
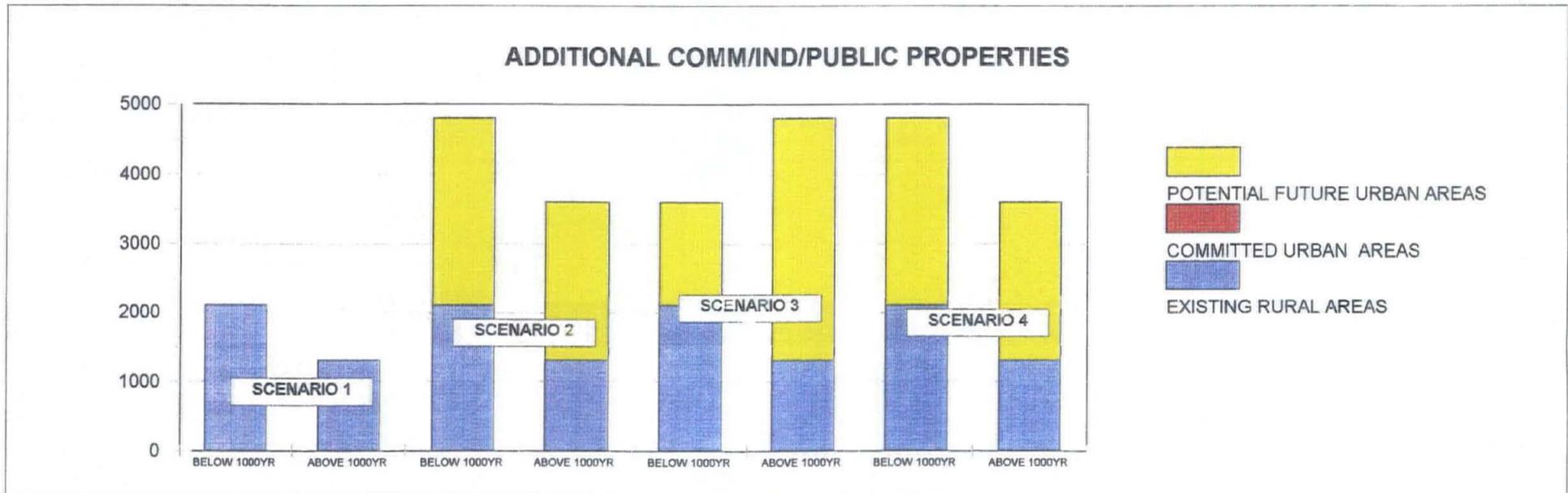
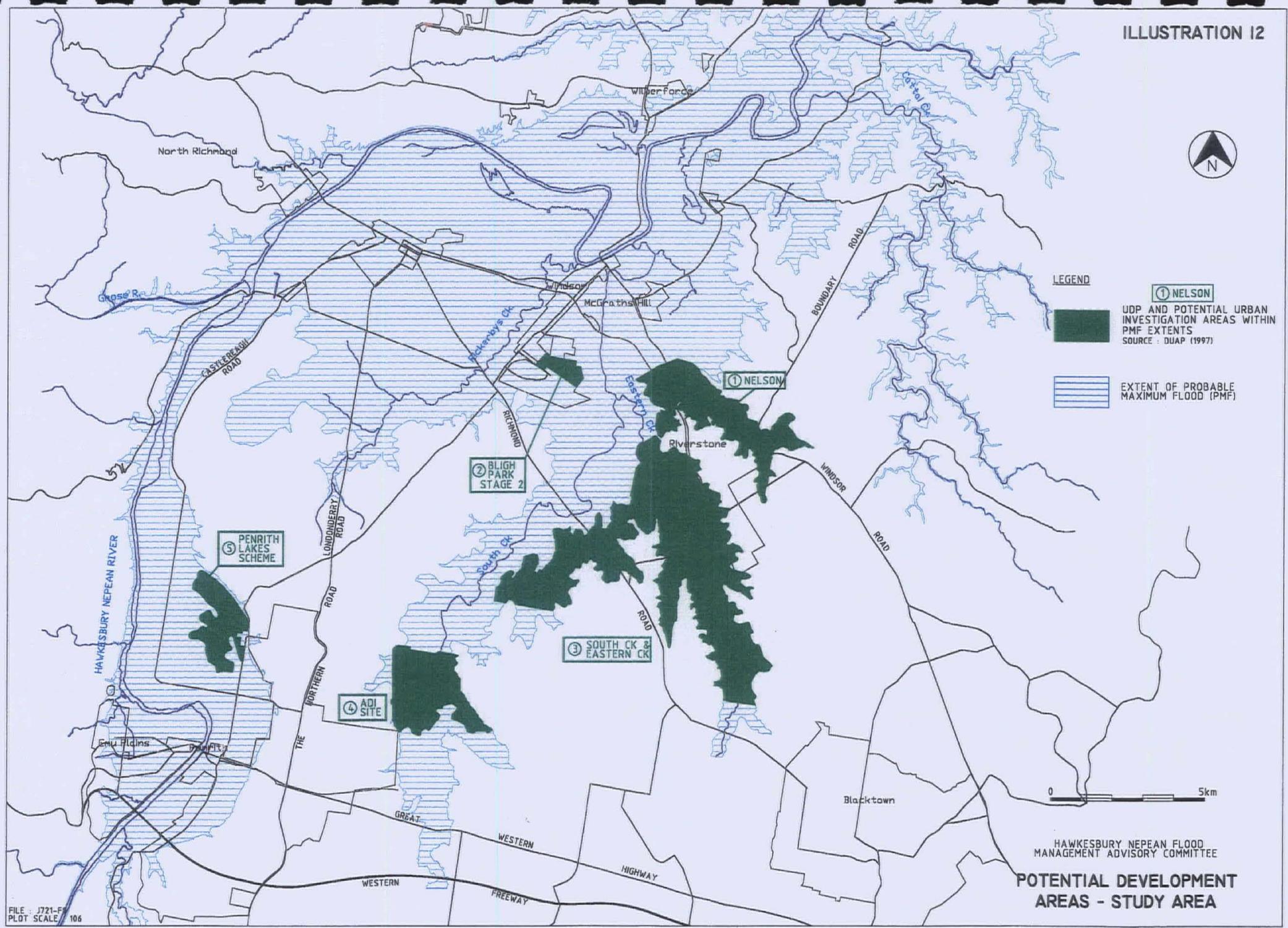


TABLE 11.4

POTENTIAL ADDITIONAL COMMERCIAL/INDUSTRIAL/PUBLIC PROPERTIES
HAWKESBURY NEPEAN FLOODPLAIN

AREAS	SCENARIO 1 NO INCREASES IN DEVELOPMENT POTENTIAL		SCENARIO 2 MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & DISTRIBUTION OF LAND USES TO BE CONSTANT		SCENARIO 3 MAXIMUM DEVELOPMENT OF POTENTIAL URBAN INVESTIGATION AREAS & LAND USES MANAGED TO REDUCE FLOOD RISK		SCENARIO 4 INCREASED DEVELOPMENT POTENTIAL FROM SCENARIO 2 WITHOUT FACTORING FLOOD RISKS	
	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD	BELOW 1000YR FLOOD	ABOVE 1000YR FLOOD
	EXISTING RURAL AREAS	2100	1300	2100	1300	2100	1300	2100
COMMITTED URBAN AREAS	0	0	0	0	0	0	0	0
POTENTIAL FUTURE URBAN AREAS	0	0	2700	2300	1500	3500	2700	2300
TOTAL	2100	1300	4800	3600	3600	4800	4800	3600





HAWKESBURY NEPEAN FLOOD
 MANAGEMENT ADVISORY COMMITTEE
**POTENTIAL DEVELOPMENT
 AREAS - STUDY AREA**

SUMMARY

Purpose of this Report

This report addresses land use planning and development control measures for future development. It also provides a review of existing floodplain planning within the region and makes recommendations for future changes.

This report is one of a number being prepared for the Hawkesbury – Nepean Flood Management Advisory Committee (the Committee) on various issues relating to flood management of the area downstream of Warragamba Dam, referred to elsewhere as the 'study area', with a view to the inclusion of relevant recommendations in the Committee's Flood Management Strategy (FMS) for the area..

Lack of Appreciation of the Real Flood Hazard by the Community

In general terms, the real flood hazard within the study area is poorly understood and appreciated by the community, and as such, the need for concerted local or state government initiatives to change this (except for the dissemination of flood information arising from investigations into the protection of Warragamba Dam) has not been widely appreciated.

Often the community considers there to be a flood hazard only on land below the flood planning level (FPL) which is the level below which councils place restrictions on development. This FPL is commonly the 100 year average recurrence interval (ARI) flood.

In fact, floods can occur well above this level (eg. the 1867 flood level was 2–3m above the FPL in most areas).

Illustration 1 illustrates the view of flood hazard generally held by the community. The flood hazard extent relates only to the FPL (in this case the 100 year ARI flood). In the community's mind, there is no flood hazard above the 100 year ARI flood level.

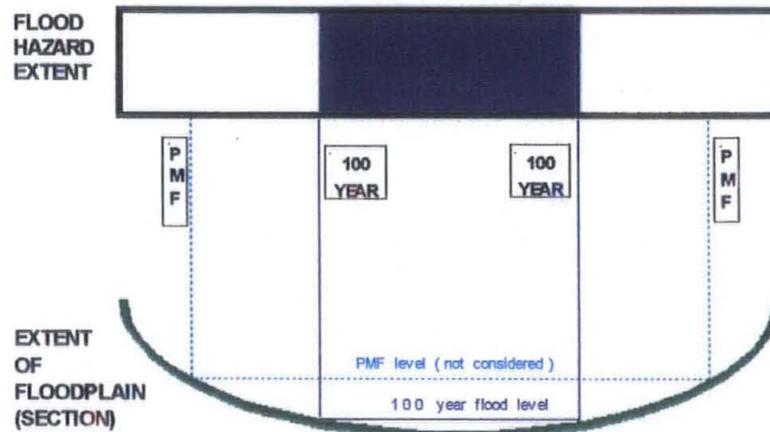


Illustration 1: Typical View of Flood Hazard Currently Held by Community

Throughout this report the term 'floodplain' has been used to define the area inundated in the probable maximum flood (PMF). This very rare flood is the largest that could possibly occur and potentially pose a threat to communities. Within many parts of the study area, the PMF level could be up to nine metres above the 100 year ARI flood level, and seven metres above the level of the 1867 flood. The depths demonstrate significant differences from most river systems where the PMF is only one to three metres higher than the 100 year ARI flood.

Confusion over the nature of the flood hazard in the study area has not been helped by the current procedures for flood notations on Section 149 Certificates under the EPA Act. Whilst councils are required only to use the certificate to advise whether a council **policy** relating to flooding exists, the certificates are often misinterpreted by the community as a statement of whether or not a **flood hazard** exists at the property. As all councils in the study area have different wording and provide different levels of information on certificates, this has further added to the confusion. Most importantly, when a council does not mention flooding on a certificate, the community may incorrectly assume that there is no flood hazard when in fact (eg. for properties just above the FPL), the flood hazard may be significant in dimension albeit rare in occurrence.

TABLE 11.5: EVALUATION OF URBAN RELEASE PLANNING SCENARIOS

Evaluation Criteria	Urban Release Area Planning Scenarios			
	Scenario 1 No further rezonings for Urban Development	Scenario 2 Continuation of Current Planning Patterns	Scenario 3 Reallocation of Landuses in Floodplain	Scenario 4 Increased Intensity of Landuses in Floodplain
1 Damages	AAD=\$0.3 Million. This damage is attributable to new development in existing zoned areas and areas for which rezoning is imminent (i.e. Lake Environs)	AAD=\$4.0 Million. This puts the cost of flood damage at approximately \$60 per person per year, in new areas.	AAD=\$2.8 Million. This represents a 30% decrease over Scenario 2	AAD=\$4.4 Million. This represents a 10% increase over Scenario 2.
2 Evacuation	Depends on the assessment of the evacuation capacity available in the area.	Significant problems likely to occur unless additional evacuation facilities provided in some areas. Note that there may be significant risk of loss of life (over and above 'misadventure' fatalities discussed below). Refer to separate report on existing evacuation strategy and facilities.	As for Scenario 2. The problem is slightly worse given that this scenario assumes more residential development below the 1000 year ARI flood. Education measures may be able to compensate for this.	As for Scenario 2. The problem is more severe than for either Scenario 2 or 3 given the additional population introduced into the floodplain.

TABLE 11.5 (Cont'd): EVALUATION OF URBAN RELEASE PLANNING SCENARIOS

Evaluation Criteria		Urban Release Area Planning Scenarios			
		Scenario 1 No further rezonings for Urban Development	Scenario 2 Continuation of Current Planning Patterns	Scenario 3 Reallocation of Landuses in Floodplain	Scenario 4 Increased Intensity of Landuses in Floodplain
3 Economic/ Social Impacts	Qualitative Overview	May have very significant social impacts and unlikely to be politically acceptable. Expectations for future development may not be realised. Maximum economic use of land between floods not achieved.	This scenario is close to the maximum development that could reasonably be expected in the floodplain. Social and economic impacts resulting from major floods would be significant. Ability to recover from impacts constrained due to the lower socio-economic levels of the population.	This scenario distributes more residential development and open space below the 1000 year ARI flood, and less above, than for Scenario 2. Impact on residential properties would be slightly greater for some residential development (over Scenario 2) but substantially reduced for industrial, commercial and public properties.	This scenario provides for an intensification of development over that provided in Scenario 2. Impacts would generally be greater than for other scenarios.
	Risk of loss of life from misadventure	Under this scenario, an additional 900 people could have their houses flooded above floor level in a 500 year ARI flood. Statistically, approximately one additional person may lose their life through misadventure under this scenario.	Between 5 and 20 fatalities from misadventure could be expected in a 500 year ARI flood.	As for Scenario 2 but with a slight increase in risk, due to the higher residential landuses below the 1000 year ARI flood.	As for Scenario 2 but with a slight increase in risk, due to the higher residential population within the floodplain.

TABLE 11.5 (Cont'd): EVALUATION OF URBAN RELEASE PLANNING SCENARIOS

Evaluation Criteria		Urban Release Area Planning Scenarios			
		Scenario 1 No further rezonings for Urban Development	Scenario 2 Continuation of Current Planning Patterns	Scenario 3 Reallocation of Landuses in Floodplain	Scenario 4 Increased Intensity of Landuses in Floodplain
4 Orderly/ Efficient Pattern of Urban Growth	Qualitative Overview	Potential opportunities to provide additional urban development in proximity to the river system. Associated scenic amenity and recreational opportunities are not realised. Similarly benefits associated with locating additional urban development near to existing urban facilities and infrastructure such as the railway line are not realised.	Missed opportunities referred to in Scenario 1 can be realised. However urban development in close proximity to the river system would continue to be avoided in recognition of the common FPL of a 100 year ARI flood.	As for Scenario 2 but high rise residential (without increasing population densities in the floodplain) could be encouraged closer to the river system subsequently taking advantage of the amenity it offers.	As for Scenario 2 but densities proportionally increase, maximising development opportunities.
	Broad Infrastructure Costs	Highest economic use of land not achieved. This may be partially offset by potential non-urban activity such as agriculture. No discernible additional infrastructure costs associated with a need to divert urban expansion of Sydney to alternate areas or with lost economies of scale.	No economic loss in use of land is expected as a result of this scenario. No discernible reduction in development costs associated with implementing future urban releases in study area as opposed to alternate areas within the Sydney metropolitan region.	As for Scenario 2.	As for Scenario 2.

Note: AAD = Average annual damage. (See Appendix C for a further description of the damage costs presented in this table)

4 FLOOD MANAGEMENT

4.1 FLOOD EMERGENCY PLANNING

The first step to success in managing flood events that affect persons and property is to ensure that an effective flood emergency plan (also referred to as a "flood plan") is in place. The plan must be applicable to various levels of flooding, must be understood by those entities tasked with plan implementation, must be flexible to allow for changing and unexpected conditions that will occur during its implementation, must have as much redundancy as is possible, and must be periodically exercised and updated based upon lessons learned during such exercises or from experience gained in actual flooding events. The implementer of the plan must be the writer of the plan.

The NSW State Emergency Service (SES) is the official agency tasked with the development of flood management plans, the mission of combating floods, and with providing public education on flooding. The SES is manned at the state level by a cadre of highly professional staff and utilises extremely dedicated volunteers located in local SES units to actually conduct operations in the flooded area.

General Recommendation

The SES, as presently structured at both State headquarters and Division level, would be severely tested if required to conduct a major flood management operation in the Hawkesbury - Nepean valley. Timely access to flood intelligence and methods to evaluate that intelligence are needed. The present flood management plan requires revision, however, to make it more effective, and extra resources are needed if the required flood evacuation and public education functions are to be effective.

Specific Recommendations

The current flood emergency plan is predicated on the concept of "onset of rain" as the trigger mechanism for the plan. This concept requires a "look back in time" before the plan is implemented. Current studies indicate that the response times are so short that the plan must be triggered based upon river levels predicted based upon a forecast of rainfall by the Bureau of Meteorology. The concept of "onset of rain" should be eliminated.

Given the increased experience and expertise in flood management capability at the SES headquarters level, the concept of the handoff of responsibility from the local SES Controller to the State Emergency Operations Controller directed by the Police Commissioner should be eliminated. This concept has inherent potential for disaster built into it because of the time necessary to effect the transfer from one authority to another and the likelihood of events requiring immediate response occurring during the change in command responsibilities. Additional complications can be expected when operational control passes to an entity that did not prepare the plan and that has other major responsibilities on a day to day basis. When major flooding is forecast, the State SES headquarters should immediately assume and retain control of the flood management activities and task other agencies with specific missions

required by the flood emergency plan..

The current flood emergency plan for the Hawkesbury - Nepean valley is predicated upon complete evacuation within 14 hours of areas expected to be isolated at river levels in excess of 14.0 meters at the Windsor Bridge. However, mid-range floods, while isolating communities on the floodplain do not totally inundate them and sufficient dry land remains to hold a significant number of residents. It is recommended that the present plan be reviewed to determine whether, by the positioning of certain basic supplies in the isolated areas, either beforehand or during a flooding event, the evacuation and consequent trauma associated with being uprooted from a community could be avoided by evacuation of a portion of the population but leaving a substantial portion in their own community. This option would be useable in floods where there is certainty in the forecast that flood levels would not rise to a point where the isolated areas become untenable. Current reliability in river level forecasting may cause this option to be somewhat risky except when it is quite certain that flood levels will stay below the level of complete inundation of isolated areas.

The current SES Flood Emergency Plan for the Hawkesbury - Nepean valley should be expanded to include certain actions required for the area between Wilberforce and Spencer.

To enable a free flow of flood intelligence between major agencies involved in the flood management role it is essential that information and data important to several agencies be readily available. The computers at State SES headquarters, the Bureau of Meteorology, the Sydney Water Corporation, and Police headquarters should be capable of being linked during a flood emergency so that vital data such as river levels and rainfall forecasts can be accessed by those with a need without the necessity of hand-copying or utilisation of facsimile transmissions.

The current method of maintaining and updating flood intelligence consists of the utilisation of "flood intelligence cards" and extensive reliance on telephone communications to pass information between field personnel and controller headquarters and between various agencies involved in the flood fight. While this method has been effective, current assessments of the time available to take mitigation action and to project future actions that will be required are critical. Recommend that a flood intelligence system based upon Geographical Information System (GIS) technology be developed that will display, on a real-time basis, the same flood intelligence in all agencies monitoring or combating the flood. This system would allow entities with differing roles to project "what if" scenarios to gain as much advance planning time as possible before actions are required. The estimated cost of a basic flood intelligence system of this type would be on the order of \$400,000.

The SES currently has in excess of 135 Flood Plans that it is responsible for implementing throughout New South Wales. Many of these plans are due for review and revision but current staffing resources are not available to conduct reviews let alone perform field validation activities. Recommend that resourcing be provided to the SES to allow for the update and validation of existing flood emergency plans, particularly, those pertaining to the Hawkesbury - Nepean valley. This can be done through the addition of staff or by out-sourcing under the direction of the SES.

Due to the critical importance of communications during an operation of the magnitude of that contemplated by the present SES Flood Emergency Plan for the Hawkesbury - Nepean valley, it is essential that all agencies involved in plan implementation be capable of communicating with each other with redundancy. Communications systems should be reviewed and tested to ensure that radio frequencies are compatible, that equipment is operational, that operators are knowledgeable, and that communication Standing Operating Plans (SOP) are integrated and functional.

To ensure that plans are kept up to date and to be certain that key players responsible for the implementation of the plan are aware of their required actions, it is essential that plans be exercised to levels where there is reasonable certainty that the plan will be effective. Current flood plans should be reviewed and exercised at least annually and the resources made available to the SES to direct these activities.

The issue of post-flooding recovery, while not the responsibility of the SES, will be a major issue given the large number of people (up to 60,000) that are displaced from their homes and the enormous amount of time (up to six months) that is projected to be needed to restore basic utility services before occupation of the evacuated areas can occur. Plans developed by the Department of Community Services and other agencies with post-flooding recovery responsibilities should be reviewed for validity in light of the new information revealed in the current study.

Costs

The costs to resource the SES properly in order to perform the necessary plan review, plan revision and updates, and to conduct plan exercises are estimated to be \$500,000 annually.

Costs for an adequate GIS Flood Intelligence System are estimated to be \$400,000 to develop and implement.

4.2 FLOOD FORECASTING

Due to the nature of the geographic and hydrologic setting of the Hawkesbury - Nepean valley, the availability of extremely accurate forecasts of precipitation early in the rainfall event is essential if a reasonable expectation of the successful evacuation of the affected populace is to be realised. This forecast of rainfall must be the basis for accurate river response modelling which provides estimates of river levels relied upon to trigger evacuation. These forecast river levels must take into account rainfall occurrence in the Hawkesbury - Nepean valley as well as the accurate forecast and awareness of river response in the Grose and Colo Rivers due to the very large backwater effect of discharge from these catchments on flooding levels upstream of their confluences with the Hawkesbury River.

The lack of accurate and timely forecasts of precipitation and river levels in major flood events will almost surely result in major loss of life and property damage.

General Recommendation

The Bureau of Meteorology (BOM) is the agency officially tasked with providing forecasts of rainfall and river levels in response to rainfall. The BOM must be resourced to ensure that data acquisition techniques are available to allow the timely development and updating of forecasts of rainfall and that river models used to predict river levels are current, validated and upgraded on a continuous basis.

Specific Recommendations

Immediate arrangements should be made to provide the BOM with direct access on a "real-time" basis to Sydney Water Corporation rainfall and river level data collected on the catchment above Warragamba Dam. This recommendation, alone, could reduce forecast times by up to one hour.

Arrangements should be made to allow for increased polling frequency of Sydney Water Corporation gauges upon request of the BOM.

Redundancy of communications access to vital rainfall and river gauges should be established. The use of up-to-date radio communication systems and utilisation of existing satellite communication technology for remote data access and transmission should be considered.

An adequate network of automated rainfall and river level gauges must be established throughout the catchment above Spencer, including the catchments of the Grose and Colo Rivers, to ensure the availability of those data essential for generation of forecasts of rainfall and river levels.

The BOM must be able to provide a continuous working interface between meteorologists and river modellers to ensure a coordinated forecast product on a timely basis.

The enhancement of weather radar acquisition capabilities is essential if timely and accurate forecasts of rainfall are to be expected.

Costs

Cost estimates of various levels of data acquisition enhancement are provided at Annex A of this report. They range from basically no cost to provide BOM access to Sydney Water Corporation raw data; \$190,000 for a redundant reporting system on existing key gauges; \$580,000 for a comprehensive rainfall and river gauge network; and up to \$16 million for a fully operational weather radar acquisition system that would provide a state of the art flood forecasting and flash flood warning system and provide a public education component for flood awareness.

4.3 FLOOD WARNING

The availability of the most accurate and timely flood forecast is of no avail if a warning system that is effective, timely, and understood by the affected population is not in place. Current plans rely on some utilisation of the broadcast media, both radio and television, with heavy reliance upon a "door knocker" system utilising as many as 600 volunteers who must be inserted into the evacuation area and then evacuated themselves. The present plan does not have the redundancy necessary nor does it utilise techniques that have been proven to be effective in other flooding situations.

General Recommendation

Consideration should be given to the adoption of early warning techniques such as development of an emergency warning broadcast system for both radio and television, and installation of a warning siren network that supplement those warning actions presently relied upon. Validation of existing warning systems should be performed.

Specific Recommendations

Development of a public broadcast emergency warning system should be implemented that utilises both radio and television media. This system could designate specific radio stations as key stations to which listeners to any station are directed when there are emergency warnings to be disseminated or the warning message could be disseminated to all stations in the affected area. The immediate transmission of the warning message must be mandatory. For television, a short warning tone should be used during regular programming which alerts listeners to the fact that a "trailer message" is about to be displayed.

The use of warning sirens is widely recognised as one of the most effective methods of warning the general populace of a specific emergency. Warning sirens should be installed in all urban communities susceptible of flooding and should be mandatory in those requiring evacuation before isolation occurs. The sirens should be of sufficient loudness to be heard while people are sleeping or listening to radio or television, should be sufficiently robust to ensure dependability of operation during periods of inclement weather, and should be tested periodically as an element of public education as well as to test operability. The sirens should be used to warn of flooding only so as not to confuse the public as to the meaning of their peculiar warning sound. The warning system might consist of three separate sequences, i.e. one blast indicates a flood watch and means the public should prepare to evacuate, two blasts is the signal to immediately begin the evacuation of the area, and a continuous sound used to indicate that flooding is occurring and immediate action is necessary to avoid loss of life.

The effectiveness of the "door-knock" system should be tested by identifying the human resources that will be tasked to do the work and by identifying the methods to be used to provide ingress and egress to and from the evacuation area. Actual field tests should be conducted by SES personnel to verify procedures to be used and to determine the length of time volunteers can be expected to work and the number of contacts per hour that can be reasonably expected.

4.4 FLOOD EVACUATION

The evacuation of persons from a disaster area, such as that created by flooding, is contingent upon the availability of safe evacuation routes, a level of public awareness of the necessity for such a measure that generates cooperation during the evacuation process, the availability of a warning system that alerts the public when to begin the evacuation, the provision of adequate evacuation methods that assures full evacuation of the populace, and sufficient command and control resources so that the evacuation is conducted in a timely and disciplined fashion.

Current indications are that without any improvement in existing evacuation routes and if local flooding is occurring in the evacuation area, the majority of the 40,000 to 60,000 persons to be evacuated during a severe to extreme flood event will be without a means of escape from isolated areas surrounded by water. Unless rescued, these persons can be expected to drown if flooding levels occur that inundate the islands. Even if presently designated evacuation routes are improved to eliminate the threat of local flooding, up to 15,000 persons will remain unevacuated and subject to total isolation or worse depending upon the final flooding depth.

The Hawkesbury - Nepean valley is particularly dependent upon the use of the local road system for evacuation because of the large number of people involved, the inability to predict the availability of rail resources due to the loss of power, and the unlikelihood of being able to count on watercraft or aerial means of evacuation except for limited rescue operations.

General Recommendations

It is imperative that the existing road infrastructure leading out of the flood inundation zone be immediately upgraded to allow for evacuation of all persons affected to high ground. This option will give people marginal assurance that they will avoid the prospect of drowning in severe to extreme flood events but does not provide for their movement to evacuation centres where they can be cared for.

Costs for road improvements to implement this option are estimated to be \$6,220,000. Part of these costs include improvements to Londonderry Road which are currently planned.

Resources should be immediately budgeted to begin the upgrading of evacuation routes, beyond that described above, to provide reasonable assurance that the evacuation plan envisioned in the current SES flood emergency plan will be successful. This option will allow for evacuees to reach the prescribed evacuation centres assuming no contingencies occur.

Costs for the necessary improvements to road systems for this option are an additional \$7,150,000.

Plans should be implemented to upgrade the evacuation routes to a point where there is sufficient redundancy to be reasonably assured that all potential evacuees can be removed from the flooded areas. This option will require additional road improvements and

identification and selection of alternate routes but will function under adverse conditions or during unforeseen circumstances that could be reasonably expected to prevent the full evacuation of the threatened population otherwise.

Costs for this final option are estimated to be \$24,740,000.

Specific Recommendations

The existing road system serving the evacuation area must be upgraded IMMEDIATELY to minimise local flooding impacts in order to avoid major loss of life.

Additional work must be done in enhancing the evacuation routes and developing alternate routes if the population is to be assured of safe evacuation in a major flood event.

The accessibility of evacuation routes from local neighbourhoods should be assessed to be certain that people in private vehicles can reach the prescribed evacuation route.

The requirements for bus evacuation should be verified and validated to existing and future demands, the availability of the requisite number of buses should be confirmed, and the traffic control plan and dispatching system should be revisited to assure, in so far as possible, the availability of needed assets.

The availability of rail assets which can be used on a shuttle basis in and out of the evacuation area and the feasibility of utilising Richmond RAAF Base for aerial evacuation should be investigated. These assets should not be considered as primary assets for evacuation, but the planning for their use, should they be available at the time of evacuation, should be done beforehand.

Costs

Cost estimates for evacuation route upgrades are summarised as follows. Specific details and priorities for construction can be found in the supporting reports prepared by Patterson - Britton Partners, Pty. Ltd. and Masson and Wilson, Pty. Ltd.

Table 4.1: COSTS for EVACUATION ROUTE IMPROVEMENTS

PHASE	DESCRIPTION	COST
A	Immediate Works to Evacuate to High Ground (includes planned upgrading of Londonderry Rd.)	\$6,220,000
B	Additional Work Necessary to Marginally Implement Current SES Evacuation Plan	\$7,150,000
C	Additional Work to Assure Evacuation and Provide Redundancy	\$24,740,000
TOTAL		\$38,110,000

4.5 PUBLIC AWARENESS

A public education program is essential if effective flood evacuation and response to flooding is to be expected of the public. Without effective education programs, evacuation times are much longer because of the lack of knowing what to actions to take on the part of the public, resistance to relocation is much greater due to lack of knowledge of the threat, warning systems are rendered less effective and other effects adverse to the efficient implementation of flood emergency plans occur. Current levels of resourcing have not permitted the development of even a rudimentary public awareness program.

General Recommendation

A comprehensive public flood awareness program must be developed to educate the flood impacted community on the magnitude of the threat they face, the rudiments of the plans in place to protect them, and the necessity for immediate and disciplined response to flood warnings and evacuation orders.

Specific Recommendations

The SES is responsible for development and implementation of public awareness programs related to flood threats. Currently, this agency has little or no resources available for this activity. The creation of full-time Division Controllers in the two affected regions will substantially increase the capability of the SES to provide education with respect to flood awareness, but additional funding should be made available to the SES to implement specifically tailored public awareness programs in cooperation with local governments..

Specific efforts at public education should be instituted at the local level such as development of instructional packets for use in schools, use of council newsletters, spot announcements in the public media, and sponsorship of flood awareness booths at local events. This educational process should be continuous and updated as specifics affecting the local community change.

Various "awareness " methods should be implemented such as the obvious designation of evacuation routes as "Emergency Flood Evacuation Routes" using signage and traffic control markers. This will have a dual effect of making the evacuation route more useable and of daily instilling in the public the message of flood awareness. Additional measures include painting the emergency flood level on streets, use of poles indicating expected flood levels for various return intervals, signs on poles showing historic flood levels such as those that occurred in the flood of 1867 and others.

It is questionable whether persons, once evacuated from the flooded areas, will report to designated evacuation centres unless there is some incentive to do so. The public education process must emphasise the necessity of such reporting for purposes of family reunification and provision of emergency services. It should be emphasised that registration is required before any public assistance such as emergency lodging, food, financial assistance, or medical services can be provided.

Costs

The cost to implement this important aspect of the flood management plan are estimated to be

\$250,000 per year to fund two full-time SES Division Controllers and provide adequate support, and \$500,000 to \$1m per year to develop and maintain an adequate public awareness program.

4.6 INFRASTRUCTURE ENHANCEMENT

Flooding of the nature envisioned for the Hawkesbury - Nepean flood plain will have enormous impacts on the infrastructure that residents depend upon and take for granted in their every day activities. The levels of flooding that can reasonably be expected cause the disruption of water, sewer, electricity, natural gas, and communications facilities early in the flood event. It is expected that flooding at the higher expected levels could cause certain utilities to be disrupted for periods as long as six months. This matter is being considered in detail by Molino Stewart, consultant to the Committee, in a report entitled "Impact of Flooding on Communities and Infrastructure".

General Recommendation

Inquiry should be undertaken to ascertain what provisions the various utility providers have taken to ensure the availability of service for as long into the flood event as possible, and for the restoration of service as soon as possible after the flooding subsides.

Specific Recommendations

Utility providers should be alerted to the nature and extent of the flooding that can be expected and urged to take flood proofing measures that will ensure continued service as far into the flood event as possible. This may include the flood proofing of buildings and key facilities, the stockpiling of necessary commodities or equipment, the provision of standby power sources, the relocation of certain lines to levels that are not easily affected by flooding as well as other measures.

Utility providers should be requested to consider measures that will provide restoration of services as quickly as possible after flooding subsides. This may include the provision of back-up equipment, planning for the increased work force necessary to affect the repairs and other actions.

The criticality of the existing road network and the absolute necessity for the upgrading of the system has been elaborated on in a previous section.

4.7 FUTURE GROWTH

The Hawkesbury - Nepean valley which is subject to the kinds of cataclysmic flooding addressed in this study is estimated to have some 40,000 to 60,000 persons at risk from severe to extreme flooding events. Projections of future growth that would be in the flood inundation zone are estimated to be between 17,000 to 80,000 persons. Given the fact that current estimates indicate that the likelihood of evacuation of the existing "at risk" population is problematic, the allowance of further growth of residential populations within the expected evacuation areas, without requiring the development of measures to ensure their safe

evacuation, would be almost unconscionable and potentially vulnerable to litigation. Preliminary estimates of the impact of future climatic changes due to "green house" effects and other climatic changes, indicate that floods of a given recurrence interval will tend to be larger and of longer duration pointing up the need to continually update the estimates of flood frequency and magnitude.

The following recommendations are suggested to allow for future development without unduly jeopardising the safety of persons currently living in the area or of persons who choose to live there in the future.

General Recommendations

Specific measures must be implemented to mitigate the effects of flooding on further development in the Hawkesbury - Nepean floodplain before such development should be planned or allowed to become a reality.

Because of the extreme complexity of the Hawkesbury - Nepean flooding threat, a coordinated and comprehensive Flood Plain Management Study should be undertaken.

Consideration is being given to altering the method of operation of the spillway gates at Warragamba Dam to provide additional dam safety for the structure and to reduce the level of downstream flooding resulting from actual spill from the reservoir. Preliminary indications reveal that any change from the present operational scheme may slightly reduce flood levels but will substantially reduce available evacuation times. Detailed studies of gate changes must be done before any decision is made to ensure that evacuation times are maximised. This matter is currently under review by the Department of Land and Water Conservation.

Specific Recommendations

Implementation of the evacuation route upgrades as recommended in preceding paragraphs must be completed before additional persons are allowed to occupy the evacuation area as the present road net does not allow for evacuation of existing residents. The requirement for these routes to carry additional evacuees will certainly result in impacts on inhabitants that has the potential to be measured in terms of loss of life.

Future decisions allowing development in the evacuation areas should be based upon a full assessment of the inundation zone and the availability of evacuation routes. The sole reliance upon a "flood prone - flood free" concept based upon a specific recurrence interval (usually the 1 to 100 year flood) can lead to exacerbation of the present problem by creating additional areas of residential development that require extensive evacuation from flooding.

The provision of full-time SES Division Controllers will provide a source of advice to the local councils on flood impacts that can be used when areas for re-zoning or future development are under consideration.

Contrary to the situation that exists with the growth of Fire Brigade personnel as a population grows, the growth of the SES is in no way related or tied to population since it is strictly a volunteer force at the local level. As the area urbanises, the fashionableness of voluntarism becomes less attractive because of other activities being available which indicates a decline in

SES staffing at the local level might be expected. Consideration of creation of incentives to local councils in the form of financial assistance to provide the necessary real estate and buildings to house new SES units that might be created in the areas of new growth is suggested.

Conduct a coordinated and comprehensive Flood Plain Management Study that would provide both a regional and detailed consideration of all aspects of the existing flood threat and propose actions for the future that minimise the flood threat to future populations. The study would ultimately provide the basis for preparation of local Flood Plain Management Plans for each of the local government areas of Penrith, Hawkesbury, Baulkum Hills, and Blacktown, thereby providing flood management information to the local planning process when development stages are being considered.

The regional Flood Plain Management Study should consider the flood threat on a valley-wide basis taking into account such issues as the change in the flood profile upon modification of Warragamba Dam, future growth and where it should occur, infrastructure evaluation and enhancement, the pooling of local government resources to provide regional flood relief and planning, evaluation of current estimates of large flood events taking into account observed flood events of large magnitude and potential future climatic changes, and other matters that can be identified that will enhance the protection of the present and future populace.

The Role of Floodplain Planning

Floodplain management is about occupying the floodplain and optimising its use in a manner which is compatible with the flood hazard and at a level of risk which is expected by the community.

Flooding is only one issue which decision makers must consider. However it has become a very important issue, particularly where there is a direct and significant risk to the community because of the potential for loss of life or huge flood losses. These risks must be clearly understood by decision-makers as they result directly from planning decisions, and importantly, they are readily foreseeable. The least the community expects is that these decisions are made on an informed and reasonable basis.

Floodplain management involves more than setting a FPL. It is about comprehensively managing the risk to people and assets both below and above the FPL, by applying and integrating a range of available measures.. In the study area, there are many areas above the FPL which although they have a low chance of inundation, have a significant flood risk given that flooding would result in disastrous consequences (eg. whole suburbs requiring evacuation to prevent catastrophic loss of life). This flood risk must therefore be understood and pro-actively managed. Simply raising the FPL may not be the answer as this may lead to unnecessary land sterilisation or failure to address other flood risks.

There are different types of flood risks and a range of ways in which each type of flood risk can be managed. This includes floor level controls, flood awareness and warning, evacuation facilities, building design, distributing land uses in a flood compatible manner, subdivision design (eg road layouts), structural works, etc. Effective regional, local and emergency planning is the key mechanism by which the flood risks can be managed.

The State of Local Floodplain Planning in the Study Area

Of the six councils in the study area, only one (i.e. Blacktown) has prepared a floodplain management study and plan. The other councils have experienced difficulty and have either not begun the process, or have started and then failed to carry through to completion of a plan.

In general, current local environmental planning has not fully recognised the extent and potential consequences of the flood hazard and councils have been unable to adequately

address the more complex range of issues associated with floodplain planning in the study area. By way of example, although the area contains portions which may be extremely hazardous during floods (due to velocity, depth, restricted evacuation facilities, inadequate flood warning, etc, or a combination of these), and it is almost inconceivable that future urban development could be permitted in these portions, none of the six councils have yet identified specific zones to restrict development because of the flood hazard.

Floodplain planning in the study area has almost wholly relied on the definition of a singular FPL, which has usually been the 100 year ARI flood level. While such an approach has generally been adequate in other parts of the State, it has led to a number of problems in the study area including:

- lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there are very few measures in place to manage the consequences of flooding above the FPL);
- distribution of development within the floodplain in a manner which does not recognise the risks to life or the economic costs of flood damage;
- unnecessary restriction of some land uses from occurring below the FPL, while allowing other inappropriate land uses to occur immediately above the FPL;
- polarisation of the floodplain into perceived 'flood prone' and 'flood free' areas;
- creation of a political climate where the redefinition of the FPL (due to the availability of more accurate flood behaviour data, or for other reasons) is fiercely opposed by some parts of the community, due to concern about significant impacts on land values — ie. land which was previously perceived to be 'flood free' will now be made 'flood prone' — (despite the likelihood that such impacts may only be short term);
- creation of a 'hard edge' to development at the FPL.

Accordingly, it is clear that continuation of the sole reliance on the 100 year ARI FPL is inappropriate for the study area because it cannot effectively manage all the foreseeable flood risks.

The current approach to floodplain planning discussed above may be typified by the example shown in **Illustration 2**, which flows from the inappropriate view of flood hazard presented in **Illustration 1**. No development is permitted below the FPL (ie 100 year ARI flood) because of an acknowledgement of the flood hazard. Above the FPL, no flood hazard is perceived and therefore there are no additional controls on development. Thus an abrupt change in development control occurs at the FPL.

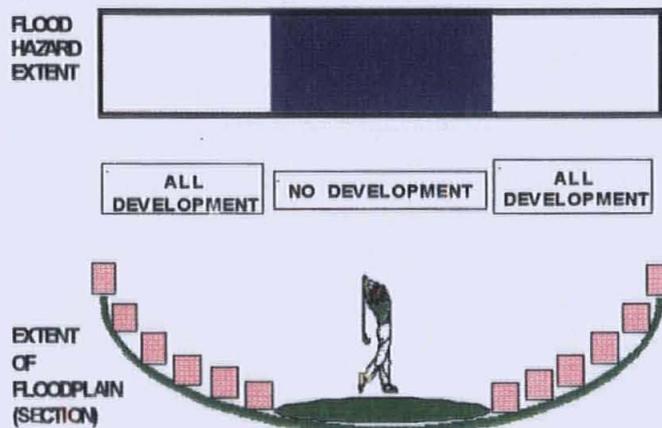


Illustration 2: Current Floodplain Planning

(Derived from an inappropriate view of flood hazard and the use of a singular flood planning level)

In addition, none of the councils have determined their FPL using the procedures suggested in the State Government's Floodplain Development Manual (1986), ie. by:

“ balancing the social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. ”

By default, most councils have therefore adopted the 100 year FPL, given that this FPL has been widely used across the State and that councils have been unable to carry out the assessment necessary to establish appropriate alternatives. The process suggested in the Manual, being complex and without detailed guidelines for town planners, has been difficult for councils to follow.

Interviews carried out with council officers during the course of the study have indicated some councils are also looking to the State Government for further assistance by preparing a floodplain management study on a regional basis. Given the regional flood problems, such a study (or studies) is essential and subsequent guidance to councils to prepare their own floodplain management plans may also be necessary.

Regional Planning

Based on development within areas identified for future development by DUAP (1997), the population of the floodplain could increase by between 17,000 and 80,000 in the next 50 years. This could more than double the existing population of 62,000 (1996). Without coordinated planning and development controls, the introduction of this number of people into the floodplain has the potential to place a significant economic and social burden on the community, having regard to the potential flood damages and the risk to loss of life if safe evacuation of these people is not possible during major floods.

Various scenarios for urban release planning in the floodplain have been investigated to evaluate the potential for controlling flood damage consequences by varying the release of additional land and the land use distribution within these releases. These investigations indicate that there would be substantial costs associated with scenarios which realise the maximum possible additional urban development within the floodplain and while there is unquestionably benefits associated with such development, it would be difficult to conclude that it is appropriate to permit any further release of urban land without fully addressing flood risk. In this regard the investigations indicate that substantial reductions in damages and risks to life can be easily achieved by distributing land uses within the floodplain in a manner which recognises their differing vulnerability to flood risks.

While regional planning is complex and involves many factors in addition to flooding, the process of managing the flood risk discussed above, is a key element which must be included.

The Planning Matrix Approach

Given the extensive flood range and the difficulty in addressing the associated variability in flood risks with simple rules, the report recommends the use of the planning matrix approach, based on consideration of the full flood hazard within the floodplain.

The approach distributes land uses within the floodplain and controls development to minimise the flood consequences as depicted in **Illustration 3** below.

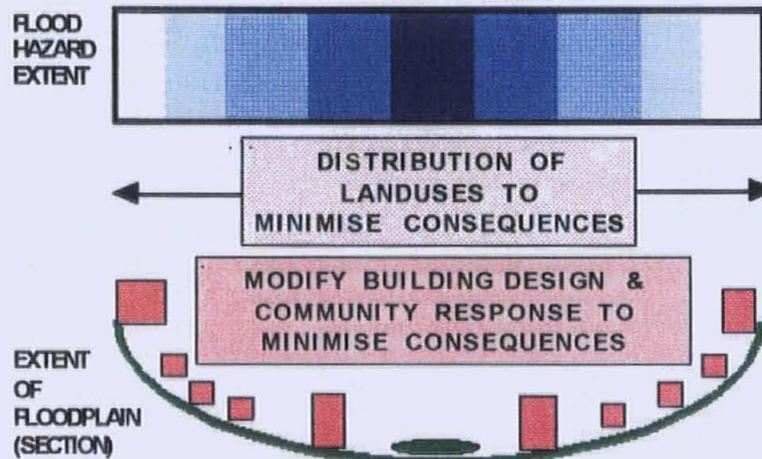


Illustration 3: The Planning Matrix Approach to Floodplain Planning

Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain. This approach has been previously applied within the Blacktown, Narrabri and Molong Floodplain Management Studies, and the resulting matrix has been pivotal in the new draft DCPs recommended for implementation as part of these floodplain management plans (see **Illustration 10** in **Section 8.2.4**). The approach is fully consistent with the current Floodplain Development Manual (1986) or its prospective replacement, the Floodplain Management Manual (currently being drafted).

To provide the necessary guidance to council planners to implement the planning matrix approach and the principles contained within the Floodplain Development Manual (and the new Floodplain Management Manual), it is recommended that best practice guidelines be prepared for town planners. The cost of preparation of these guidelines, and their introduction to council planners is estimated to be approximately \$200,000.

Contained within these guidelines there needs to be clear definition of areas of extreme hazard within the floodplain. For these hazardous areas to be defined, a separate study initiated by the Department of Land and Water Conservation (DLWC) is required. This would cost approximately \$100,000. It would examine the full range of factors which contribute to flood hazard (eg. depth, velocity, evacuation potential, flood warning, etc). While most of the background data necessary to quantify these factors is now available, the study would provide a comprehensive methodology and consistent basis for mapping areas of extreme hazard across the various local government areas within the floodplain.

In addition to the best practice guidelines, companion guidelines relating to flood-compatible subdivision and building design are also required. These latter guidelines would cost a further \$200,000 each to prepare and could build upon initial investigations already undertaken by the DLWC.

Communicating Real Flood Risk to the Community

As the flood risk is poorly recognised and appreciated by the community, there is a pressing need for the development, implementation and maintenance of an effective public education programme to raise the awareness of the community to flooding issues. Communities which understand the hazards they face can be better prepared for them and therefore will have a better chance of mitigating the effects to avoid disaster than those who do not.

A multi-faceted education programme is recommended involving such things as flood warning poles, preparation of a video, signage of evacuation routes, flood displays, training of key people, and special education measures for new business owners, residents and tenants. This programme which would require coordination at the State level, probably by the State Emergency Service (SES), would cost between \$0.5 to \$1.0 million per annum to implement and maintain. This recommendation is consistent with that made by Danielson & Associates in their report to the Committee.

In addition, it is recommended that revision of the regulations for Section 149 certificates to include a flood certificate stating all flood risks up to the PMF (not just the FPL), and the separate distribution of the flood certificate to all property owners (say) every three years with rates notices, will significantly improve the community's knowledge of flood risks in the area.

Study Recommendations

Nine specific recommendations are made in **Section 13.2** at the rear of this report and summarised in the table below.

The recommendations provide an appropriate package of measures to address the critical issues associated with land use planning and development controls in the Hawkesbury – Nepean floodplain.

Unless the community is made fully aware of the flood hazard and a comprehensive assessment of all flood risks is carried out as part of local and regional planning, past problems in the valley will continue and be exacerbated by future development pressures.

SUMMARY OF STUDY RECOMMENDATIONS

No	DESCRIPTION	CAPITAL COST	ANNUAL COST
Communicating Risk			
1	Modify Section 149 Regulations	n.a.	n.a.
2	Issue flood certificates regularly	n.a.	n.a.
3	Implement flood awareness programme	n.a.	\$500,000– \$1,000,000
Strategic Direction			
4	Metro plans to consider all flood risks up to the PMF	n.a.	n.a.
5	Metro plans to exclude extremely hazardous land	n.a.	n.a.
6	Establish sub committee of Metro Strategy Committee to consider flood emergency response	n.a.	n.a.
7	State Government to demonstrate concern and provide direction to local councils through directives and planning instruments set out in the EPA Act, e.g. REP, S117 directions, etc.	n.a.	n.a.
Local Planning			
8	Prepare best practice planning guidelines, and guidelines for extreme hazard definition, subdivision and building design	\$700,000	n.a.
9	Discontinue reliance on the 100 year FPL	n.a.	n.a.
	Total	\$700,000	\$500,000– \$1,000,000

13.0 CONCLUSIONS AND RECOMMENDATIONS

13.1 Discussion of Issues

13.1.1 Regional and Local Planning

Flood behaviour within the study area is complex and unique, and management of the flood risk through planning is of major importance to the region.

The issues cannot be dealt with by continued reliance on a singular flood planning level (FPL). Changes to the planning approach at the regional and local levels are therefore required.

The issues cannot be addressed solely by individual councils as normally encouraged through the State Government's policy expressed within the Floodplain Development Manual (1986). Investigations undertaken clearly conclude that councils in the study area require general guidance at a regional planning level in order to ensure that the flooding issue within the Hawkesbury – Nepean floodplain is addressed comprehensively and consistently.

Discussions with councils reveal there is considerable disparity between available flood related information, flood management strategies, flood standards for development control, notification of Section 149 Certificates, criteria for rezonings and internal administration of development and related strategic policy. While the variations in floodplain planning, and flood standards in particular, may superficially appear to be the desired outcome of the State Government's 'merits based approach', under closer examination the standards are not equally justifiable and are certainly not based on a consistent rationale across the floodplain.

In all cases the current FPLs have not been adopted as a result of the floodplain management study process outlined within the Floodplain Development Manual (1996).

To achieve consistency across the various LGAs and to ensure that planning proceeds beyond setting FPLs, the FMS will need to deal with issues which have not been able to be addressed at a local level, by application at the regional planning level.

13.1.2 Problems with a Singular Flood Planning Level

The reliance on a singular FPL has probably become the critical obstacle to implementation of appropriate floodplain management principles in the Hawkesbury – Nepean region. The traditional approach to floodplain planning confuses the identification of flood related hazards with the imposition of restrictions on development and consequently land values.

The identification of hazards and the formulation of land use planning and development controls to address the potential risks should necessarily be recognised as separate processes within the FMS. The process involving the identification of hazards is important in developing emergency response procedures, increasing flood awareness and guiding regional planning decisions (e.g. such as major road construction) being essential components of the FMS and which may actually assist in reducing the need for restrictive planning controls.

13.1.3 Urban Release Planning

The greatest potential for reducing the future vulnerability of persons and property to flooding over the full range of flood risks, is through the planning of major urban release areas in the floodplain. This must consider the location of urban release areas and the distribution of land uses within urban releases and residual areas, relative to the flood hazard.

Various scenarios for urban release planning in the floodplain were considered. This involved evaluation of the likely consequences associated with alternate scenarios for the release of additional land and the distribution of land uses within this land. These investigations indicate that there would be substantial flood losses associated with scenarios which realise maximum development within the floodplain. There are unquestionably benefits associated with such development and if it proceeds, it would be worthwhile to distribute the most vulnerable land uses higher in the floodplain where flood hazard is lower, so that the resultant flood risk could be significantly reduced.

It would be difficult to conclude that it is appropriate to permit any further release of urban land without fully managing the flood risk.

13.1.4 Integration of Flood Risks in Planning

Appropriate planning within the floodplain must include the integration of a full understanding and treatment of flood risks within each level of planning in much the same manner as other factors such as water quality, bush fire hazard, transport, endangered species and so on, contribute to the planning process. The investigations undertaken in this study conclude that at present only a partial consideration of the flood risk has been included in the planning process. In general, risks of flooding above the current FPLs have not been widely understood and therefore are not adequately considered.

Recognition of the full flood risk can be integrated at various levels of planning input, eg. through:

- the proposed Floodplain Management Manual;
- instruments such as SREP 20 which deal with environmental management within the Hawkesbury – Nepean region; and
- preparation of advisory documents to assist local Councils in implementing detailed flood related planning controls (eg. in areas above current flood planning levels).

13.1.5 Evaluation of Options

Table 13.1 discusses the planning issues which need to be resolved and provides recommendations for a way forward. It also suggests organisations which could be responsible for implementation of the recommendations.

TABLE 13.1: FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>1. Inconsistent Section 149 notifications issued by councils</p>	<p>a) Issuance of a DUAP circular advising councils of the appropriate interpretation to Section 149 of the EPA Act and associated Regulations</p> <p>b) Pursue amendments to the EPA Regulations which specify the required contents for Section 149 Certificates</p> <p>c) Do nothing</p>	<p>All councils within the study area provide different notifications on Section 149 Certificates in regard to the issue of flooding. In some cases the same council provides different notifications for different areas. In many cases, councils have received independent legal advice in regard to the interpretation of the existing legislation relating to Section 149 Certificates. Accordingly, the ability for DUAP circulars to provide clarification would be constrained by the existing independent legal advice obtained. The significance of this issue would sway against the do nothing option.</p>	<p>Option b)</p>	<p>DUAP</p>
<p>2. Section 149 notifications do not differentiate between flood hazards</p>	<p>a) Incorporate within the floodplain management study and plan processes a requirement to advise all potentially affected persons of the hazards of flooding, independent of the Section 149 Certificate process.</p> <p>b) Amend the existing Regulations to provide for the issuance of a flood certificate to all property owners in the floodplain identifying the flood hazard when established by a flood study or floodplain management study. Such certificates to be appended to Section 149 Certificates and regularly distributed (to owners and tenants.)</p>	<p>Option b) provides greater flexibility for councils and an approach which can assist in divorcing the identification of flood hazard from the imposition of planning controls. This Option is consistent with a council's duty of care as indicated in Section 10.4 of this report. With the possible exception of Hawkesbury City Council, it would appear that none of the local councils are currently exercising their duty of care in a manner consistent with the legal advice presented in Section 10.4.</p>	<p>Option b)</p>	<p>DUAP and DLWC</p>

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>3. The community is generally uninformed regarding the whole risk associated with flooding – primarily due to confusion between flood planning levels and risk.</p>	<p>a) The State and Local Governments consider additional measures which may increase flood awareness and preparedness in the floodplain inclusive of flood warning markers, a public education programme, appropriate Section 149 Certificates and separate Flood Certificates.</p>	<p>Increased flood awareness is generally accepted as desirable and can assist in reducing the need for restrictive planning controls. The public education with living in particular areas. To be effective, and cost-efficient, the programme must be consistent across the study area (or beyond) and coordinated at a regional level. The SES appears to be only department or authority with a clear mandate to implement such a programme. However at present the SES is restricted from fulfilling this role by a lack of funding.</p>	<p>Option a). Note that this issue is partly addressed by the recommendations for Issues 1 and 2.</p>	<p>DLWC, SES and individual local councils</p>
<p>4. Metropolitan strategy plans do not recognise the range of flood hazard specific to the primary Hawkesbury – Nepean floodplain</p>	<p>a) Future decisions in regard to the metropolitan strategy plan should take into consideration these hazards.</p>	<p>The metropolitan strategy plans for Sydney over the last 50 years have commenced the process of creating expectations for future urban development. Consideration of flood hazards above the 100 year ARI flood has had little significance in past planning primarily due to the lack of base information and the complexity of issues involved. Appreciation of the full flood hazard within the metropolitan strategy is an important component of the overall package of planning considerations. This will allow informed decisions to be made, particularly in regard to urban release planning.</p>	<p>Option a)</p>	<p>DUAP</p>

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>5. No consistent methodology has been applied to define areas unsuitable for the intensification of development (i.e. extreme flood hazard areas) having regard to the unique characteristics of the floodplain.</p>	<p>a) Continue the general approach contained within the Floodplain Development Manual (FDM). b) Promote additional guidance on the FDM approach by identifying a specific methodology for the Hawkesbury – Nepean floodplain. This would consider a number of factors inclusive of depth of inundation, the velocity of flood waters, capacity for unaided evacuation, and social and economic consequences.</p>	<p>The specific characteristics of the Hawkesbury – Nepean floodplain demand a specific methodology. The guidelines incorporated within the FDM are applicable over the whole State and are necessarily general. Whilst the FDM provides principles which are consistent with Option b), insufficient guidance is available for local councils to effectively and consistently apply these principles. Without such additional guidelines, a cursory application of the FDM which fails to adequately address the social, economic, evacuation and other major issues, may unnecessarily restrict development over a significant portion of the study area. The difficulty in applying the FDM principles in a practical manner is probably one of the main reasons local councils have failed to properly identify such hazard areas.</p>	<p>Option b)</p>	<p>DLWC</p>
<p>6. Further rezonings which increase the potential population (permanent residents, workforce or transient population), may not be able to be accommodated within the evacuation strategy.</p>	<p>a) That relevant draft LEPs be referred to the SES for consultation. b) That relevant draft LEPs be referred to the SES for concurrence. c) That major urban releases undergo a review process, having regard to the flood evacuation strategy for the area, achieved by the establishment of a sub-committee of the Metropolitan Strategy Committee to include representatives from the SES, DLWC, DUAP, the Transport Taskforce, relevant Local Government and other bodies as appropriate.</p>	<p>Any proposed rezonings in the study area which would likely result in additional population, must be able to be accommodated within the flood evacuation strategy for the area with or without ameliorative measures such as the construction of additional roads. A failure for this to occur could be critical in regard to risks to life. In some cases, the potential risk of loss of life is so large that it is inconceivable that the Government could allow development to proceed without appropriate evacuation facilities in place. In these circumstances it is therefore considered that the issue of evacuation should override any other factors and the concurrence of the SES (i.e. ability to provide an overriding veto) is the preferred Option. The management of this issue can be assisted by providing an input in the early stages of planning of urban release areas within the UDP process, by the establishment of an appropriate subcommittee.</p>	<p>Options a) and c)</p>	<p>DUAP, DLWC, SES, The Transport Taskforce, relevant local councils.</p>

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>7. The issue of flooding in the Hawkesbury – Nepean floodplain is not given appropriate weight in the planning process (plan making and development control)</p>	<p>a) Amend SREP 20 b) Provide appropriate advice to local councils through a DUAP circular c) Issue an appropriate Section 117 direction to the relevant local councils d) Expand the provisions of the Floodplain Development Manual (and future Floodplain Management Manual) to incorporate advice on how this may be achieved)</p>	<p>Option a) is considered to have substantial advantages over the remaining options for a number of reasons inclusive of:</p> <ul style="list-style-type: none"> • The flooding issue in the study area raises considerations relevant to both the plan making and development application processes (e.g. evacuation) which cannot be accommodated within the statutory scope of Section 117 directions. • The aim of SREP 20 and its structure logically provides for the inclusion of a specific policy and recommended strategies in regard to floodplain management for the area. • The scope and detail of the imminent SREP 20 is such that it would provide an appropriate basis to establish a consistent framework from which local councils can initiate and implement detailed local floodplain planning. The inclusions within the REP should not be prescriptive but only establish basic principles such as consideration of risks up to the PMF, understanding that different land uses have different vulnerability to the flood hazard and emphasising the importance of evacuation having regard to the specific characteristics of the Hawkesbury – Nepean Floodplain. • The existing state of floodplain planning in the study area demonstrates a need for input at the regional planning level, and indeed a number of the local council have expressed an expectation for such direction. 	<p>Option a)</p>	<p>DUAP and DLWC</p>

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
7. (Continued)		<ul style="list-style-type: none"> • The existing Section 117 directions, DUAP circular and Floodplain Development Manual provisions have not been adequate in regard to facilitating appropriate floodplain management in the study area, despite the significance of the issue and extensive debate over numerous years. Only one council in the study area has undertaken the preparation of a floodplain management study and plan in accordance with the Floodplain Development Manual and only over a portion of its LGA. • Recognition of the issue of flooding and identification of principles within an REP would form an important component within the overall package of mechanisms required to achieve an appropriate floodplain planning outcome. Without the appropriate direction at the regional level to tackle the identified regional planning problems, floodplain planning by local councils is likely to continue to be inadequate. 		

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>8. The specific nature of the Hawkesbury – Nepean Floodplain has prevented a consistent and comprehensive application of planning controls by local councils to address the flooding issue.</p>	<p>a) Allow Councils to individually and independently apply the principles of the Floodplain Development Manual (or the forthcoming Floodplain Management Manual).</p> <p>b) Incorporate specific provisions in the forthcoming Floodplain Management Manual to deal with specific issues associated with flooding in the Hawkesbury – Nepean Floodplain.</p> <p>c) Prepare best practice guidelines to assist local councils in the preparation of relevant planning instruments having regard to the specific nature of the Hawkesbury – Nepean floodplain and the recommended Planning Matrix Approach. These guidelines could be issued to councils through a DUAP circular and statutorily reinforced by an appropriate Section 117 Direction, and referenced in the proposed changes to SREP 20.</p>	<p>The Floodplain Development Manual (and forthcoming Floodplain Management Manual) are relevant to the State of New South Wales as a whole and cover a broad range of considerations of Government policy in regard to flooding, of which planning controls are only one component. The issue of floodplain planning controls is appropriately dealt with within the scope and intent of these documents, and their expansion to address specific issues relevant to individual floodplains would be inappropriate. More importantly, the issuing of best practice guidelines, will be directed to environmental planning practice and would provide an important mechanism to encourage and assist the integration of flood risk management within the planning process.</p>	<p>Option c)</p>	<p>DUAP and DLWC</p>

TABLE 13.1 (Cont'd): FLOODPLAIN PLANNING ISSUES — EVALUATION OF OPTIONS

ISSUE	OPTIONS	COMMENTS	RECOMMENDATION	ACTION
<p>9. Applications for major developments may create difficulties with regard to the implementation of the evacuation strategy for the floodplain.</p>	<p>a) Incorporate a provision within the imminent SREP 20 requiring consultation with the SES with regard to major development applications.</p> <p>b) Incorporate a provision within the imminent SREP 20 effectively requiring concurrence with the SES with regard to major development applications.</p> <p>c) Require via Section 117 directions that councils incorporate provisions within future LEPs to require consultation with the SES in regard to major development applications.</p> <p>d) Required via Section 117 directions that councils incorporate provisions within future LEP to require concurrence with the SES in regard to major development applications.</p>	<p>Given the present critical nature of the evacuation strategy in the floodplain and the issue being common throughout the region, it is important that the SES be provided a concurrence (and not just a consultation) role and that this be consistently and expediently provided via the REP process.</p>	<p>Option b)</p>	<p>DUAP, SES</p>

13.2 Summary of Recommendations

Based on the evaluation of options in **Table 13.1**, nine specific recommendations emerge for inclusion in the Committee's Flood Management Strategy. These can be categorised into the areas of:

- ♦ communicating flood risk;
- ♦ strategic direction; and
- ♦ local planning.

13.2.1 Communicating Flood Risk

Recommendation 1: That the notification responsibilities of local councils pursuant to the provisions of Section 149 of the Environmental Planning and Assessment Act, 1979, and associated Regulations, be reviewed to clarify and require councils to notify the whole of the potential flood hazard (ie up to the PMF).

Under the existing Regulations, councils are not required to identify flood hazards on S149 certificates (only flood policies). This creates confusion in the community as the notations are often considered as statements of flood hazard.

The notification should distinguish the difference between identification of flood hazard and the imposition of development restrictions and reference explanatory information regarding the transition of risk across the floodplain. This may be most conveniently achieved through the use of a flood certificate (see Recommendation 2 below)

Recommendation 2: In conjunction with Recommendation 1, that councils regularly issue a flood certificate to all property owners and residents in the floodplain identifying the flood hazard, where such hazard has been established by a flood study or floodplain management study.

This certificate could be appended to the S149 certificate and separately distributed to owners (e.g. with rates notices), and to tenants, every three years. To allow councils to prepare such certificates, flood study reports should include the necessary details for councils in a clear and unambiguous manner.

It is noted that there may be other statutory mechanisms available (or necessary) to achieve the desired outcomes behind Recommendation 2 (eg. amendment to the Local Government Act).

Recommendation 3: That the State Government develops, implements and maintains an effective flood awareness program in the study area, in partnership with local government (as also recommended by Danielson and Associates).

Annual Cost: \$500,000 to \$1,000,000 per annum.

The community is largely unaware of the extent of the flood risk in the area. Both the State and local governments need to consider additional measures which may increase flood awareness and preparedness in the floodplain, inclusive of:-

- flood warning markers;
- a public education program;
- appropriate Section 149 Certificates, and
- flood certificates.

Under the State Emergency Service Act (1989) the SES has an important role in raising flood awareness, but is largely restricted in fulfilling this role due to a lack of resourcing.

13.2.2 Strategic Direction

Recommendation 4: *Future metropolitan strategy plans to continue to recognise the need for a holistic risk management approach to floodplain management, by further including consideration of flood risks up to and including the PMF.*

This is an important component of the Government's Floodplain Development Manual (1986) and the forthcoming review of this document known as the Floodplain Management Manual. However the implications of risk relating to floods larger than the 100 year ARI have had little significance in past planning primarily due to the lack of base information and appropriate guidelines.

Recommendation 5: Future metropolitan strategy plans for the Sydney region should exclude land identified as being unacceptably hazardous for future development due to the potential destruction of property and risk of loss of life caused by the inability for unaided evacuation.

These areas are unsuitable for intensification of development potential. Technical guidelines which are specific to the Hawkesbury – Nepean floodplain are necessary to properly define such hazards, given the valley's unique flood behaviour. A consistent methodology for the establishment of these areas across local government boundaries is required. This will necessitate extension of the procedures contained within the Floodplain Development Manual in a manner which will facilitate implementation by local councils. (The cost of preparation of these guidelines is included under Recommendation 8).

Recommendation 6: Establish a special sub-committee of the Metropolitan Strategy Committee to consider flood emergency response

Any further proposed rezonings in the study area which may result in additional population (permanent or transient) could potentially impact upon the SES's flood evacuation strategy. For new urban areas, early review of evacuation issues, well before the preparation of the LEP, would determine whether the additional development resulting from the rezoning could be accommodated within the evacuation strategy, with or without ameliorative measures such as the construction of additional major road capacity. It is anticipated that this review process would best be achieved by the establishment of a sub-committee of the Metropolitan Strategy Committee (an official officer level committee responsible for the implementation of the metropolitan strategy). This sub-committee could include representatives from the SES, DLWC, DUAP, the Transport Taskforce, relevant local governments, and other bodies as considered relevant.

Recommendation 7: State Government to demonstrate concern and provide direction to local councils through directions and planning instruments set out in the EPA Act, e.g. REP, S117 directions, etc.

As part of this process, SREP 20 could be amended to provide specific measures to address floodplain management of relevance at a regional planning level.

These amendments to SREP 20 should:

- include a specific policy and recommended strategies in regard to floodplain management (as currently provided for within Part 2 of the draft SREP 20 in regard to matters other than floodplain management.). The policy should be aimed at reducing risks to property and life while the strategies should aim at consistently encouraging flood compatible development and may include:-
 - a requirement to be consistent with floodplain management plans when they have been prepared;
 - a mandatory requirement that the evacuation of people from development can be accommodated by the SES's flood evacuation strategy;
 - restrictions on the construction of new buildings in areas of extreme flood hazard;
 - encouragement for development in the floodplain to be sited, designed and managed in a manner which minimises the potential consequences of flooding;
 - a requirement for planning and development to be consistent with the State Government's Floodplain Development Manual (or its proposed future substitute - the Floodplain Management Manual) and any relevant 'best practice guidelines' which may be prepared.
- amend the definition of 'flood liable land' in the dictionary to include all land within the floodplain that is potentially affected by flooding up to the PMF. This is critical in establishing a basis for the abandonment of a single FPL in favour of a graded set of planning controls to manage land use to minimise flood risks as espoused within the Planning Matrix Approach. It is emphasised that the management of land use is not necessarily directed to the prohibition of urban development but rather at the allocation of land uses based on their sensitivity to the flood hazard, and the modification of building form and design;
- amend the consultation requirements of SREP 20 to include a mandatory requirement to consult with the SES for all major development (to be specified in a schedule) in the floodplain. This would in effect reinforce and supplement the above policy

strategy requiring that all development be accommodated within the SES's evacuation strategy; and

- ensure that a background report is prepared to accompany the amendment to SREP 20 which explains the need to consider and manage all flood risks up to the PMF.

The above changes to SREP 20 should be accompanied by alterations to the Hawkesbury – Nepean Environmental Planning Strategy (a complementary document) to reflect the principles within this report and the recommended changes to SREP 20. Section 3.4.5 of the Hawkesbury – Nepean Draft Environmental Planning Strategy and Policy No. 4 include components of the strategy where changes would be appropriate.

13.2.3 Local Planning

Recommendation 8: That best practice guidelines be prepared to assist local councils in the preparation of the relevant planning instruments (LEP and DCP/LAP), which are relied upon to implement floodplain management at a local level. This would include definition of extremely hazardous areas and guidelines for subdivision and building design.

Capital Cost: \$700,000

These guidelines would provide a consistent basis for the preparation of LEP and DCP/LAP documents across local government boundaries. Such best practice guidelines could be supported by a Departmental circular, statutorily reinforced by an appropriate ministerial direction pursuant to Section 117 (2) of the EPA Act, and referenced in the proposed changes to SREP20.

In addition to providing guidance to planners on the implementation of risk management approaches such as the Planning Matrix Approach, the guidelines would also contain specific sections relating to:

- the definition of extremely hazardous areas of the floodplain (estimated to cost \$100,000);
- guidelines for flood-compatible subdivision and building design (estimated to cost \$200,000 each).

The planning guidelines alone, together with appropriate training for council planners are estimated to cost \$200,000. A preliminary outline of these guidelines is provided in **Appendix F**.

Recommendation 9: Discontinue reliance on the 100 year FPL as the principal means of managing flood risks and promote implementation of comprehensive floodplain management plans.

This report clearly concludes that a continuation of the common practice of relying solely on the 100 year ARI FPL is unacceptable. Future planning must recognise this conclusion as a starting point from which to address flooding issues in the study area.

It is essential that the above recommendations flow on to changes in local planning. Most importantly, councils must be encouraged and assisted in the preparation of local floodplain planning controls (utilising the LEP and DCP/LAP instruments), within a specified timeframe, which accords with the best practice guidelines referred to in Recommendation 8.

Further, councils will need to apply the provisions of the REP referred to in Recommendation 7, in the assessment of individual development applications and the preparation of LEPs.

Councils must also consider evacuation issues for all proposed developments in the floodplain and refer major development proposals to the SES (Recommendation 7).

13.3 Concluding Comments

It is considered that the above recommendations provide an appropriate package of mechanisms to address the critical issues associated with land use planning and development controls within the Hawkesbury – Nepean floodplain.

The above recommendations focus on the processes rather than the outcomes, as such outcomes should appropriately remain the subject of the merits based assessment process which is central to the State Government's flood policy.

It is essential that the Planning Matrix Approach be applied at both the regional and local planning levels to fully address the flood issues in the Hawkesbury – Nepean floodplain which have not been appropriately tackled to date.

Hawkesbury Nepean Flood Management Strategy

Land Use Planning And Development Control Measures

APPENDIX E

**SUMMARY OF LOCAL GOVERNMENT
PLANNING MEASURES**

Prepared for
Hawkesbury Nepean Flood Management Advisory Committee

Prepared by
Don Fox Planning
and
Bewsher Consulting

DFP Project No: 3748
BC Filename: J721-7.R#

October 1997

8. Summary

- (a) The above investigations clearly demonstrate that between the four contiguous local government areas located within the one floodplain (which has been the subject of numerous flood related investigations), there is **considerable disparity** between available flood related information, flood management strategies, flood standards for development control, notifications on Section 149 Certificates, criteria for rezonings and internal administration of development and related strategic policy.
- (b) Generally, **no Councils have flood related zones**, even to identify those areas which are considered to be of such extreme hazard that no buildings would be appropriate. The flood standard applied for the purposes of development control varies from the 15 year to the 100 year ARI floods with consideration of the impact of larger floods in some cases.
- (c) While the **variations in flood standards** may superficially appear to be the desired outcome of the State Government's "merits based approach", in reality the variations in standards are not equally justifiable and are certainly not based upon a consistent rationale across the floodplain. In all cases (except for the Eastern Creek sub-catchment within Blacktown), the flood standard has not been adopted as a result of the floodplain management study process outlined within the Floodplain Development Manual.
- (d) To achieve consistency across the various LGA's the Hawkesbury Nepean FMS will need to deal with issues which have not been able to be addressed at a local level. The application of an **amendment to the imminent SREP 20** would be one appropriate instrument in a package of recommendations to address these issues.
- (e) The form of notification provided on **Section 149 Certificates** is also a major issue with Councils, and there is generally no consistency in the manner in which this is approached.
- (f) The internal administration of any development proposal application or strategic policy related to the issue of flooding is normally dealt with by the **Engineering Division** (with the exception of Hawkesbury City Council). While this does not raise any particular concern itself, it does explain to some extent the low priority to floodplain planning, often reported in the literature. A **regional planning framework** to provide overall direction, and detailed guidance by way of **best practice guidelines** would provide a mechanism to allow for **greater integration of the floodplain management process into the town planning process**.

Hawkesbury Nepean Flood Management Strategy
Land Use Planning And Development Control Measures

APPENDIX F

Preliminary Outline
BEST PRACTICE PLANNING GUIDELINES

Prepared for
Hawkesbury Nepean Flood Management Advisory Committee

Prepared by
Don Fox Planning
and
Bewsher Consulting

DFP Project No: 3748
BC Filename: J721-9.R#

October 1997

Preliminary Outline

HAWKESBURY NEPEAN FLOODPLAIN

FLOODPLAIN PLANNING

BEST PRACTICE GUIDELINES

Purpose of guidelines

- Why is flooding in the Hawkesbury Nepean floodplain different ?
- Floodplain covers a number of LGA's
- Relationship with metropolitan planning & orderly & efficient growth of Sydney
- Complexity of issues constrained effective floodplain planning to date
- Guidelines on the application of the FPM Manual to this floodplain

What is floodplain management ?

- Explanation of total concept- refer to "Floodplain Management Manual
- Three levels- modify flood, activity in floodplain & response to floods

How is the floodplain defined ?

- Up to the PMF
- Why consider the whole floodplain ?

What is the role of town planning in floodplain management?

- Assessing impacts of proposed modifications to the flood
- Ensuring activities in the floodplain are located & designed compatibly with the hazard
- Contributing to improving response to floods

Relationship between risk management & floodplain management

- Risk is dependent of hazard & exposure
- Consequences determine acceptability of risk
- Avoid, accept or modify risk?

Analysing the planning context

- Metropolitan, regional & local planning strategies
- Existing landuses & infrastructure investment
- Social & economic context
- Environmental considerations

Understanding the hazard

- Frequency
- Depth
- Velocity
- Evacuation

Identifying high hazard areas

- Technical Guidelines by DLWC
- Consider depth, velocity & frequency
- Unaided evacuation-warning times, evacuation routes, etc
- Aided evacuation-SES

Reference to associated guidelines

- Guidelines for subdivision layout
- Guide to building in flood prone areas

Flood standards

- Traditional approach (single FPL) inappropriate
- Consider whole of floodplain
- Define areas of similar hazard
- Standards to vary with land use and degree of hazard

Determining specific development controls

- Floor levels
- Flood compatible building components & design
- Structural soundness
- Flood effect on others
- Evacuation/ access
- Flood Awareness
- Management & design (subdivision layout, site design & building control)

Reviewing structural flood mitigation options

- Statutory planning controls
- Environmental impact

Application through local government planning & building control instruments

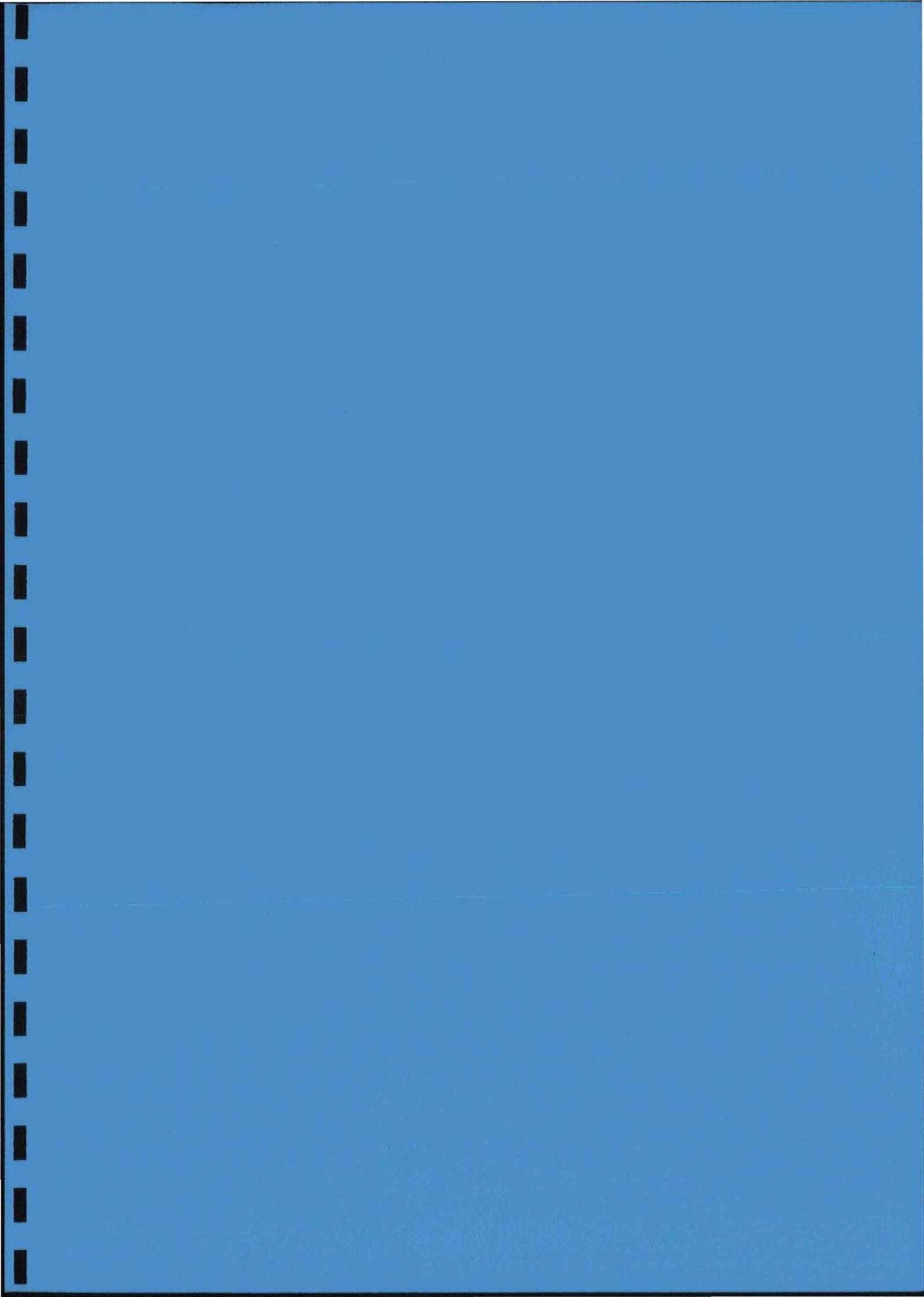
*→LEP (zoning, objectives, matters for consideration & consultation/concurrence
→DCP & LAP (details)
→S94 Contribution Plans
→How to integrate findings into the environmental study process*

Sample application

Blacktown(Eastern Ck) FPMS & P

References & Government contacts

*→Existing studies, literature & information sources
→DLWC, SES, DUAP*



**APPENDIX D
EMERGENCY RESPONSE AND TRAFFIC
INFRASTRUCTURE**

**HAWKESBURY NEPEAN FLOOD MANAGEMENT
ADVISORY COMMITTEE**

**EMERGENCY RESPONSE
PLANNING AND TRAFFIC
INFRASTRUCTURE**

**Issue No. 1
SEPTEMBER 1997**

CONSULTANCY TEAM

**Danielson
& Associates, Inc.**

**Patterson Britton
& Partners Pty. Ltd.**

**Masson & Wilson
Pty Ltd.**

THE PROBLEM

The flood threat to the Hawkesbury - Nepean valley in NSW from above the city of Penrith downstream to Spencer has the potential to result in loss of life numbered in the tens of thousands and property damage will be counted in the hundreds of millions, if not billions, of dollars unless mitigation activities are implemented immediately. Current studies indicate that if no action is taken to upgrade existing evacuation routes from their present condition and local flooding occurs, the majority of the flood prone population, which is estimated to be some 40,000 to 60,000, will be isolated and potentially drowned if severe to extreme flooding occurs. Even if the threat of local flooding is mitigated by improvement of currently designated evacuation routes, in excess of 15,000 persons can be expected to remain un-evacuated and potentially drowned.

This report addresses this potential for a major disaster by considering actions in the following areas:

- ◆ Flood Emergency Planning
- ◆ Flood Forecasting
- ◆ Flood Warning
- ◆ Flood Evacuation
- ◆ Public Awareness
- ◆ Infrastructure Enhancement
- ◆ Future Growth

GENERAL RECOMMENDATIONS

- ◆ Immediate upgrading of the evacuation routes must be done in order to avoid the potential for a major disaster. Existing designated routes must be improved and alternate routes selected and enhanced to provide redundancy and to assure a successful evacuation. Costs to upgrade current evacuation routes to simply move people to high-ground to prevent drowning are estimated at \$6,220,000 including currently planned improvements to Londonderry Road. To implement full evacuation to evacuation centres as contemplated by the SES Flood Emergency Plan, giving only marginal assurance of success assuming no unforeseen circumstances occur, will require additional road improvements of \$7,150,000. To provide an evacuation route system which will give reasonable assurance that a successful evacuation can be completed of the existing threatened population (up to 60,000 persons) and that has sufficient redundancy to accommodate unforeseen circumstances will require an additional expenditure of \$24,740,000. In summary, the evacuation routes can be upgraded to give reasonable assurance that all existing residents are evacuated safely for approximately \$38,110,000.
- ◆ The SES as presently structured at both State headquarters and Division level would be severely tested if required to conduct a major flood management

operation in the Hawkesbury - Nepean valley. Improvements in the forecasting of flood levels and access to flood intelligence are required to allow current flood plans to be implemented with a reasonable chance of success, the institution of a public education program is recommended, and resources to ensure timely review and exercise of flood plans and the development of the necessary volunteer services are sorely needed.

- ◆ The Bureau of Meteorology must be resourced to ensure that data acquisition techniques required for accurate and timely forecasts of precipitation and river levels are state of the art. Costs for this action range from \$580,000 for the needed rainfall and river level gauging network to \$16 million for a state of the art flood forecasting and flash flood warning system.
- ◆ An early flood warning system must be developed that supplements the existing warning system. Consideration of an early warning broadcasting system for radio and television and the installation of a warning siren system are urged.
- ◆ The evaluation of existing utilities infrastructure emergency plans and restoration and recovery plans is recommended. Current estimates are that loss of key utilities could extend for up to six months after a major flood event unless actions are taken.
- ◆ A comprehensive public awareness program must be developed and resourced to educate the flood impacted community on the magnitude of the threat they face, the contents of the plan in place to protect them, and the necessity of immediate disciplined response to flood warnings and evacuation orders.
- ◆ Specific planning measures dealing with future growth in the area must be implemented to ensure that the expected potential increase in population of some 17,000 to 80,000 new residents doesn't preclude the evacuation of the existing population.

SPECIFIC RECOMMENDATIONS

Specific recommendations for implementation of the major points listed above are contained in the accompanying text and appendices to include specific costs and benefits of development of the required flood forecasting system and a prioritized list with associated costs of essential evacuation route improvements.

EVACUATION ACCESS ROUTES

- Main routes flood free
- - - Main routes flood liable
- Alternate routes flood free
- - - Alternate routes flood liable
- - - Additional new routes
- Low points affected by local and/or main river flooding with reference code.
- EC Evacuation centres
- Limit of potential flooding

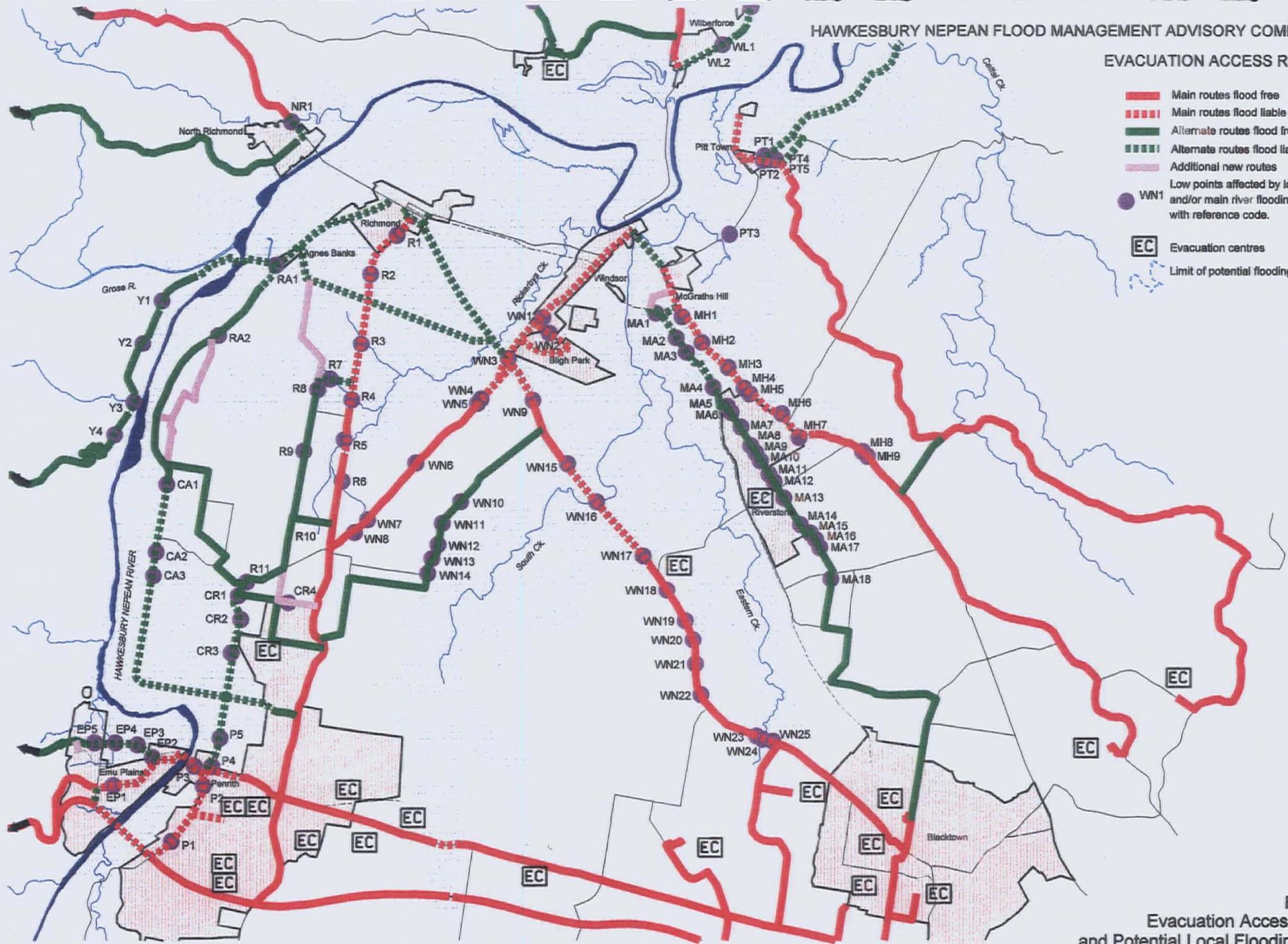


Figure 1
Evacuation Access Route
and Potential Local Flooding Sites

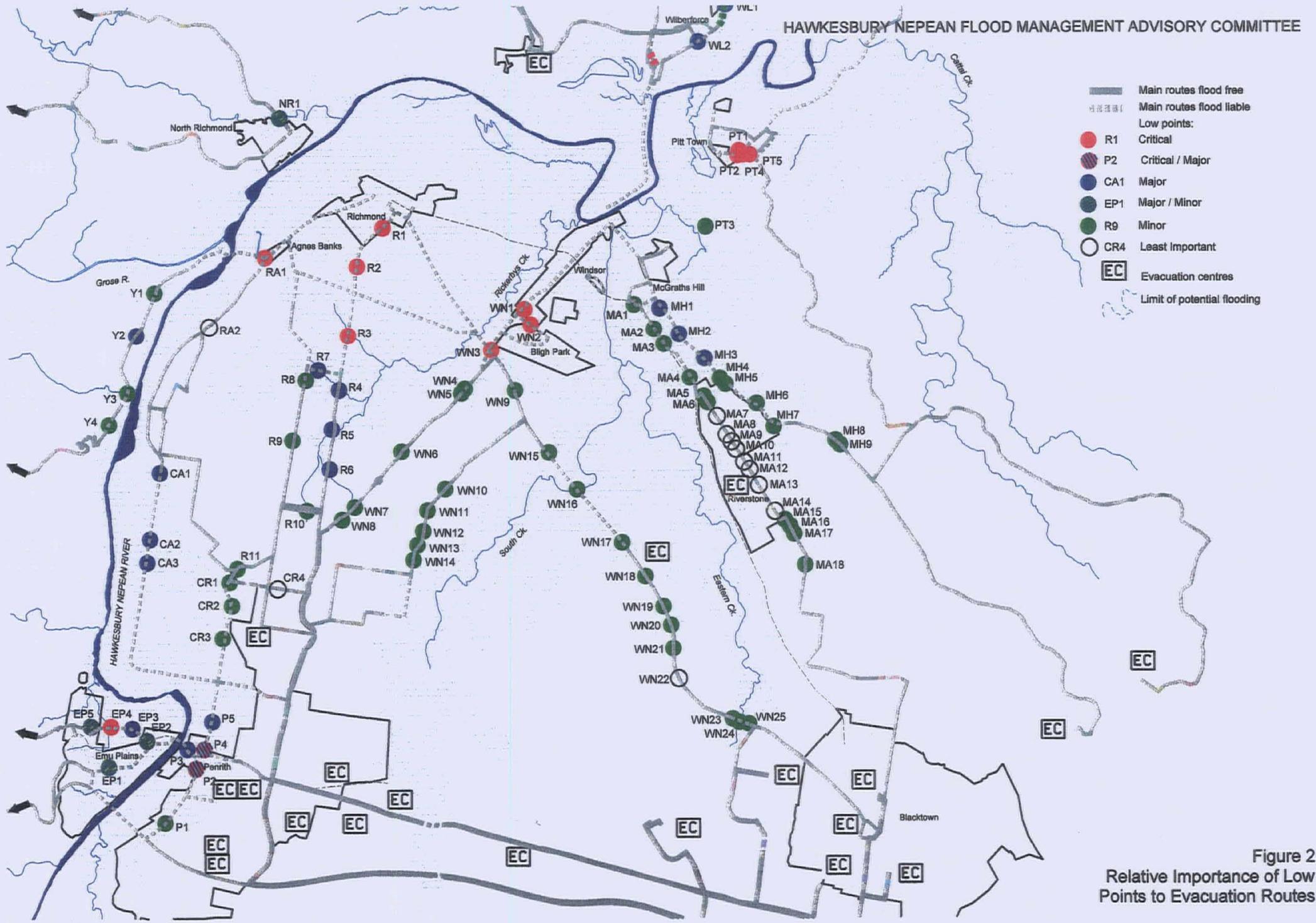


Figure 2
Relative Importance of Low Points to Evacuation Routes

Figure 3.1
Commencement of Evacuation
10 Hours (11.4m @ Windsor Bridge)
Total Traffic Demand (Vehicles)

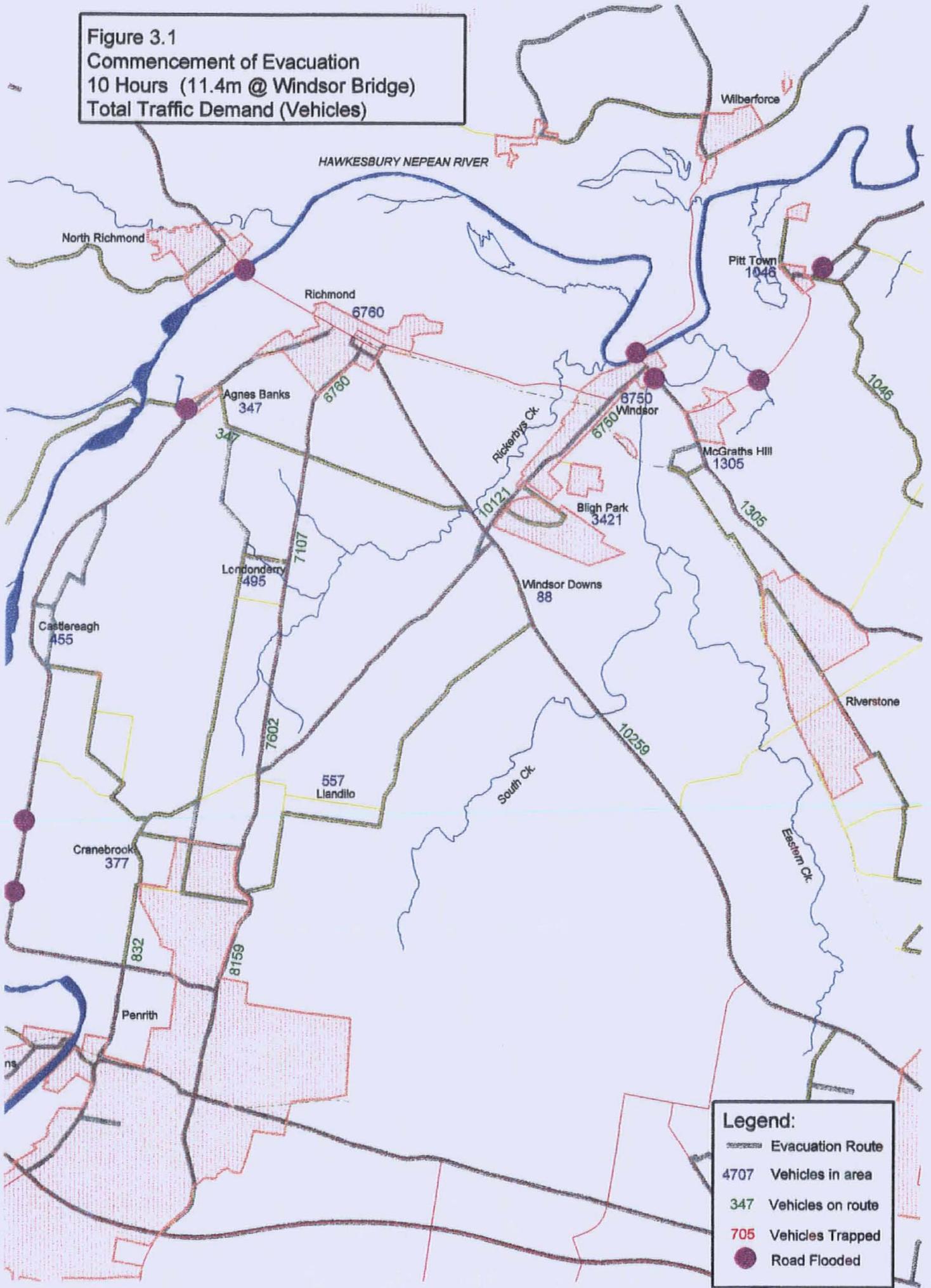
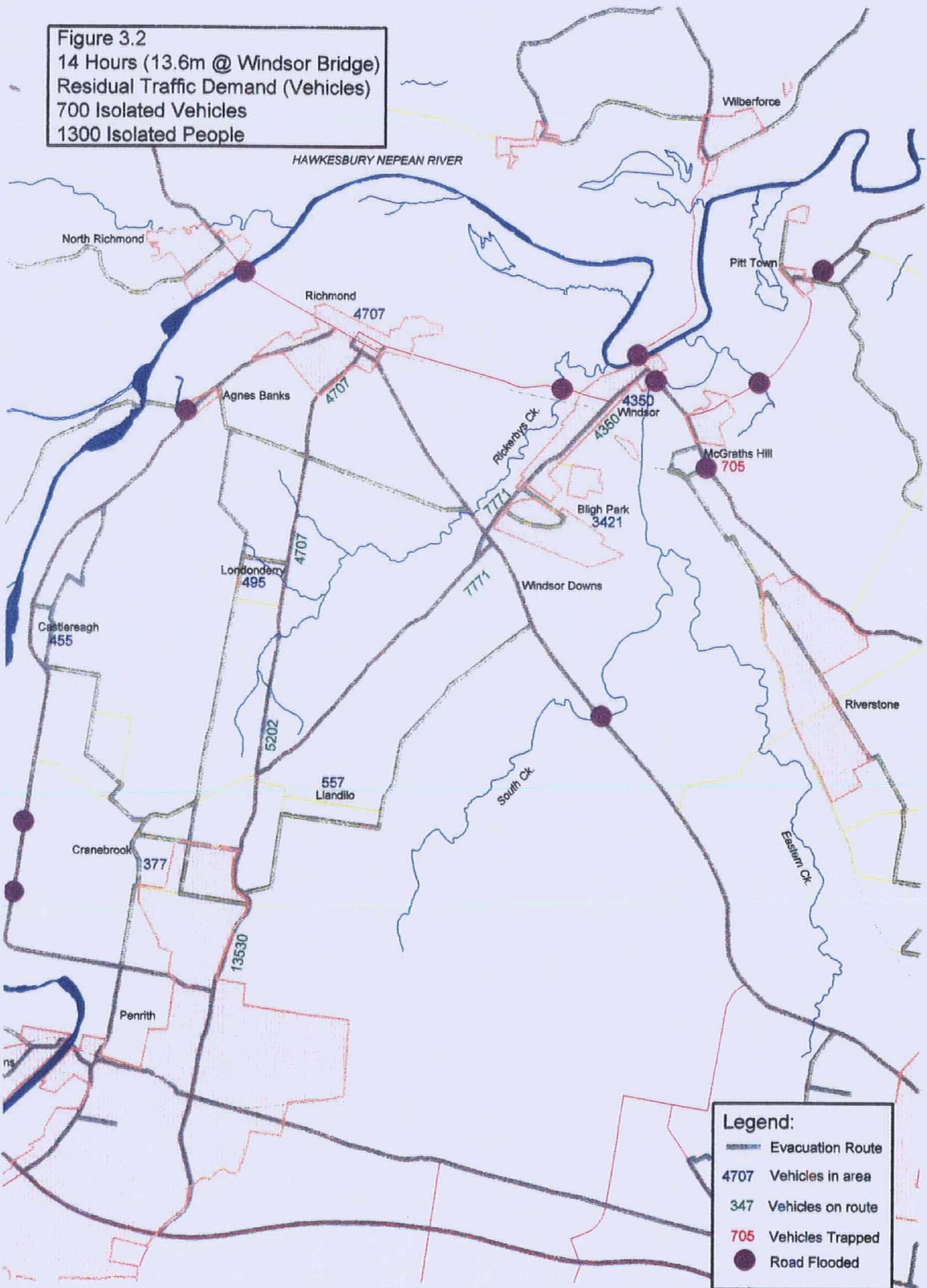


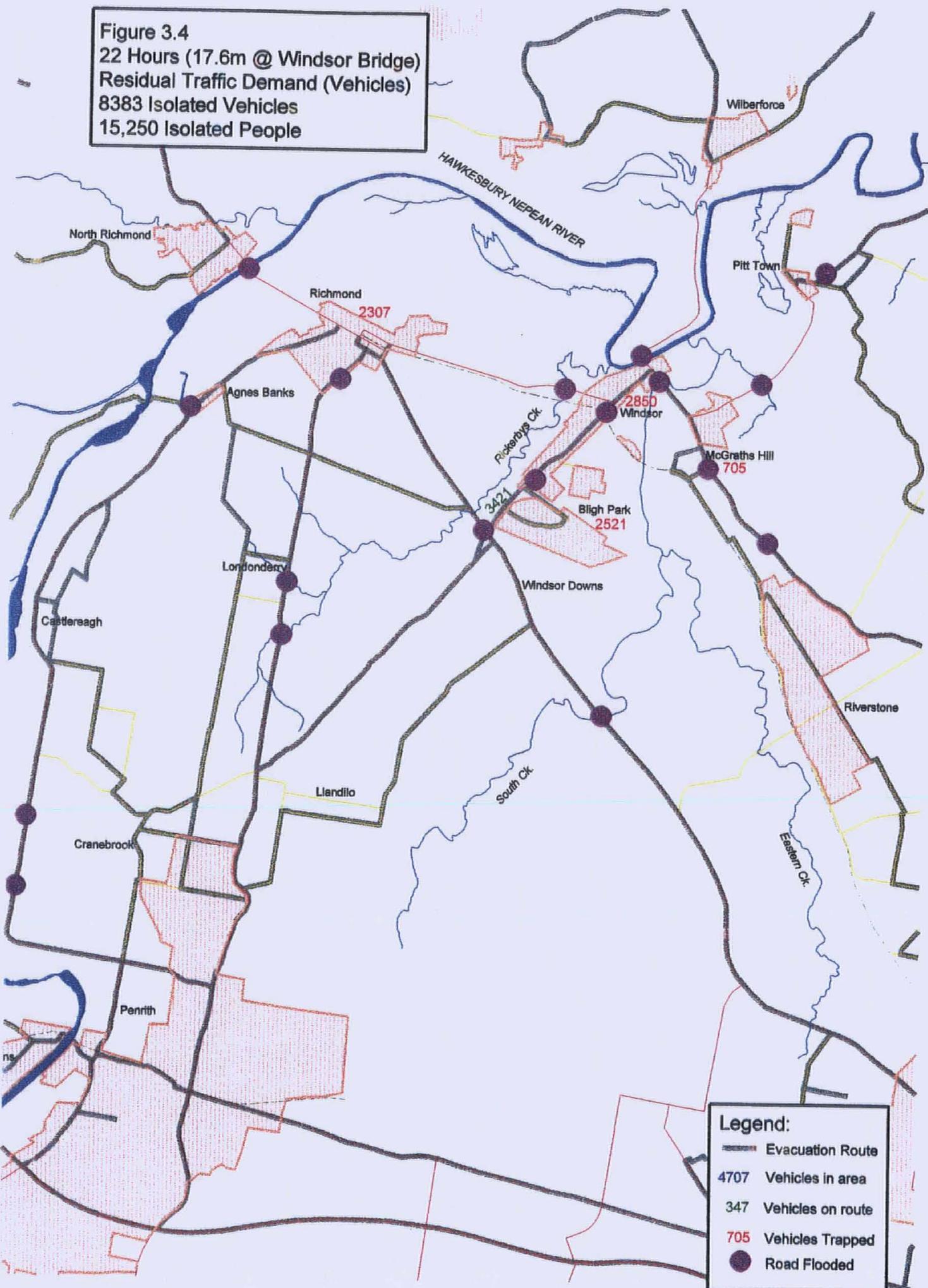
Figure 3.2
 14 Hours (13.6m @ Windsor Bridge)
 Residual Traffic Demand (Vehicles)
 700 Isolated Vehicles
 1300 Isolated People



Legend:

- Evacuation Route
- 4707** Vehicles in area
- 347** Vehicles on route
- 705** Vehicles Trapped
- Road Flooded

Figure 3.4
22 Hours (17.6m @ Windsor Bridge)
Residual Traffic Demand (Vehicles)
8383 Isolated Vehicles
15,250 Isolated People



EVACUATION TIMING

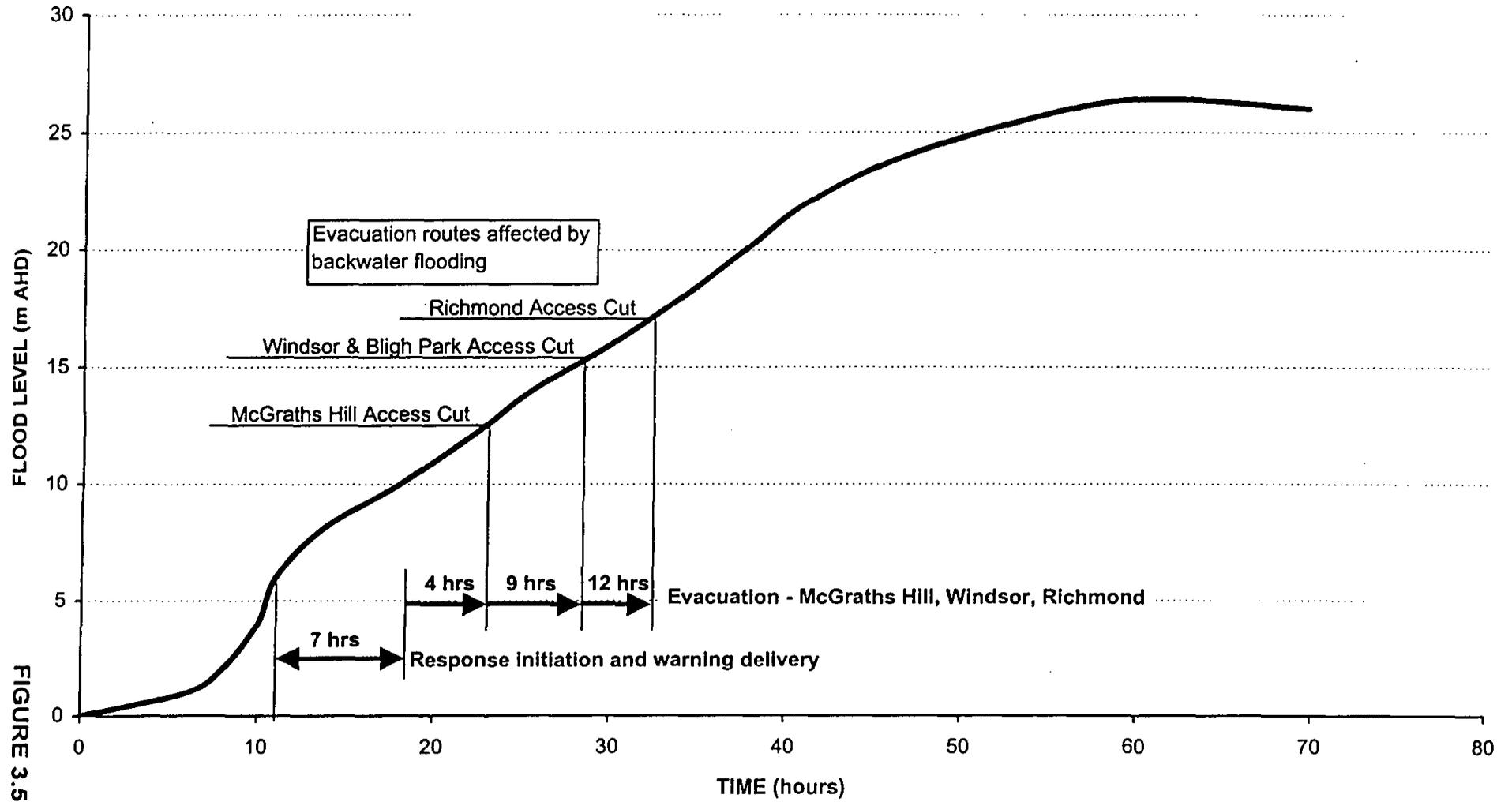


FIGURE 3.5