MANAGING FLOOD RISK THROUGH PLANNING OPPORTUNITIES

Guidance On Land Use Planning In Flood Prone Areas

Prepared for the Hawkesbury-Nepean Floodplain Management Steering Committee

In April 2007, sections within the former Department of Natural Resources NSW where incorporated within the new Department of Environment and Climate Change NSW.

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ACKNOWLEDGMENTS

These guidelines have been produced through the Hawkesbury-Nepean Floodplain Management Steering Committee. The contribution from the many sources involved in their production is gratefully acknowledged.

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- Department of Community Services
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In 2006 the three guidelines covering Landuse Planning, Building Construction and Subdivision Design for development on flood prone land received two awards from Emergency Management Australia - the NSW Safer Communities Award and a "highly commended" Australian Safer Communities Award for pre-disaster activities.

In 2007 the three guidelines covering Landuse Planning, Building Construction and Subdivision Design for development on flood prone land won the "Projects and Reports" section of the Engineering Excellence Awards conducted by the Sydney Division of Engineers Australia.

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FOREWORD

Floodplains provide land for both urban and rural development, however, there remains an ever-present risk in occupying land which is subject to flooding, even if that flooding occurs only rarely. Land-use planning for new areas provides opportunities to locate development to limit vulnerability to flooding and enable flood-aware design and materials to be incorporated into the construction of new subdivisions and homes. In this way, we can better manage future flood risk so that potential losses and damages are reduced.

In the floodplain downstream of Warragamba Dam, the potential for serious flood damages and losses following severe flooding of the Hawkesbury-Nepean River first became apparent during studies in the early 1990s. A strategy was required to ensure that should a flood event occur, that all loss, both personal and economic be minimised. The NSW Government has addressed this flood risk by allocating over $71 million to the Hawkesbury-Nepean Floodplain Management Strategy. A Steering Committee which included key government agencies, local councils and community representatives, oversaw the implementation of the Strategy. Under the Committee's guidance, improved flood warning and emergency response measures, upgraded evacuation routes, recovery planning and a regional floodplain management study have been put in place.

A key component of the regional floodplain management study is a suite of three guidelines on land use planning, subdivision and building on flood prone land. These guidelines accord with the Government's Flood Prone Land Policy and the NSW Floodplain Development Manual (2005). They have been produced by staff of the Department of Natural Resources, working under the oversight of the Steering Committee, with technical assistance from the CSIRO, Macquarie, New South Wales and Newcastle Universities, and a number of specialist consultants.

The three documents provide guidance to councils and others involved in land-use planning on flood hazards and risks and suggest practical and cost-effective means to reduce the risk both to occupants and to new buildings on flood prone land. Although specifically designed to address the unique flooding of the Hawkesbury-Nepean valley, they include information which can be readily applied to other floodplains where new development is proposed.

The guidelines will prove to be a valuable source of reference and information for councils and others involved in planning and building new development on flood prone land. Application of the guidelines can only result in safer communities and a more rapid recovery following flood events.

Brian Dooley
Chairman
Hawkesbury-Nepean Floodplain Management Steering Committee

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1 HAWKESBURY-NEPEAN REGIONAL FLOODPLAIN MANAGEMENT

Natural hazards including floods have the potential to threaten life and property. They impose social and economic costs on governments and the community. Indeed, flooding is recognised as the costliest natural disaster in Australia.

Historically, floodplains have always attracted settlement and today they are no less in demand to meet the needs of urban expansion. Posing risks to the relatively heavily populated east coast of New South Wales, riverine flooding tends not to follow a predictable pattern, occurring at any time of year and at irregular intervals. Floodplain risk management is a compromise which trades off the benefits of human occupation of the floodplain against the risk of flooding. The risk includes the flood hazard, social, economic and environmental costs and adverse consequences of flooding.

The scale and magnitude of the Hawkesbury-Nepean flood problem in the highly developed valley became apparent during studies in the early 1990's into the safety of the Warragamba Dam wall. The landforms of the Hawkesbury-Nepean valley have created a unique flood setting that has the potential for isolating and then totally inundating long-established towns and villages. Entire towns and extensive suburbs lie well below the level of the probable maximum flood (PMF) and would experience floodwater depths of up to 2 metres in a repeat of the 1867 flood of record and up to 9 metres depth in the extremely rare PMF above the current flood planning level (based on a 1 in 100 AEP flood event). Such depths create very hazardous situations for both people and property.

In order to address this problem and to protect existing and future communities and prevent an increase in damages and losses arising from new floodplain development, the NSW Government committed $71 million over six years from 1998 to the implementation of the Hawkesbury-Nepean Floodplain Management Strategy (the Strategy). This was done in conjunction with the decision to build an auxiliary spillway to protect the dam itself. The Strategy was directed by a multi-agency Steering Committee, chaired by the Department of Natural Resources (DNR).

Partner Agencies in the Hawkesbury-Nepean Floodplain Management Strategy

Department of Natural Resources (DNR)

Department of Planning

State Emergency Service (SES)

Roads and Traffic Authority (RTA)

Department of Community Services (DoCS)

Sydney Catchment Authority (SCA)

Baulkham Hills Shire Council

Blacktown City Council

Gosford City Council

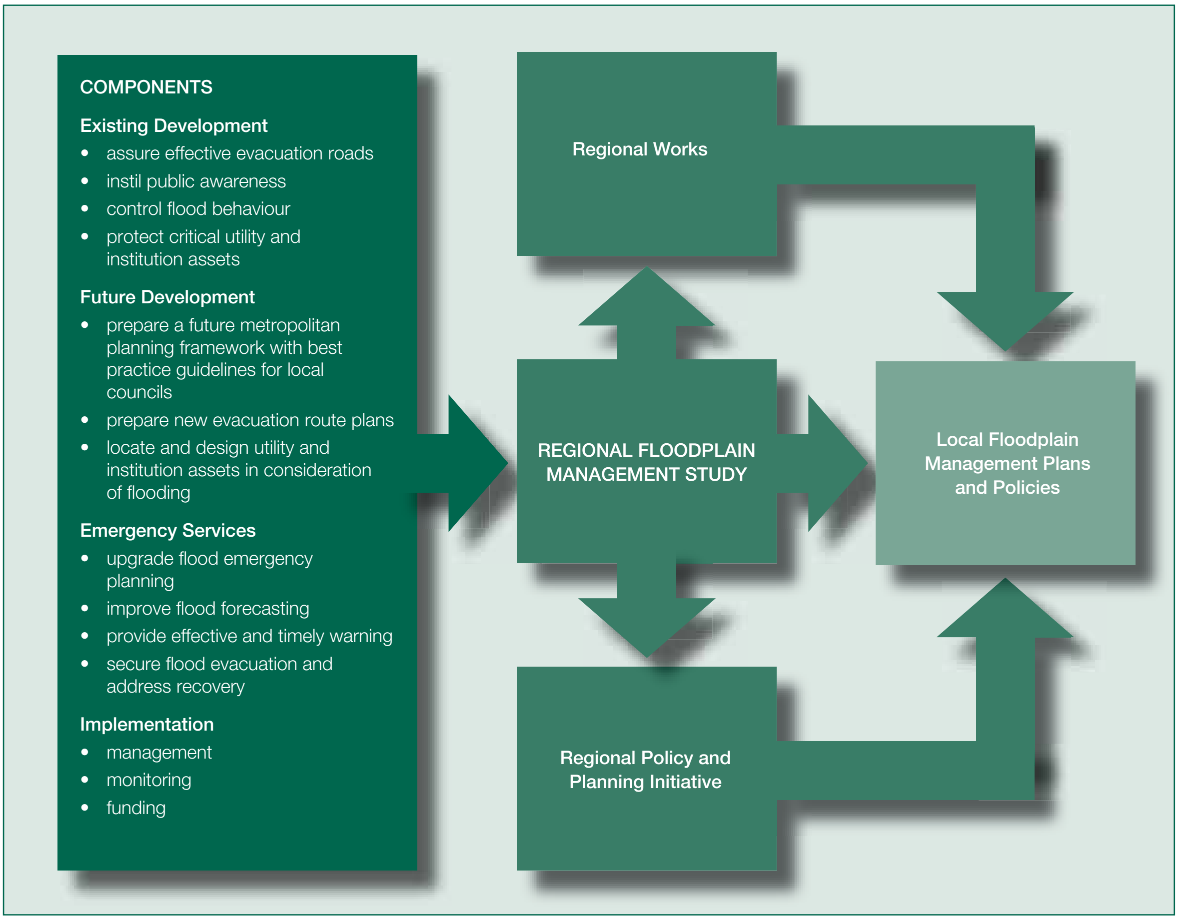
Hawkesbury City Council

Hornsby Shire Council

Penrith City Council

The structure for the implementation of the Strategy, including overall components and proposed outcomes which was adopted by the NSW Government in 1998, is shown in Figure 1.

Figure 1 *Integrated implementation process adopted for the Hawkesbury-Nepean Floodplain Management Strategy*

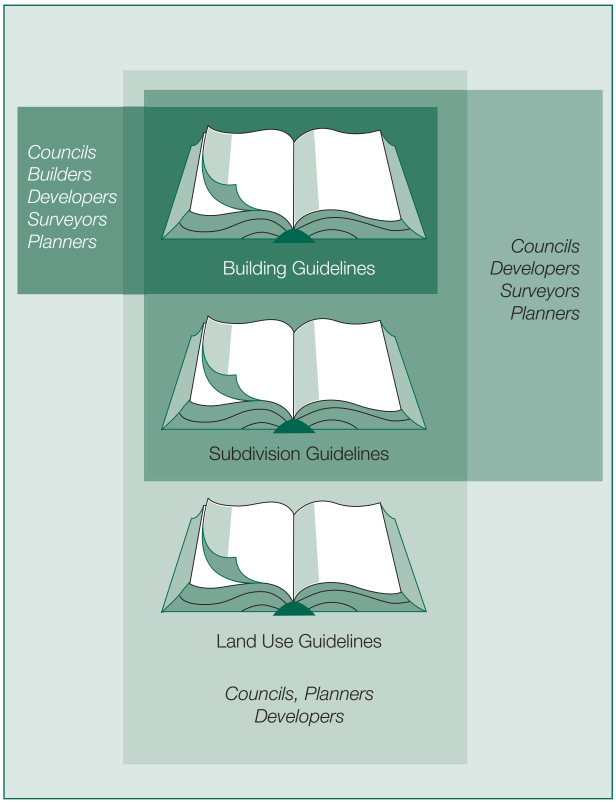


In NSW, councils have responsibility for floodplain risk management in their areas, assisted by technical and financial support from the State Government. One of the key Strategy outputs to assist Hawkesbury-Nepean floodplain councils in this process is the Regional Floodplain Management Study (RFMS). The RFMS includes a suite of emergency management and floodplain risk management measures including guidance on land use planning, subdivision and building on flood prone land. The information provided through the RFMS facilitates informed decision-making about development on flood prone land to assist in reducing the increase in the adverse consequences resulting from flooding.

What is the Hawkesbury-Nepean Regional Floodplain Management Study?

- Detailed evacuation routes upgrade program
- Guidance on land use planning in flood prone areas including a methodology to identify flood risk
- Guidance on subdivision design in flood prone areas
- Guidance on building in flood prone areas
- A flood hazard definition tool compatible with GIS
- Concepts for a regional public awareness program
- Briefing plans to assist utility providers prepare recovery plans
- Improving flood forecasting and flood warning

Figure 2 *Who can the Guidelines help?*



The guidance provided through the RFMS is available to *guide* development; in itself it does not *regulate* development. It offers a regionally consistent approach to floodplain risk management designed to facilitate informed decision making for strategic land use planning, infrastructure planning, subdivision design and house building on flood prone land. The guidelines provide councils, government agencies, developers, builders and the community with in-depth background information, methodologies, strategies and practical means to reduce the flood risk to new development and hence provide a more sustainable future for residents, the business community and workers.

MANAGING FLOOD RISK THROUGH PLANNING OPPORTUNITIES – GUIDANCE ON LAND USE PLANNING IN FLOOD PRONE AREAS

The guidance contained in *"Managing Flood Risk Through Planning Opportunities – Guidance on Land Use Planning in Flood Prone Areas"* (referred to here as the Land Use Guidelines) aims to provide local councils, government agencies and professional planners with a regionally consistent approach to developing local policies, plans and development controls which address the hazards associated with the full range of flood events up to the probable maximum flood (PMF). In accordance with good risk management practice these guidelines give weight to finding solutions for the more frequent flooding problems.

Guidance is provided on the development of flood prone land for a range of common land uses. A methodology to rate risk and define risk bands is included to assist councils in their flood risk analysis (Chapter 9). For residential development, it proposes a series of risk bands as a tool to better manage the flood risk for the full range of floods. It is specifically aimed at all professionals involved in strategic, regional and local planning including development control.

Users are strongly advised to not limit their information sources only to the Land Use Guidelines, but to familiarise themselves with the concepts put forward in *"Designing Safer Subdivisions – Guidance on Subdivision Design in Flood prone Areas"* and *"Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas",* Figure 2. Together the three documents provide comprehensive information on how finished landforms, road layouts, building design, construction methods and materials can influence the consequences from flooding and hence flood risk.

DESIGNING SAFER SUBDIVISIONS – GUIDANCE ON SUBDIVISION DESIGN IN FLOOD PRONE AREAS

"Designing Safer Subdivision – Guidance on Subdivision Design in Flood prone Areas" provides practical guidance to assist in the planning and designing of safer residential subdivisions on flood prone land. Referred to here as the Subdivision Guidelines, the document aims to provide practical means to reduce the risk to life and property for new subdivisions. Although specifically written for development in the Hawkesbury-Nepean valley, it is generally applicable to all flood prone land. The Subdivision Guidelines offer increased safety for residents through the promotion of efficient design solutions, which are responsive to the varying range of flood risk. The guidelines include cost-effective and environmentally sustainable solutions to minimise future flood impacts on buildings and associated infrastructure.

The Subdivision Guidelines contain detailed information regarding site preparation, road layout and drainage information relevant to professionals engaged in the planning, surveying, development and assessment of residential subdivisions on flood prone land.

Users of the Subdivision Guidelines would find it beneficial to also familiarise themselves with the concepts of flood aware housing design provided in the Building Guidelines when designing or assessing flood-responsive residential subdivisions.

REDUCING VULNERABILITY OF BUILDINGS TO FLOOD DAMAGE – GUIDANCE ON BUILDING IN FLOOD PRONE AREAS

Modern housing construction results in houses that are ill equipped to withstand inundation or fast flowing water. Given the lack of availability of comprehensive domestic flood insurance, most homeowners of flood prone property are potentially very vulnerable to major losses. *"Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas"*, referred to here as the Building Guidelines, provides specific and detailed information on house construction methods, materials, building style and design. This approach can reduce structural damage due to inundation or higher velocities and facilitate the clean up after a flood, thus reducing the costs and shortening the recovery period.

The Building Guidelines include information on how flooding affects the structural components of a house. The document:

- highlights potential problems for houses subjected to flood water;
- discusses the benefits and disbenefits of choosing various materials and construction methods and discusses methods to solve those problems;
- provides indicative costs of adopting those solutions; and
- advises of the appropriate post-flood actions to repair or reinstate the damaged components.

The guidance is provided for the building industry, council health and building surveyors, builders and owner builders. Assuming the appropriate zoning applies when a residential project is proposed, it is not anticipated that builders or owner-builders involved in single house projects would need to seek further information from either the Subdivision or the Land Use Guidelines. However, for larger scale housing developments or multi-unit housing, reference should be made to the relevant information contained within the companion Subdivision and Land Use Guidelines.

2

INTRODUCTION TO THE GUIDANCE ON LAND USE PLANNING IN FLOOD PRONE AREAS

What is the Need for Guidance?

Floodplains are attractive places to live and work but also store or convey floodwater in times of flood. Flooding is part of the natural regime of all river systems. The Land Use Guidelines recognise these natural processes and the hazard they pose to occupation of the floodplain. The guidelines put forward a rationale and a methodology which aims to achieve a reasonable balance between the need to contain the flood risks associated with new development in the Hawkesbury-Nepean floodplain with the social and economic consequences associated with that flood risk.

In order to reduce the hazards associated with the complex and exceptional Hawkesbury-Nepean flood behaviour, a floodplain risk management approach is justified which goes beyond the approach of a single flood planning level (FPL) based on the 1 in 100 AEP[1] or 1% flood event. Putting this single management tool aside in favour of something more rigorous and responsive to the actual hazard requires a better understanding of what exactly the risk is in order to identify and implement management strategies which meet the needs of the communities who will bear the risk.

The guidance supplements the Floodplain Development Manual (NSW Government 2005) to assist in tailoring land use and development controls, which are

- regionally consistent yet locally appropriate;
- achievable, equitable and reasonable in terms of current practice;
- capable of reducing the increase in flood damages which would otherwise occur as development continues on the floodplain;
- expected to meet the needs of the future occupants of the floodplain; and
- designed to safeguard the well-being of future occupants.

Who Should Use the Guidance on Land Use Planning?

Although specifically written for the Hawkesbury-Nepean valley flood problem, many of the principles discussed here can be applied to other floodplains. The guidance is aimed at professional planners and other related professionals in the public and private sectors with responsibilities for planning and development in the Hawkesbury-Nepean valley.

Planners guide and provide direction for growth and change through strategic and local land use and development control policies and plans. Through environmental planning instruments and other plans (e.g. REPs, LEPs and DCPs) planners set development standards and prepare or determine development applications. These guidelines are provided to assist:

- Local council staff responsible for preparing local environmental plans and development control plans, determining development applications, determining activities under Part 5 of the *Environmental Planning and Assessment Act 1979,* advising councillors on planning issues and preparing and implementing local floodplain risk management plans;
- State Government agencies responsible for setting land use planning policies, preparing or determining applications for major projects;
- State and Federal Government agencies responsible for land or property management decisions;
- Private sector land managers responsible for land and property management decisions;
- Planning consultants engaged to prepare detailed large-scale or site-specific plans or development proposals.

[1] *AEP or annual exceedance probability means the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (see average recurrence interval).*

What Guidance is Offered

Wherever people are subjected to flooding they are at risk. The deeper or faster flowing the floodwater, or if there is a potential for isolation, the greater is the flood hazard and the higher the risk. The Guidelines examine the factors which influence flood risk and how the range of flood hazards can be managed to ensure safer occupation of flood prone land. Guidance is provided to reduce property damages in new development and thus fewer unacceptable socio-economic outcomes in the event of a flood rarer than the flood selected for planning purposes. The evacuation of at-risk communities is critical and the guidelines discuss matters for consideration in this regard, when planning for new development.

The guidance includes a methodology for graduated development controls. Benefits are obtained by having more protection measures for development in higher risk areas. The graduated controls overcome the problem of having a single flood planning level (e.g. the 1 in 100 AEP flood level plus freeboard) and offer opportunities to limit structural damages, reduce contents losses and limit occupation of high hazard locations.

Given the known flood risk, authorities have a responsibility and duty of care when making decisions for flood prone land. These guidelines identify how this duty of care can be exercised to reduce the potential for adverse outcomes.

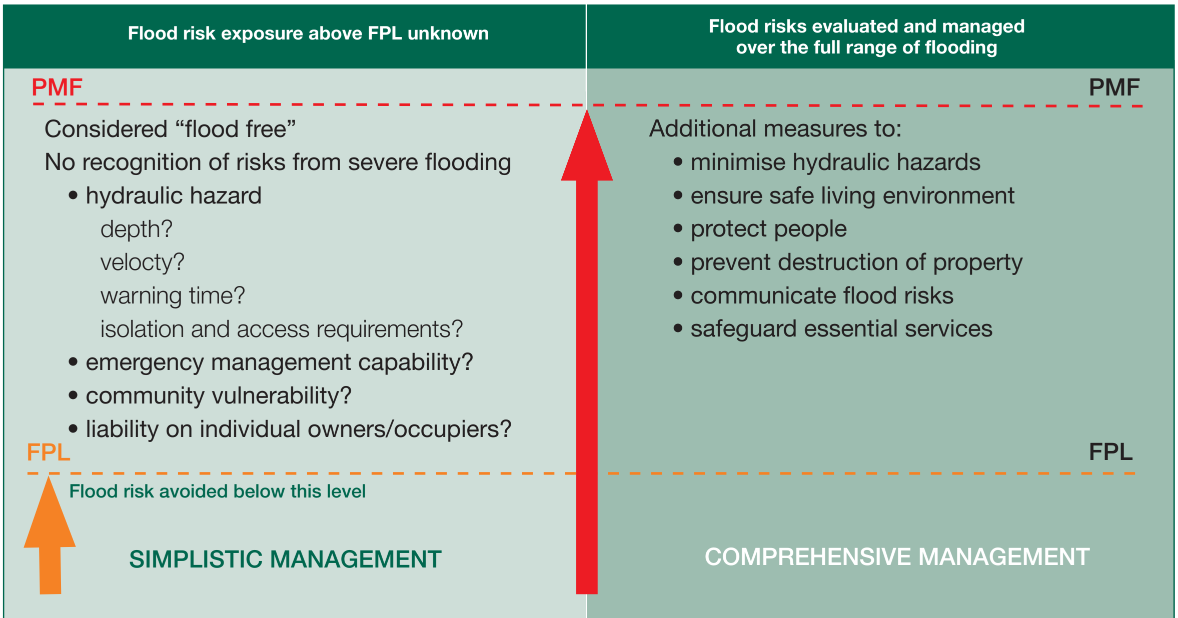
Also included are strategies that can be used to raise awareness and knowledge of the flood risk. This leads to better and more informed decision making regarding floodplain development and to improve community resilience.

3 LIVING WITH THE FLOOD RISK

The Unique Hawkesbury-Nepean Flood Problem

Due to a combination of factors, Hawkesbury-Nepean flooding demonstrates quite exceptional characteristics when compared to flooding in other NSW floodplains. The most serious difference is the ponding effect above Sackville Gorge, which results in greater depths of floodwaters compared to other NSW rivers. Water depths reaching above ceiling height were experienced in Windsor in the flood of record in 1867, estimated to be about a 1 in 200 AEP flood event. There is a difference of up to 9 metres between the flood planning levels adopted now by local councils (the 1 in 100 AEP flood event) and the probable maximum flood level. This substantial range in flood depths has much greater implications for the magnitude of the flood risks compared to other floodplains. This therefore gives a greater necessity for comprehensive floodplain risk management of these areas, (Figure 3). Rapid rates of rise of floodwaters combined with the existing urbanised floodplain settlement pattern and low-lying roads compound the flood hazard. This increases the need to recognise all aspects of flood hazard so that they can be carefully planned for rather than be overlooked and lives endangered. There is little doubt that the Hawkesbury-Nepean valley can experience one of the most serious flood problems in Australia. The unique characteristics of the Hawkesbury-Nepean flooding has been described as exhibiting a combination of the worst characteristics of riverine flooding (depth and extent), and the worst characteristics of flash flooding (rapid rise of floodwaters and limited warning time) (pers. comm. J. Danielson).

Figure 3 *How comprehensive floodplain risk management can reduce flood risk to people and property*



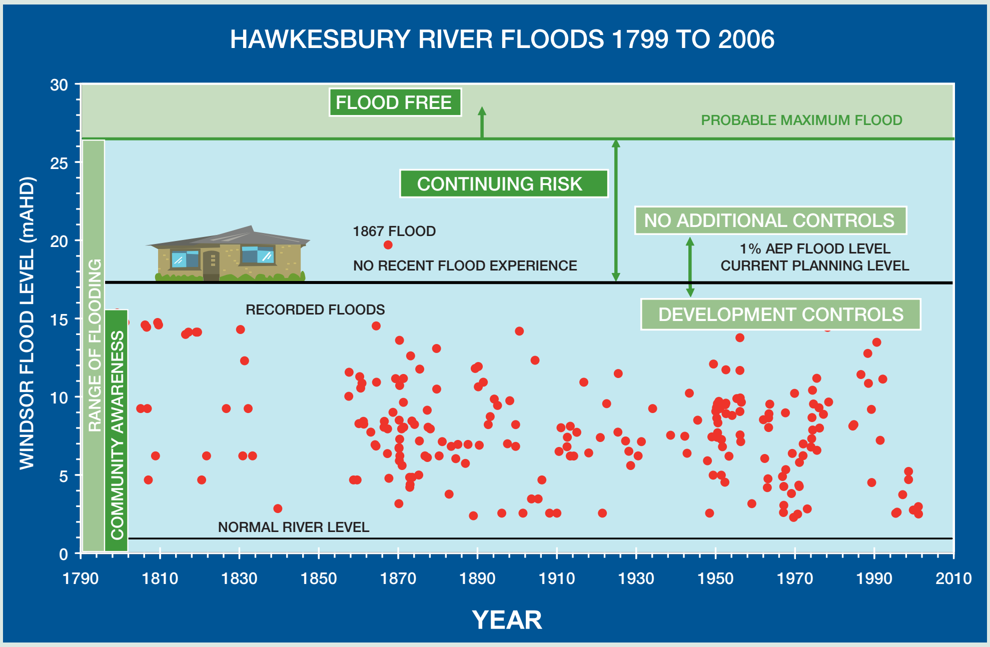
The reliance on placing development above the flood planning level to reduce the frequency of properties flooding has led to a very simplistic and narrow management focus. In comparison, comprehensive floodplain management considers different types of risks, all of which can be managed through a set of tailored measures.

Historic Perspective

Floodplains throughout the world have been regarded as favourable places to live since early settlement. It did not take many years for the early colonists of Sydney Cove to recognise the agricultural potential of the fertile Hawkesbury-Nepean floodplains and in the absence of good roads, the navigable Hawkesbury River was used to transport produce and timber to the emerging urban markets on the coast. The first 22 settlers in 1794 chose riverside sites for their simple homes and farms at Mulgrave Place at the confluence of South Creek and the Hawkesbury River. Eight unexpected major inundations then occurred in rapid succession during in the first fifteen years of European settlement resulting in fifteen deaths and devastating loss of property and stock. In 1810 Governor Lachlan Macquarie, with remarkable far-sightedness, appreciated that these tragedies were going to continue and would get worse as the area became more populated and so he commenced the planning of the five ridge-land townships that are known today as the Macquarie Towns: Windsor, Richmond, Pitt Town, Wilberforce and Castlereagh. Armed with only limited local knowledge and experience of flooding, Governor Macquarie managed to offer a solution to one of the perils of farming rich river lowlands by urging settlers to *'establish their future residences in the Townships….. on the High Lands'….* to prevent a recurrence..... *'of the deplorable losses sustained in the preceding years of the Hawkesbury-Nepean flooding'* (Figure 4).

The early settlers did not know even larger floods could occur. They were unfamiliar with the region's irregular weather patterns characterised by long periods of drought followed by unusually high rainfall. There were 27 major Hawkesbury-Nepean floods in the 19th century with the highest being that of 1867 (Figure 5). The 1867 flood is referred to as the flood of record, it being the most severe flood recorded in the valley since settlement, with about a 1 in 200 chance of occurrence in the Windsor and Penrith areas. This is not to say it was the highest flood ever to occur, only the highest since records have been kept. There is evidence from high-level sediments in Fairlight Gorge, upstream of Penrith that there has been at least one flood possibly much larger than the 1867 flood.

Figure 5 *Hawkesbury River floods above 9m AHD since 1799*



Many Hawkesbury-Nepean river floods have been recorded since 1799. However, the present community's recent experience of flooding has been confined to moderate sized events, such as the March 1978 flood – a 1 in 35 AEP event.

***Figure 4** Governor Macquarie's General Orders, 5th March 1817*

GOVERNMENT AND GENERAL ORDERS

GOVERNMENT HOUSE, SYDNEY, WEDNESDAY, 5th MARCH, 1817.
CIVIL DEPARTMENT

THE GOVERNOR's official Communications from the Interior within the last few Days have excited in HIS EXCELLENCY's Mind the most sincere Concern and Regret for the recent Calamities in which the unfortunate Settlers on the Banks of the Nepean and Hawkesbury have been once more involved, by the late dreadful Inundations of those Rivers.

WHILST it does not fall within the Reach of human Foresight or Precaution to be able to guard effectually against the baneful Recurrence of such awful Visitations, or to avoid being more or less involved therein, yet when the too fatal Experience of Years has shown the Sufferers the inevitable Consequences of their wilful and wayward habit of placing their Residences and Stock-yards within the Reach of the Floods (as if putting at Defiance that impetuous Element which it is not for Man to contend with); and whilst it must still be had in Remembrance that many of the deplorable Losses which have been sustained within the last few Years at least, might have been in great Measure averted, had the Settlers paid due Consideration to their own Interests and to the frequent Admonitions they had received, by removing their Residences from within the Flood Marks to the TOWNSHIPS assigned for them on the HIGHLANDS, it must be confessed that the Compassion excited by their Misfortunes is mingled with Sentiments of Astonishment and Surprise that any People could be found so totally insensible to their true Interests, as the Settlers have in this Instance proved themselves.

HIS EXCELLENCY, however, still cherishes the Hope that the Calamities which have befallen the Settlers will produce at least the good Effect of stimulating them to the highly expedient and indispensible Measure of proceeding to establish their FUTURE RESIDENCES in the TOWNSHIPS allotted for the Preservation of themselves, their Families, and their Property, and that they will, one and all, adopt the firm Resolution of forthwith erecting their Habitations on the High Lands, cheered with the animating Hope and fair Prospect of retrieving, at no very distant Day, their late Losses, and securing themselves from their further Recurrence.

THOSE who, notwithstanding, shall perversely neglect the present Admonition and Exhortation to their own Benefit, must be considered wilfully and obstinately blind to their true Interests, and undeserving any future Indulgencies, whilst, on the contrary, those who shall meet this severe Dispensation of PROVIDENCE with manly Fortitude and unbroken Spirit, may rest assured that their Exertions and Industry will not only merit, but obtain the favourable Consideration and Protection of this Government.

THESE ORDERS are to be read during the Time of DIVINE SERVICE at each of the CHURCHES and CHAPELS throughout the Colony, on the three next ensuing SUNDAYS.

"LACHLAN MACQUARIE"

BY COMMAND OF HIS EXCELLENCY,

JOHN THOMAS CAMPBELL, SECRETARY.

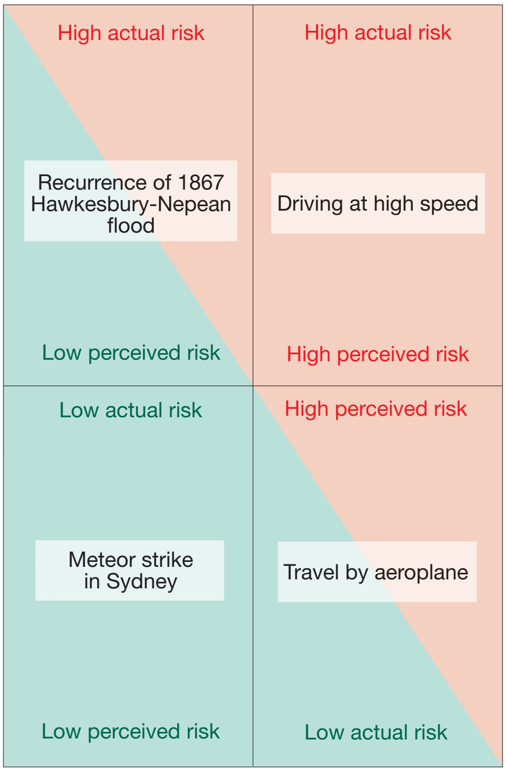
This order highlights that while flooding cannot be averted; simple measures can be taken to avoid the severity of its consequences.

Appreciation of the Flood Hazard Today

Since the flood of record in 1867, there have been many minor and moderate Hawkesbury-Nepean floods, inundating rural land and cutting local roads, but there have been no major floods. In the absence of any large floods locally in living memory, towns in the valley have thrived and grown and continue to be attractive places to live on the fringe of the Sydney metropolitan area. There is increasing pressure to increase densities and subdivide land for both urban and rural residential development.

Today, there are flood records spanning two hundred years and sophisticated, rigorous mathematical flood models which provide confidence that the information now available on flood behaviour can be relied upon when making decisions to develop on the floodplain. However, limited experience of major floods combined with a lack of readily accessible or easily understood information about flooding and its consequences, has inevitably produced a lack of awareness of the real hazard associated with occupation of the floodplain. Consequently, a future scenario in which extensive urban areas are inundated in severe Hawkesbury-Nepean flooding is perceived by many as a having low risk even though it actually has a high risk, (Figure 6). Even though detailed information from increasingly sophisticated flood models is available to developers, councils and government agencies, the lack of awareness of flood hazard continues to have implications for decision making on the floodplain. It is unsurprising therefore that floodplain controls have focussed solely on protection from the frequent floods rather than the severe floods which pose rare but extreme risks.

***Figure 6** Perception of Risk*



Planning standards have evolved and changed over time as more information has become available and expectations and living standards become higher. Standards that only recently were considered to be acceptable, based on limited understanding of flood behaviour, are today considered to be inadequate for protecting property against severe Hawkesbury-Nepean flooding and would do nothing to prevent people being isolated by rising floodwaters. As a result, many existing properties and their occupants remain at risk in major or severe Hawkesbury-Nepean flooding with consequent property losses and damages when a flood greater than the 1 in 100 AEP flood occurs.

In recent years dual occupancies, town houses and villas have replaced older single dwellings on large lots. New release areas have resulted in major increases to the urban footprint and rural residential subdivision has replaced agricultural land. Unless there is a paradigm shift in current development and building practice to a more sustainable approach as advocated in the guidelines, the result will be:

- higher densities with a net gain in the number of households and residential properties on flood prone land and consequently more people requiring evacuation; and
- an inevitable increase in future property damages.

Variations in Flood Behaviour

To understand the hazard posed by human occupation of the Hawkesbury-Nepean floodplain, it is important to distinguish between two categories of flooding:

- **Mainstream flooding** in the Hawkesbury-Nepean River and its tributaries such as South Creek and Eastern Creek and the Colo River and MacDonald River.
- **Backwater flooding** or ponding of water, resulting from a restriction in the flow of water in the river or creek. In the Hawkesbury-Nepean River the narrow gorges downstream of Sackville restrict the flow of water in the river causing ponding upstream, whilst high water levels in the Hawkesbury-Nepean River itself can restrict the flow of tributary creeks causing backwater flooding especially in the lower reaches of South Creek where backwater flooding dominates water depths.

Local mainstream flooding can occur independently of, or concurrently with backwater flooding. However, in the Hawkesbury-Nepean valley it is the scale of backwater flooding which dominates the flood environment and creates the unique flood hazards to both people and property.

Flood behaviour, and its consequences for development, is vastly different in the lowland areas from the upper and middle parts of the river catchment. The nature and extent of the floodplain proper is dependent on the size of the catchment area upstream. Where the terrain is much flatter, the floodwaters can extend across a broadening floodplain. Typically, floods in the range up to 1 in 2 to 1 in 5 AEP stay within the banks of the main stream, while they spread extensively across the floodplain for larger events.

The lowland area comprises the zone in which deposition of sediments typically occurs leading to the formation of natural levees along the riverbank. It is this fertile alluvial soil with river access for transport and bridging points across the river that have contributed to human settlement of the lower Hawkesbury-Nepean floodplain.

By being situated at the lowest part of the catchment, the lowland areas generally have relatively longer warning times of flooding than in the upper reaches. The larger the catchment, the longer the warning time but also there is greater potential for high volume run off and longer periods of inundation. The extended lag time required for run off from the upper tributary reaches to build up and coincide, can lead to a slower rate of rise (and fall) for flood levels compared to the upper reaches. It is in this part of the catchment where water depth poses the greatest hazard. However, there are places where high velocity floodway conditions also apply and some higher locations within the floodplain have the potential for initial isolation and eventual inundation.

The topography downstream in the Hawkesbury-Nepean catchment at the Sackville gorge, together with high rainfall in the upper reaches means that even mainstream flooding in this part of the catchment is characterised by rapid rates of rise of water in the river and short warning times making evacuation a key issue. Evacuation is affected not only by the warning time available, but also the suitability of the road network and infrastructure, and the number of people that have to evacuate in major floods up to the PMF. This matter is examined further in Chapter 5.

The depths of inundation and flow velocities in the lower floodplain vary significantly as the topography changes. The Hawkesbury-Nepean floodplain generally expands and becomes larger as it proceeds downstream until it reaches the gorges at Sackville. In this part of the floodplain areas can be categorised in terms of their hydraulic function as:

- floodway,
- flood storage,
- flood fringe.

It should be recognised that these categories will apply to both mainstream flooding of the Hawkesbury-Nepean River itself and to local flooding of the tributary creeks. As stated previously, these types of flooding can occur independently or concurrently.

The area of land which is defined as floodway, flood storage and flood fringe is different for floods of different size. Some areas are benign or have a very low risk in small floods but may experience much greater and therefore more hazardous flows during larger floods. This needs to be determined before informed choices can be made about the flood risk to future development.

Floodways, flood fringe and flood storage areas should be defined for a range of floods, not just a single flood such as the 1 in 100 AEP event.

Floodways

Floodways are primarily defined by their hydraulic function. They are where most conveyance of floodwater along a particular flow path occurs. Typically, adjacent to the main channel and any remnant anabranches, velocity may be relatively high compared to other areas of the floodplain resulting in high hazard areas. However, in some circumstances they may have very low flow velocities. Floodways are best kept free of obstructions such as structures or buildings, as development has the potential to redirect flows, increase danger to personal safety and lead to significant financial losses due to damage potential. Floodways can be utilised for agriculture or recreation to maintain them as open generally undeveloped areas. The extent and behaviour of a floodway may change in rarer floods but obstructions can have a significant impact on upstream flood levels even in the flood selected for planning purposes. Obstructions have the potential to divert water away from existing flood flow paths resulting in new flow paths and associated adverse impacts.

Figure 7 *Flood behaviour is site dependent*

In a major flood, the narrow floodplains along the lower reaches of the Hawkesbury River can develop floodway conditions i.e. deep fast moving waters, and become hazardous.

Floodways need to be examined and risk identified for a range of flood events. Areas which may be flood storage or flood fringe in a 1 in 100 AEP flood may become floodways in an extreme event or new floodways may develop, (Figure7).

Flood storage

Flood storage areas are typically affected by low to moderate flow velocities, which slowly fill up, and then drain once the flood peak has passed. Backwater flooding falls into this category. Flood storage areas are often upstream of a landform that restricts flood flows – such as the gorges on the Hawkesbury River at Sackville. Flood storage areas play a significant role in determining general flood behaviour and it is therefore vital that such areas are retained. A small percentage loss of flood storage through fill or development will usually not have any measurable impact if considered in isolation, but cumulative impacts of widespread development can reduce available storage. To avoid loss of storage, there should be a balance of cut and fill whereby the net change in storage volume is minimal, (Figure 8). There may be alternative means to achieve no net loss of storage and each situation should be considered on its merits.

Flood fringe

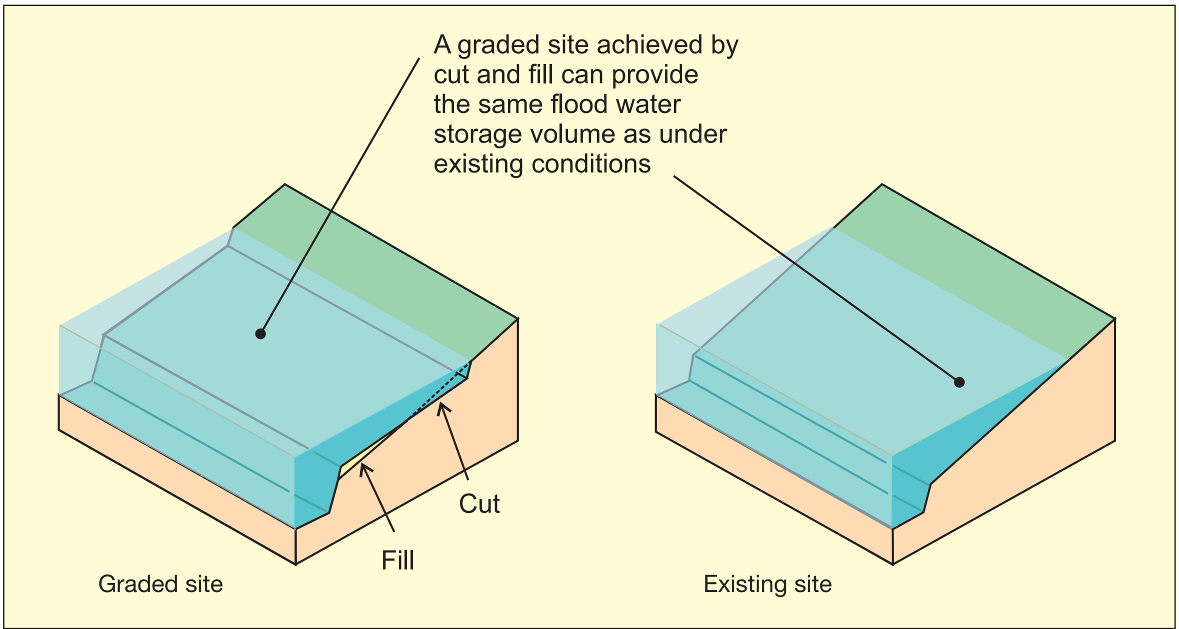
Flood fringe is essentially the floodplain area remaining after floodways and flood storage have been identified. Flood fringe areas are generally situated around the edge of the floodplain, and the hydraulic impacts associated with development of this land are low and evacuation to higher ground is usually readily available. This part of the floodplain can be suitable for development depending on the frequency and nature of flooding.

Floodplain Risk Management

The varied nature of Hawkesbury-Nepean flood hazards has significant implications on risks associated with human occupation of the floodplains. What is required is a series of practical measures tailored towards addressing these wide-ranging risks in an equitable manner.

An important aim of these guidelines is to assist council planners to introduce graduated planning controls with tailored measures to balance the greater variation in flood risks found across the floodplain. For example, higher potential flood losses in more hazardous areas, such as at lower elevations can make more stringent development controls worthwhile.

***Figure 8** Minimising loss of flood storage*



In highlighting the problems and many limitations caused by the reliance on a single flood planning level, the Land use, Planning and Development Control Measures Report prepared for the Hawkesbury-Nepean Advisory Committee in 1997, outlined a straight forward risk management approach which involved three basic tasks.

1. **Differentiate the risks** and determine which risks are to be:
   - **avoided** e.g. danger to life;
   - **modified** e.g damage to property (both public and private); or
   - **accepted** e.g. disruption to normal daily activities (during and after the flood).

   This approach overcomes the tendency to regard flood risk as being merely the occurrence of a flood, not what is threatened by that flood. Hazards pose numerous types of risks that can be entirely different e.g. damage to assets and infrastructure, environmental degradation, loss of employment, reduced profitability, danger to lives.

2. **Determine what degree of risk** can be borne by the community and individuals, taking into consideration vulnerability as well as economic, financial and social benefits and costs arising from the decision to avoid/modify/accept each type of risk.

   This depends on the severity of the impacts of the risk. Are they going to be catastrophic, major, moderate or insignificant? Who will be affected: individuals, families, communities, businesses, large enterprises, government? Society's tolerance of different risks varies depending on who and what are harmed, how seriously they are harmed and whether the decisions which resulted in the risk were made with due diligence and duty of care.

3. **Determine measures to adjust risk** to match the levels of protection which the flood affected community expects and can sustain.

   This recognises that different types of risk require different floodplain risk management solutions, which need to be tailored to the situation.

Floodplain risk management measures basically comprise three categories:

- modifying the flood,
- modifying the response to floods,
- modifying activity on the floodplain.

Table 1 shows a range of measures covering these three categories. However, in practice a combination of options is generally found to produce optimal solutions.

Since 1984, the NSW State Government has provided guidance to councils and others on how to manage the flood risk through its Flood Prone Land Policy. Since 1986 this was achieved through the Floodplain Development Manual (1986) and subsequently, the Floodplain Management Manual (2001). In 2005, the Government gazetted an updated and revised Floodplain Development Manual (2005).

The policy has consistently promoted a merit-based rather than a prescriptive approach to floodplain risk management, balancing social, economic and environmental considerations in reaching decisions through a community-based committee-led process. This involves the production of a local Floodplain Risk Management Study and then the preparation of a Floodplain Risk Management Plan. The three basic tasks (differentiate the risk, determine what degree of risk and determine measures to adjust risk) can form the basis of the Study. The floodplain risk management plan should determine the measures, strategies and controls to be put in place to effectively manage all forms of flood risk so that they are not excessive for those exposed to the risks. A plan should strike a reasonable balance between the need to permit or promote continued occupation of flood prone land and contain increases in flood risk, including risks to health, social well being and property.

Measures to mitigate the flooding were investigated as part of the Hawkesbury-Nepean Strategy but after considering both environmental

Table 1 *Floodplain risk management measures in the Hawkesbury-Nepean valley*

Modifying the flood		
Measure	**Comment**	**Suitability**
Major structural engineering solutions very limited due to magnitude of the flood hazard and the nature of the valley which leads to an extreme range of depths and the flooding *(Hawkesbury-Nepean Flood Management Advisory Committee Report 1997).*	Scope limited in the Hawkesbury-Nepean	Not suitable
Only at local level are minor works worthy of further consideration.	Worthy of consideration, but economic, social and environmental grounds may preclude their construction.	Locally suitable
Modifying the response to floods		
Measure	**Comment**	**Suitability**

The emergency planning and operational management of floods can be enhanced by:
• having better information about
  – flood behaviour, and
  – flood-affected communities,
• having advanced warning and communications systems,
• ensuring suitable evacuation routes, and
• promoting flood awareness in communities.
 	
Sections II and III discuss how land use planning can influence the risk outcomes.
	Essential for all flood prone land	Essential

Modifying activity on the floodplain		
Measure	**Comment**	**Suitability**
The guidance in this and the companion guidelines offer solutions to manage the risk through: • controlling the location of new land uses, • adoption of flood aware housing construction and materials. Section III explores these aspects further.	Opportunities for change	Suitable

and cost implications, no measures were identified which would reduce the possibility of severe flooding due to the topography of the floodplain, the potential depth of flooding and the flood behaviour.

Risk can be reduced by setting a level for planning purposes (the flood planning level or FPL) and by imposing development controls which limit the types of development in hazardous areas below the FPL or by a combination of both. (More information on the use of FPLs can be found in Chapters 8, 9 and 10). In some cases the hazard is so high, that a council may decide to make available voluntary purchase of homes so that residents have an equitable option to relocate to a safer location elsewhere. The merit-based approach enables the adoption of different solutions for varying hazard levels and risk.

- Flooding is a natural hazard in the Hawkesbury-Nepean valley.
- Flooding potential and its consequences are predictable and so flood risks can be defined and managed.
- Flooding is a relevant head of consideration when developing floodplains because floodplain communities are exposed to potential physical and economic harm.
- Flood risk decisions should be subject to a duty of care as they determine to what level of long term risk the public will be exposed.
- Excessive flood risks can be reduced through appropriate development strategies and controls.

Integrating Floodplain Risk Management into the Planning Process

Given the unique and exceptional Hawkesbury-Nepean River flooding characteristics which include extreme depths of water and in some locations, high velocities, it is essential that flooding is factored into development decisions on flood prone land in order to ensure higher levels of risk are adequately managed.

When flood prone land is identified for urban release, if actual flood risk is factored into the regional and local strategic planning processes and subsequent environmental planning instruments and development control plans, then safer occupation of the floodplain is ensured.

As council is the floodplain risk management authority and generally the consent authority for development within its local government area, councils are encouraged to use the guidelines to assist in reviewing flood risks to determine locally applicable flood-related controls through local strategies, a local environmental plan (LEP) and development control plan (DCP).

Flood prone land is defined as land below the probable maximum flood level (PMF).

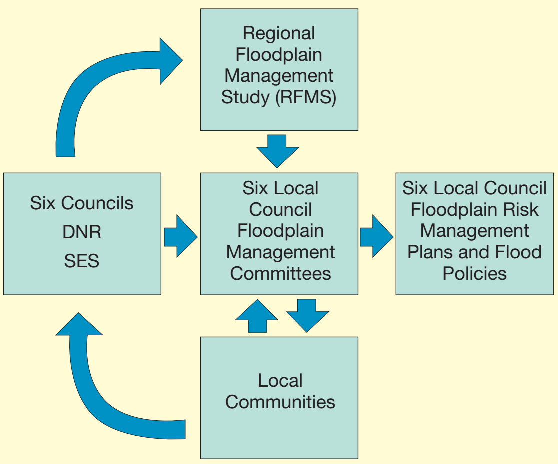
An environmental planning instrument can include objectives aiming to achieve safe occupation of flood prone land, supported by heads of consideration for use in the assessment of development proposals on flood prone land.

If the subject land is flood prone, provisions to reduce flood risk should be included in:

- Metropolitan, regional and local strategies
- Structure plans
- State environmental planning policies (SEPP)
- Regional environmental plans (REP)
- Local environmental plans (LEP)
- Development Control Plans (DCP)
- Council policies

In order to identify the floodplain risk management needs of their area, councils are encouraged to establish a Floodplain Risk Management Committee which includes government agencies (including DNR and SES) and effective community representation. The committee directs the preparation of a Floodplain Risk Management Study and Floodplain Risk Management Plan. The Floodplain Development Manual (2005) details the process for preparing FRMPs.

Figure 9 *Hawkesbury-Nepean Regional Floodplain Management Study process*



The relationship between the Hawkesbury-Nepean Regional Floodplain Management Study (RFMS), State government agencies, the community and the six Hawkesbury-Nepean councils' floodplain risk management process.

However, it should be remembered that the aim of the process is to achieve the objectives of the Flood Prone Land Policy i.e. to reduce adverse consequences of flooding to a reasonable level. Too often, there is a tendency to assess success according to adherence to the processes in the Manual rather than how well the actual Policy objectives can be delivered through resultant council policies and plans. There are opportunities through the adoption of a range of cost-effective measures (explored in detail in these and the companion guidelines) to gain a dramatic reduction in risk. The difficulty with over-simplification of the decisions relating to floodplain risk management, especially for greenfield development, is that these opportunities are overlooked, leading to either:

- development being precluded from extensive areas which, had more comprehensive measures been explored, may have been released for development, or
- development allowed to proceed where the continuing risk could have been lowered considerably.

The information produced under the Hawkesbury-Nepean Strategy's Regional Floodplain Management Study is available to assist the six councils in the Strategy area in achieving the objectives of the Policy, (Figure 9).

> The Hawkesbury-Nepean River will flood again to depths not seen in living memory; what is not known, is when it will flood.

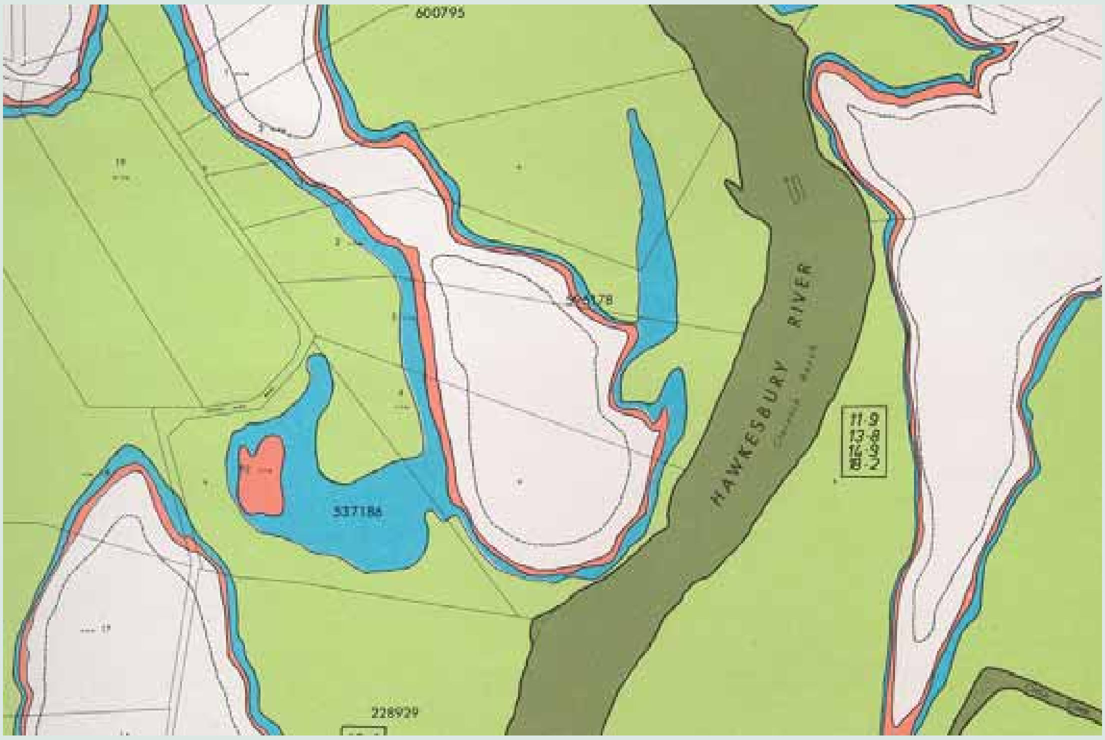
Understanding the nature of the flood hazard

Understanding the nature of the flood hazard is a key step to floodplain planning. The ability to understand the hazard has been enhanced in recent years through digital flood hazard information which can portray far more information than traditional flood maps were able to do. They focussed solely on flood levels for a range of floods e.g. the 1 in 20, 1 in 50 and 1 in 100 AEP floods and also the approximate level of the flood of record (Figure 10). The maps were unable to show critical details such as depth, velocity, rate of rise and potential for isolation.

The six Hawkesbury-Nepean councils in the Strategy area, relevant government agencies and utility providers have been provided with information on mainstream Hawkesbury-Nepean River flood hazard through a computer software application known as the Flood Hazard Definition Tool. The Flood Hazard Definition Tool is designed to be used with a geographical information system (GIS) which generally includes cadastral maps, topographic base maps, aerial photographs etc. It provides the user with information on flood hazard (i.e. flood extents, flow paths, velocities, water depths and rate of rise) for a range of flood events. The Flood Hazard Definition Tool uses ground height data provided in a digital terrain model (DTM). Data from flood models covering the Strategy area are combined in the tool to create a continuous water surface profile for minor floods up to the PMF, (Figure 11).

The development of the Flood Hazard Definition Tool enables councils to evaluate the distinct components which make up the hazard i.e flood extents, flow paths, velocities, water depths and

Figure 10 *Traditional Flood Map*



Flood maps, such as this extract from the Lower Hawkesbury Floodplain Atlas 1982, do not include critical details such as depth, velocity, rate of rise and potential isolation, which are important for assessing flood hazard.

rate of rise, (Figure 12). This is a shift away from the limitations inherent in relying on a single flood level for planning purposes as a tool for protecting property on floodplains.

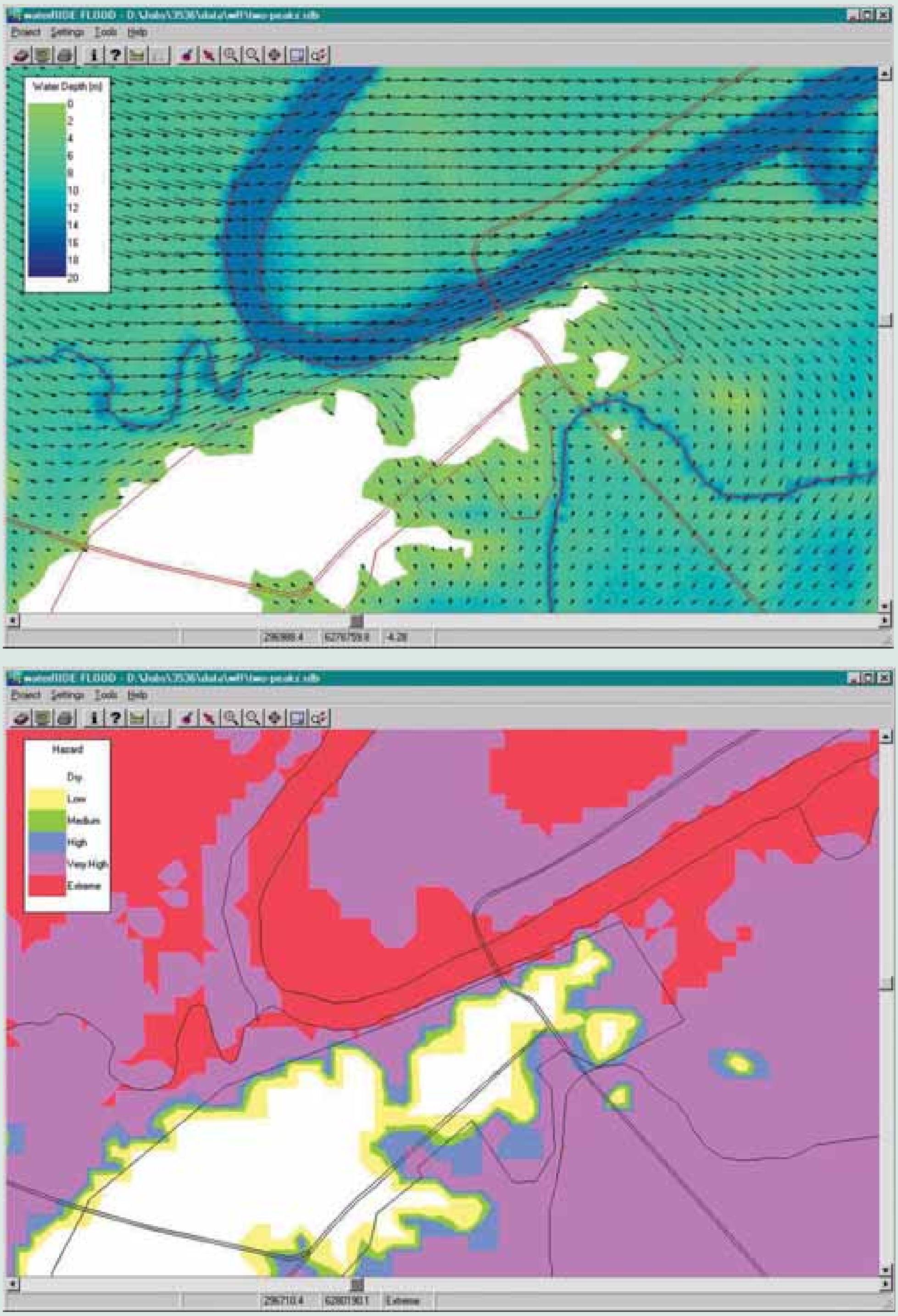
Using the flood risk band methodology, which is described in Section III, councils can choose to apply the guidelines to determine precinct-specific or even site-specific development and building controls appropriate to the flood risk of each locality. Each council can decide what is an appropriate level of control for its area.

It should be recognised that application of the guidance given here can only lead to a risk reduction for new development on the floodplain. It is generally impractical or overly costly to retrofit existing buildings with measures to protect against flood damages, except for some individual older properties which are located in lower lying locations when house raising may be a practical option. In the Hawkesbury-Nepean, measures to protect existing communities are focused on saving people, moveable property and contents, there being no practical means to protect existing building structures in the Hawkesbury-Nepean floodplain against damage from either water depth or velocity in severe floods. However, older buildings tend to be constructed from more durable materials and are thus less vulnerable to flood damage than modern buildings.

Although specifically written in the context of the Hawkesbury-Nepean floodplain, many of the principles and the methodology put forward here are readily transferable to other floodplains where urban communities are at risk of extreme flood depths and/or velocities.

Hawkesbury-Nepean floods cannot be eliminated, but the flood risks can be managed. It is in everyone's interests to be forward thinking and adopt a sustainable floodplain risk management approach to manage the unique flood risks in this valley.

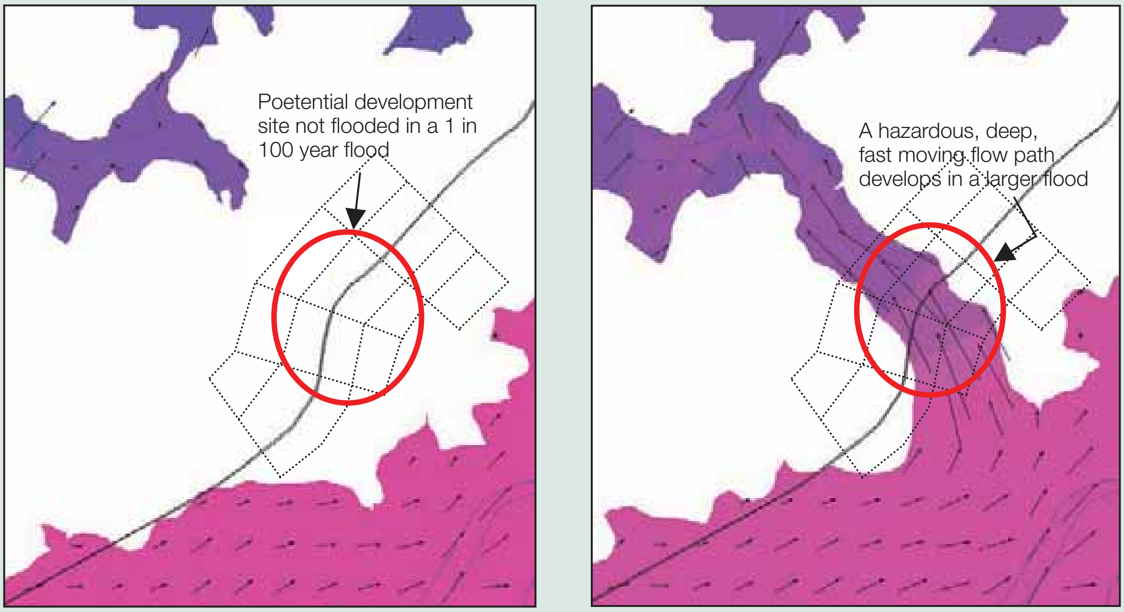
__Figure 11__ The Flood Hazard Definition Tool



The Flood Hazard Definition Tool can illustrate flow velocities across selected parts of the floodplain at different times in the flood event. The overlaying of the water surfaces on the DTM can show variations in flood depth at different locations. This allows a clearer visualization of flood behaviour and the degree of flood hazard on a computer screen. An important advantage is that it can show flooding over a large area to give a "big picture" perspective so that regional issues can be examined e.g. isolation problems and evacuation needs. The tool is not intended to determine the precise extent of flooding.

3

Figure 12 *Flood Hazard Definition Tool used to display range of flood events*



The ability of the Flood Hazard Definition Tool to display flood behaviour for a range of flood events allows sites which become potentially hazardous in events larger than the 1 in 100-year flood to be readily identified.

Determining the suitability of land for development based on a flood planning level alone is too simplistic and can lead to communities being exposed to greater flood risks.

4 RISK AND HAZARD

Distinguishing Between Risk and Hazard

It is useful to clarify the meaning of risk in the context of flooding.

Floodplains are hazardous areas

The floodplain of a river comprises flood prone land, which is defined as land up to the level of the largest flood that could possibly occur – the probable maximum flood or PMF. Flooding creates a hazardous environment and is a source of harm to people and property when they occupy flood prone land.

Flood Hazard is the

- water depths and/or velocities or combinations of depth and velocity; and
- rate at which floodwater rises and therefore how much warning time is available; and
- potential for isolation by rising flood waters.

Flood hazard relates to how dangerous a site on the floodplain can be. It depends on:

- location and landform e.g. low lying and easily isolated;
- flood behaviour e.g. deep inundation and subject to rapidly rising and fast moving floodwaters; and
- frequency e.g. the site could be flooded regularly or only in an extremely rare event.

Hazards can be known beforehand

While the *hazard* only exists when there is a flood, the hazard potential of a site on the floodplain can be reliably identified at any time provided the information is available. As it is directly related to flood behaviour, the hazard can be defined through the outputs of a flood model. This can provide information about what will happen at a site and how it will happen. Knowledge of the nature and severity of the hazard can be used to inform planning decision making. However, what is not known is when the flood will occur.

Occupying a floodplain invites risk

Flooding becomes a risk when flood prone land is occupied, irrespective of what flood planning level (FPL) is selected. The level of risk can be measured in terms of a combination of the consequences of a particular flood event and their likelihood of occurrence. How serious or how much of a risk this becomes depends on the hazard potential and what responses and actions are taken to deal with the hazard.

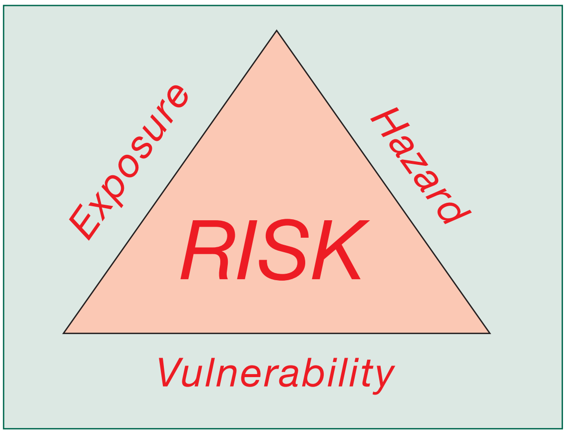
The *flood hazard* becomes a *flood risk* to people and property only when people occupy or use flood prone land.

Risks can be controlled through planning decisions

Flood Risk is the

- probability of the flood occurring – how likely it is to happen; and
- exposure to flooding – how often or for how long a time is the floodplain occupied by people or assets; and
- flood hazard – how fast/deep is the floodwater, how much warning time, potential for isolation; and
- consequences – what or who is vulnerable and what damages will result, how personal safety is compromised.

Figure 13 *Risk triangle*



A Risk Triangle (Figure 13) offers a useful and easily understood model to illustrate the combination of elements that make up risk. Insurance catastrophe modellers use a similar model. It comprises the area of an acute angled triangle. Hazard, vulnerability and exposure are represented along the sides. If any one of these factors increases, so the area of the triangle increases and the risk increases; if any one side reduces, so the risk reduces. Risk is therefore a combination of hazard, exposure and vulnerability. If any one of three elements that make up risk is missing or eliminated, then there is no risk. (Smith Handmer, 2002)

It should be remembered that the risk to people is not necessarily the same as the risk to property as the consequences can differ markedly; each needs to be considered in parallel.

> The planning system has the ability to control each of these elements of flood risk for new development by determining what can be built, where it can be located and how it is developed.

As these decisions are made by consent authorities and professionals on behalf of future occupants (rather than by the occupants themselves) it is important that decisions should be based on community attitudes and expectations as well as the ability of occupants to bear the risks when a flood occurs.

The *'Hazard'* side of the Risk Triangle cannot realistically be eliminated in some floodplains, such as in the lower Hawkesbury-Nepean. Traditionally, the emphasis has been towards engineering solutions to reduce the incidence of flooding. However, measures such as channel works and levees are not a feasible means to mitigate the flood hazard because the volume of floodwaters and range of flood depths are so large.

The only way to completely eliminate the *'Exposure'* side of the triangle in relation to flood risk to people and property is to have no development in the floodplain. As this is quite impractical as well as socially and economically undesirable, ways of managing the risk need to be found. This can be achieved by either:

- limiting the exposure, by reducing the likelihood of flooding on certain types of development; and/or
- reducing the vulnerability of occupants and assets on the floodplain.

> There is immense potential to minimise adverse consequences by reducing vulnerability to flood damage. This step has yet to be used to advantage in areas where flood risks remain relatively high.

Identifying and prioritising the risks

In floodplain risk management, different types of risks need to be identified and distinguished to enable:

- prioritisation for decision making; and
- selection and evaluation of different strategies and measures which can be tailored to treating each type and level of risk.

Different risks relate to different consequences. The types of risks dealt with in floodplain risk management are usually:

- safety of people;
- financial losses; or liability of losses (on assets) from flooding on individual owners and occupiers;
- outage of utility services and transport, communications and utility infrastructure damage;
- impacts on business outputs and employment;
- intangible losses to communities and individuals;
- environmental impacts resulting from flooding or arising from management decisions.

The highest priority in risk management is almost universally agreed to be protecting people by taking steps to prevent loss of life and serious injury. This is the case whether the hazard creating the risk is natural or a result of human activity. The only difference is the way in which risk is treated.

Floodplain risk management has now matured to a stage where it has recognised that land use controls alone are not sufficient to address this type of risk adequately unless development is prevented in all but very low flood hazard areas.

Flood response measures which include public awareness, flood warning, evacuation, together with adequate and appropriate evacuation infrastructure and flood monitoring systems have now become an integral part of floodplain risk management.

How the other types of risks – financial, public/private property damages, business losses and environmental impacts etc, are prioritised, will depend on many other factors. The solutions may vary depending whether measures are being sought to reduce danger and contain severe losses in an existing development on flood prone land, or they are part of planning for new floodplain development.

The Guidelines recommend that for floodplains such as the Hawkesbury-Nepean, where the potential flood risks are many times greater than other floodplains in NSW, a more comprehensive suite of practical and achievable floodplain risk management measures, not just a single 1% FPL can be justified. This approach would result in:

- more resilient floodplain communities,
- reduced adverse consequences to personal safety, health, family well being and financial health arising from flooding,
- a reduction in the increase in property damages through a range of FPLs, development layouts, building designs and construction methods and materials better suited to withstand hydrostatic and hydraulic forces, and
- the introduction of graduated development and land use controls tailored towards offsetting the higher levels of flood risk in locations with potential for more severe and more frequent flooding.

What level of flood risk can be tolerated?

It is widely accepted that risk is a fundamental part of normal life. However, trying to determine what level of flood risk is acceptable or at least tolerable to the community is not straightforward. In a Hawkesbury-Nepean context, the risk of severe flooding has a low probability but has high consequences. This is because unlike many rural floodplains, the Hawkesbury-Nepean floodplain is already highly developed with an increasing population.

The community trusts authorities such as councils to have appropriate controls in place in residential areas prone to natural hazards (Cox et al, 2001). From experience, individuals who have endured flooding show a range of symptoms, which include fear, anger, frustration and depression (NSW Government, June 2001). The greater the losses, the greater the potential for public outrage. Such outrage is more likely if new developments have not had any measures to protect against flooding which exceeded the adopted risk levels.

Whilst flood risk is only one of several relevant interrelated factors which have to be addressed when reaching decisions to develop land, a damage and loss-causing flood event is likely to provoke emotive reactions. What may initially have been determined to be a 'tolerable' or 'acceptable' flood risk is likely to be re-evaluated after the experience of a real flood.

A basic approach to reduce risk has been to reduce the likelihood of buildings being flooded by adopting minimum FPLs for various types of development. A debate about infrequent flood events is unlikely to engage the community in a meaningful way (Syme 1994) and may indeed stifle debate about the other elements that make up risk i.e. the consequences of flooding. In most, but not all areas of NSW, interstate and overseas, the probability of the flood selected for the FPL for residential development has been the 1% or 1 in 100 AEP design flood.

A design flood is a statistical estimate of a flood based on probability analysis of flood and/or rainfall data.

AEP or Annual Exceedance Probability means the probability of a flood of a given size or larger occurring in any one year.

The Manual (2005) recommends that FPLs for typical residential development be based around the 1% AEP flood event. Generally, habitable floor levels are required to be at or above this level and permissible land uses below that level are very limited. Good floodplain management practice also adds a freeboard to this design flood level to allow for uncertainties and give a margin for error to ensure that property will not be flooded when the flood event selected for the FPL occurs. The Manual (2005) advocates a 0.5m freeboard. More information about freeboard can be found in Chapter 8. Damages to structure, fittings and contents are reduced because the chance of over-the-floor flooding is reduced.

As a floodplain management measure on its own, a 1% FPL has limited regard for flood hazard and has no regard for the consequences of rarer flooding above that level. The consequences of flooding will vary between individuals depending on how they use the floodplain (e.g. agriculture compared to residential) and what remains exposed to the impacts of flooding. The standard is based on the premise that if a person lives in a house built at the 1% flood level for 70 years (a theoretical lifetime) then there is a 50-50 or even chance of experiencing a flood of 1% or greater during that 70 year period.

A major problem arises because the section of the community that makes decisions for flood prone land (e.g. council/government), is not necessarily the same community that will eventually own or occupy new development on that land. It is they, the future residents and house owners and not the original decision-makers, who will be exposed to the risk of floods greater than the 1% flood. It is they who will be subject to property losses and personal risk (Tweeddale 1994).

Decision-makers therefore have a duty of care when making floodplain risk management decisions, especially as the flood risk is foreseeable. Decisions made on behalf of the community, e.g. by an elected council or government, are more likely to be accepted if there has been open communication and consultation with the affected community so that the risk is readily understood. Whilst community involvement in decision-making makes the risk generally more tolerable, (Haddad 1994), in planning for new growth areas, engaging 'the community' can be challenging as the future residents are not readily identifiable. Ensuring that people are fully aware of the implications of investing or living in a flood prone property is the responsibility of government, councils and those involved directly in property development and marketing.

For more information on

Achieving safer, sustainable floodplain communities – Section IV

Roles and responsibilities, including duty of care – Chapter 12

Public awareness – Chapter 13

If one uses common practice in NSW and elsewhere as a guide, it is not unreasonable to suggest that the 1% or 1 in 100 AEP flood represents a frequency of flooding that can be tolerated by the community as a whole[1]. So whilst accepting that no-one ever *wants* to have their house flooded, many people are prepared to tolerate some risk and live on land where there is a 1% chance in any year of flooding. What is not always appreciated, if that is the only floodplain management measure aimed at reducing the risk, the corollary of that decision is in floods any greater (rarer) than the 1% flood, property that is highly vulnerable to flood impacts will incur significant damage. The deeper the water, generally the greater the damage, (Figure 14).

Figure 14 *A house in Windsor inundated above the eaves*

Flooding above the eaves level can cause severe structural damage to modern houses.

What flood risk can be tolerated?

People do not want to be impacted by flooding, but they may be prepared to tolerate a level of protection against floods up to and including the 1 in 100 AEP flood (1%).

The 1% flood could therefore be said to represent the frequency of flooding occurring that can be tolerated.

But having a 1% flood planning level does not offer any protection against rarer floods, the consequences of which may be very severe.

Where floods only slightly rarer than 1% result in over-floor flooding of more than 0.3 metre or deeper, additional measures are needed to reduce the risk to prevent the extent of property damage becoming excessive and possibly catastrophic.

Comparative risk

There is no equivalent standard in use in Australia or elsewhere to indicate what is a tolerable probability for flooding that would inundate a dwelling house to ceiling level or what probability of flooding would result in the building failing or becoming so damaged as to make repairs uneconomic and impractical.

In many catchments the difference in water depths between the 1 in 100 level and the PMF can be measured in centimetres not metres. In those locations, it is not so imperative to protect against rarer floods because not only is the chance of an extreme flood occurring very rare indeed, but also the water would never reach depths sufficient to cause structural damage to a typical dwelling house or create additional evacuation difficulties, (Figure 15).

[1] It should be recognised however, that people often have the erroneous belief that because they have built at or above the flood planning level, with the approval of council, their property is flood-free. It is critical that the continuing flood risk is properly communicated to promote flood-aware communities and to avoid misconceptions.

However, in floodplains such as the Hawkesbury-Nepean where there is the potential for water depths in severe flood events to reach or exceed the ceiling height of one or even two-storey houses, the potential for damage is much greater. When such extreme water depths can occur in events not much rarer than a 1 in 200 AEP flood, as in the Lower Hawkesbury-Nepean valley and to a lesser extent in some other east coast floodplains such as the Georges River, the risk of severe damage is high. For example, the largest recorded Hawkesbury-Nepean flood in June 1867 (a 1 in 200 AEP flood event), reached levels more than 2 metres above the current FPL in Windsor. Although only half as likely to occur as a 1 in 100 AEP (1%) flood, a 1 in 200 AEP (0.5%) flood is 500 times more likely to occur than the extremely rare probable maximum flood (PMF). A repeat of the flood of record today would cause severe damage and even total destruction of many existing houses and buildings in the Windsor area.

When does the risk become intolerable?

When floodwater exceeds mid-wall, damage to the structure of a conventional house becomes severe and most of the contents will be lost. Losses and trauma increase dramatically, costs of clean-up, repair and replacement rise and recovery is prolonged.

Direct household damage exceeding $80,000 (2005 figures) can easily occur well below the level of a 1 in 200 Hawkesbury-Nepean flood, (0.5% chance of occurring or being exceeded in any one year).

Is this a level of risk that can be tolerated?

There is no standard commonly in use that reflects community tolerance for this level of risk.

4

Figure 15 *Comparative flood risk of three NSW towns*

It is recognised that for land above the 1 in 100 AEP or 1% flood, the chance of a flood occurring is low. Nonetheless, rarer floods do occur and their consequences should not result in catastrophic devastation of new property.

Reducing the Risk

For the Hawkesbury-Nepean floodplain, the range of flood depths above the 1 in 100 AEP flood level is so great compared to other NSW floodplains, that more sophisticated tools than the 'one-size-fits-all' approach are necessary to manage the flood risk.

In accordance with the Floodplain Development Manual, the guidance given here advocates that new residential development be located preferably on land at or above the 1% or 1 in 100 AEP flood level plus freeboard and include a range of other building measures aimed at reducing building and contents damage. A methodology is provided to determine risk bands in order to reduce the risk of damage to residential development on land subject to rarer floods between the 1 in 100 AEP flood level and the PMF.

Some land uses are more suited to floodplains than others because their vulnerability to flooding is less or their exposure is less. If a use is only occasional, e.g some recreational uses, then the risk is less than it would be if the use involved occupying flood prone land 24 hours a day, 365 days a year.

There are many uses that may be suitable for areas where the flood risk is considered too great for residential development. More information can be found in Section III of these guidelines.

The Hawkesbury-Nepean valley, with substantial areas of rural land also includes many thriving towns and continuing demand for further devlopment. In severe Hawkesbury-Nepean flooding, extensive urban areas as well as intensively used rural land, will incur damages and losses. Following the guidance in these and the companion guidelines can help reduce the increase in total losses and reduce individual losses. It can achieve this by increasing the stock of housing that is flood-tolerant i.e. new dwellings which are better located and designed, and use building methods components and materials appropriate to the risk.

However, it should be recognised that there is inevitably a lengthy time lag between the adoption of new standards that address the risk and any significant reduction in total flood damages. This is because significant shifts in land use patterns only take place slowly and incrementally and new houses built according to the guidelines would initially make up only a relatively small proportion of the total housing stock on the floodplain.

Many existing dwellings, public infrastructure, community buildings and commercial assets will be damaged in severe Hawkesbury-Nepean flooding resulting in extremely high total losses as well as financial hardship and trauma to individuals.

The guidance in this report can assist in gradually reducing the total flood losses as the proportion of development built to more flood tolerant standards increases.

SECTION II

REDUCING THE RISK TO PEOPLE

5 PLANNING FOR EVACUATION

Studies undertaken for the Hawkesbury-Nepean Floodplain Management Advisory Committee (HNFMAC), found that the flood threat to the Hawkesbury-Nepean valley from above the city of Penrith to downstream of Spencer had the potential to result in loss of life numbered in the tens of thousands and property damage in the hundreds of millions, if not billions, of dollars unless mitigation activities were implemented immediately.

The studies found that if no action were to be taken to upgrade existing evacuation routes from their condition in 1997 and local flooding occurred, the majority of the flood prone population, estimated then to be between 40,000 and 60,000 persons, would be without a means of escape from isolated areas surrounded by water. Unless rescued, these persons would be expected to drown if flooding levels occur that inundate the islands. Even if the evacuation routes were improved to eliminate the threat from local flooding it was found that in excess of 15,000 people would still remain unevacuated and subject to total isolation or worse depending upon the final flooding depth. (HNFMAC 1997)

Introduction

Flooding leads to a multitude of consequences which affect people either directly or indirectly; some can be measured and quantified, such as direct damages to property and infrastructure whilst others are more indirect, intangible and unquantifiable, such as trauma, ill-health etc. Whether direct or indirect, whole communities as well as individuals, suffer the consequences. This chapter deals specifically with how severe flood risk to people's safety, can be managed through considered land use planning decisions. Further discussion of the social implications of flooding can be found in Chapter 6.

How are Flood-affected Communities Protected?

The State Emergency Service (SES) has the responsibility for combating floods in NSW. The SES ensures there is an effective flood plan in place and that the resources and infrastructure are available for it to manage flood events that affect persons and property. The principal aim of emergency planning is to save the lives of those exposed to the threat of severe floods.

In planning for development on flood prone land, the safety of all occupants be they existing or future residents, workers or visitors, cannot be underestimated. This fundamental issue warrants independent consideration and should be in addition to consideration of flood hazard impact on property damage.

In order to undertake a proper assessment of the hazard to people, information regarding the flood behaviour including flood hazard is necessary. It is not sufficient to know only the recurrence interval of a flood e.g. a 1 in 100 AEP flood event. This gives the extent of one design flood but no information on velocity or isolation. Whilst this approach has been widely adopted, it is far too simplistic to guide meaningful decision making for development of flood prone land particularly where the hazards from rarer floods is significant.

In the past, flood modelling data sets conveyed meaningful information only to specialists. Now with the advent of computer-generated information tools these data sets have been integrated and the results presented in a software package, which is easy to understand through its visual animated display. A Flood Hazard Definition Tool (FHDT) has been developed by Patterson Briton and Partners for the Hawkesbury-Nepean Floodplain Management Strategy. It has been supplied to councils, government agencies and providers of public utilities in the area to assist them with land management, planning decisions and emergency recovery plans for public infrastructure. (Chapter 3 has more information on the FHDT).

The software allows access to numerical flood information – such as the water level in metres AHD for a nominated flood, at a particular location and at a specific time in the flood. It also shows the behaviour of the flood over time. This is an extremely effective feature as it aids both the understanding of the nature of flooding and the hazard it causes. How quickly particular areas become isolated 'islands', which then overtop in more rare floods, is clearly demonstrated. The benefit lies in the ability to convey very complex information in an easily understood visual medium.

The SES has developed a comparable spatial computer tool to assist in its emergency planning. The widespread use of Geographical Information Systems (GIS) enhances the utility of these computerised systems.

Classifying Flood-affected Communities in the Hawkesbury-Nepean Valley

Flood-affected communities are those in which the normal functioning of services is altered either directly or indirectly because a flood results in the need for external assistance. This impact relates directly to the SES's operational issues of evacuation, resupply and rescue.

The SES categorises flood-affected communities in the Hawkesbury-Nepean valley into five classifications described briefly below. It is necessary to understand the different categories in order to be able to make informed decisions relating to development decisions on flood prone land.

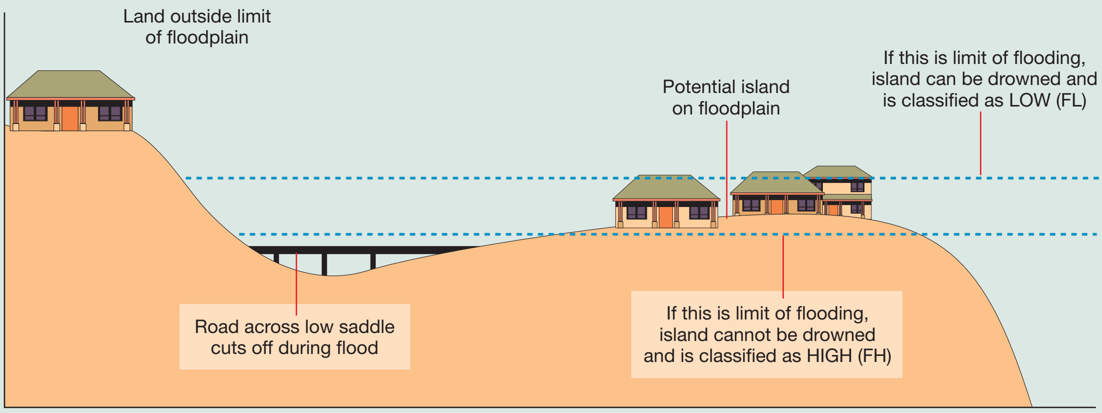
Flood Islands

These are inhabited areas of high ground within a floodplain linked to the flood-free valley sides by a road along a low ridge, (Figure 16). The road can be cut by floodwater, closing the only evacuation route and creating an island. After closure of the road the only access to the area is by boat or by aircraft, but the availability of both these means of transport cannot be relied upon in a flood event.

Flood islands are classified according to what can happen after the evacuation route is cut.

Category FH: The flood island is higher than the limit of flooding (ie above the PMF). The island is surrounded by floodwater but there is no direct risk to life or property on the island from inundation. The area will require resupply by boat or air if not evacuated before the road is cut. If it is not possible to provide adequate support during the period of isolation, evacuation would have to take place before isolation occurs. Wallacia falls into this category.

Figure 16 *Explanation of Flood Islands in SES Flood Effect Classification*



Communities who live and work on flood islands present challenges for emergency services. Population increase through new development on flood islands exacerbates this existing problem. If the flood island is 'low' it can be isolated in minor floods and then overtopped if flood waters continue to rise. People have to evacuate early in a flood event before this occurs. If the flood island is 'high' it can become an ever-shrinking island trapping occupants. If flood waters do not recede for several days, as is possible with Hawkesbury-Nepean backwater flooding, this can lead to problems associated with rescue, re-supply, health emergencies and loss of essential 'lifeline' services.

Figure 17 *Flood island at Windsor*

In the 1961 Windsor floods, this flood island was created. The 1961 Hawkesbury-Nepean flood reached a height of 15.10 metres AHD in Windsor, 2.20 metres lower than the 1 in 100 AEP flood. This is an example of a Category FL flood island i.e. it can eventually be inundated in rarer floods.

Category FL: The flood island is lower than the limit of flooding (i.e. below the PMF). If floodwater continues to rise after it is isolated, the island will eventually be completely covered. People left stranded on the island will drown and property will be inundated. Richmond, Windsor and South Windsor fall into this category, (Figure 17).

Areas Accessible Overland (Category O)

These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side. The access road(s) head down into lower lying flood prone land. Evacuation can take place by road only until access roads are closed by floodwater. Escape from rising floodwater will be possible only by walking overland to higher ground. Anyone not able to walk out must be rescued using boats and aircraft. If people cannot get out before inundation, rescue will most likely be from rooftops. Requiring people to escape from floodwater by walking overland is a poor primary emergency evacuation strategy and therefore a category O area will generally be dealt with as though it were low flood island i.e. category FL. This means that people will be evacuated before isolation occurs. Yarramundi and Londonderry fall into this category.

Areas Accessible by Road (Category R)

These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side with access road/s rising steadily uphill and away from the rising floodwaters. The community cannot be completely isolated before inundation reaches its maximum extent. Evacuation can take place by vehicle or on foot along the road as floodwater advances. People should not be trapped unless they delay their evacuation. This can be a problem for people living in two-storey dwelling houses who may initially decide to stay but reconsider only after water surrounds them. These communities contain low-lying areas from which persons will be progressively evacuated to higher ground as the level of inundation increases. This inundation could be caused either by direct flooding from the river system or by localised flooding from creeks. Wilberforce, Riverstone and North Richmond fall into this category.

Landlocked Areas (Category L)

These are inhabited areas above the PMF so there is no risk of inundation of dwellings by floodwater but the only access road(s) are across flood prone land. Road access may be closed during a flood. In some cases normal access to the area is by boat but flood conditions may prevent usual boat access. Due to isolation these areas are likely to require resupply. If it is not possible to provide adequate support, evacuation will have to take place before isolation occurs. Parts of Leonay and many small communities and recreational caravan parks along the lower reaches of the river towards Sackville and into the gorge itself, fall into this category.

Indirectly Affected areas (Category I)

There will be areas outside the limit of flooding which will not be inundated and will not lose road access. Nevertheless they may be indirectly affected as a result of flood damaged infrastructure. Due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services, they may require resupply or in the worst case, evacuation. Communities which fall in this category, include North Richmond, Bilpin and Kurrajong and parts of the Blue Mountains and Penrith local government areas.

Evacuation Requirements

As can be seen from the SES classification, not all areas are equally affected and hence the evacuation needs vary accordingly. Although evacuation may be necessary, it may be quite possible and straightforward to travel uphill along constantly rising roads to adjacent higher ground above the level of the PMF and take refuge there until the floodwaters recede. Such refuges need to be in areas where essential services can be maintained as it may not be possible to return home for many weeks or months after severe flooding.

The major challenge lies with protecting the lives of residents on flood islands in the Hawkesbury-Nepean valley in major or severe flooding. In these areas, self-evacuation by car has been identified as the prefered means of protection. As there are not enough locally available buses for general public evacuation, buses would be allocated to evacuate special needs groups including those without personal transport. The single line Richmond – Blacktown railway would be cut by rising floodwaters before the road evacuation routes are cut and would therefore have limited use, (Figure 18). The use of fixed wing aircraft or helicopters, as a means of evacuation, is not an option. Boats would be limited to rescue operations by emergency personnel, and not available for general evacuation purposes.

***Figure 18** Rail line closed over Rickabys Creek, March 1978*

Floodwaters reached 14.3 metres AHD at Windsor in this flood. This level is almost 3 metres below the current 1 in 100 AEP flood planning level in the area.

***Figure 19** Saving possessions from the flood*

The 1961 flood in Windsor saw the community gathering together to save possessions from flood damage during the evacuation to higher ground within the town.

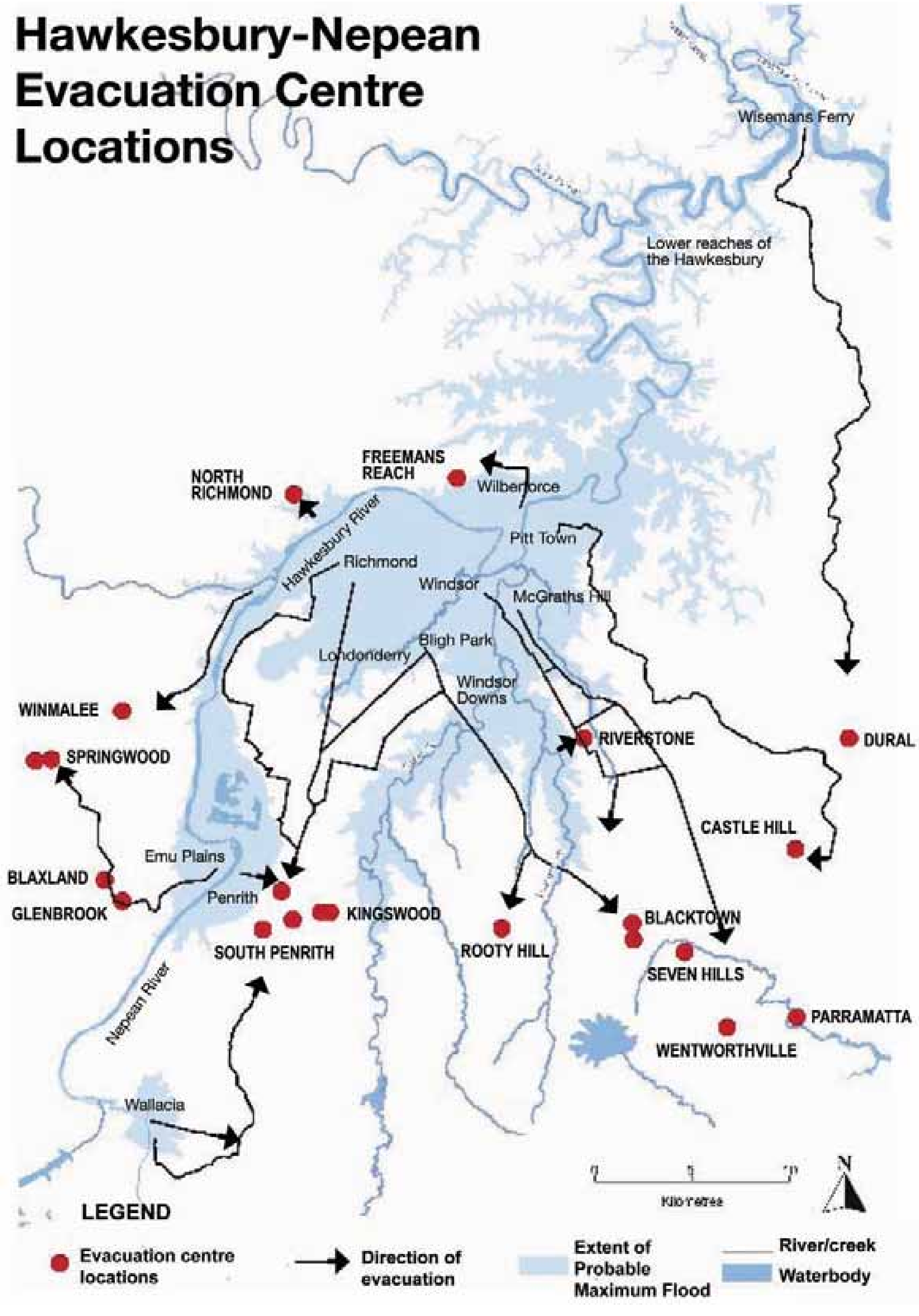
Evacuation would involve individuals driving themselves, their families and friends in their own vehicles along local and regional roads, which have been designated as evacuation routes, to the safety of higher land, (Figure 19).

The Department of Community Services (DoCS) has identified high schools, community clubs, leagues clubs etc which are beyond the extent of the PMF to be used as flood evacuation centres and where those evacuees who require it, can be provided with assistance. (Figure 20).

Regional evacuation routes for the main Hawkesbury-Nepean urban centres, were identified in the HNFMS Interim Regional Road Upgrade Plan and since 1998 have either been progressively upgraded or purpose-built using Strategy funding.

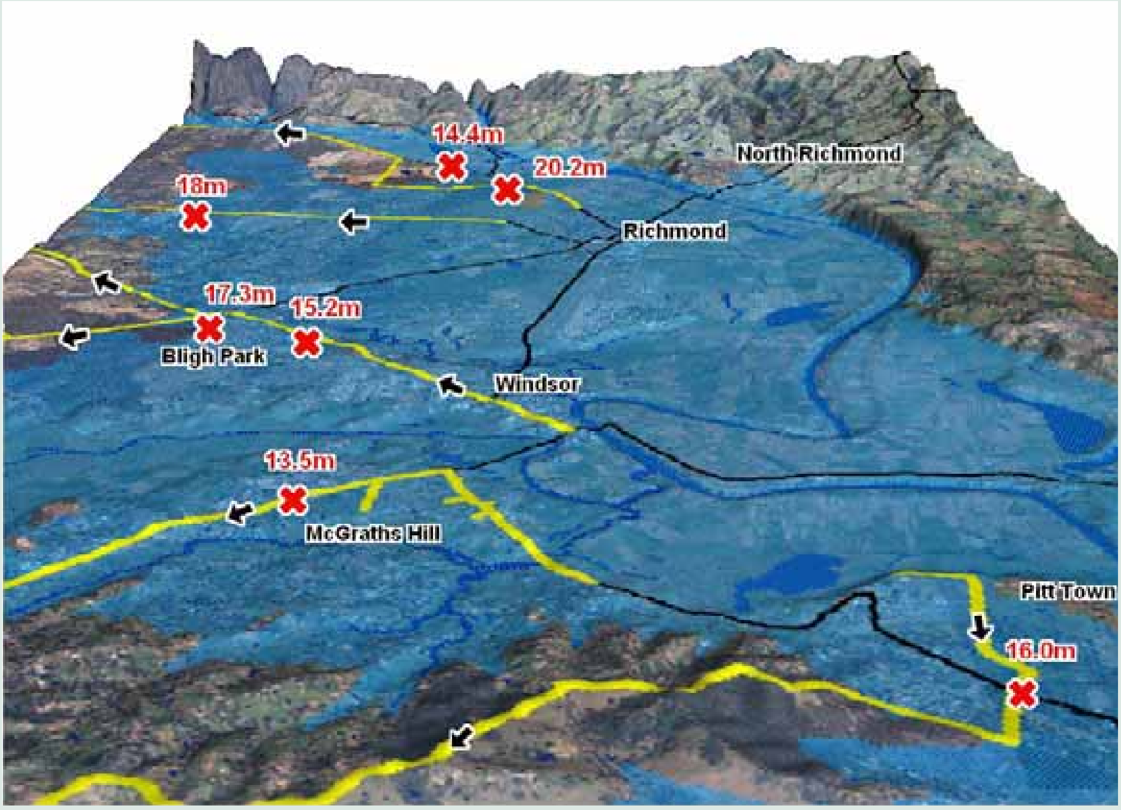
The regional routes have been chosen to facilitate the evacuation of entire towns (Figure 21). The most hazardous areas for personal safety in the Hawkesbury-Nepean, are towns and villages on

***Figure 20** Hawkesbury-Nepean Evacuation Centre locations 2004*



The Department of Community Services has identified a number of premises and facilities which could be used as evacuation centres in the event of a Hawkesbury-Nepean flood. The list of premises is periodically updated to take account of changing circumstances and in the event of a flood, locations other than those shown in this diagram may be used.

Figure 21 *Hawkesbury-Nepean regional evacuation routes*



The heights shown are the heights of the Hawkesbury-Nepean floodwater in metres AHD when the evacuation routes would close to traffic. The lower the height, the earlier in the flood the evacuation route would close.

Source: State Emergency Service

'flood islands' of higher land within the floodplain where early isolation results from rapidly rising floodwaters which inundate low-lying roads that link them to higher land on the edge of the floodplain, (SES category FL). Major centres in this category are Richmond and Windsor, which each requires two independent routes to provide redundancy in the system.

Evacuation is essential for Hawkesbury-Nepean flood islands where all the land lies below the PMF.

The ultimate height of a major flood event is only known after the highest flood peak has occurred.

Factors that Affect Evacuation

Level of public awareness

The evacuation of the existing population from isolated towns during a rising flood event continues to be a significant challenge to the emergency services. This challenge is exacerbated by the fact that the community's flood experience is limited to localised low-level flooding of mainly rural land and associated short-term road closures. Whilst these localised floods appear large and extensive, they were only minor floods and the consequences, although inconvenient and distressing to those directly affected, pale into insignificance beside the inevitable consequences of major or severe flooding, (Figure 22).

There have been no severe floods in the Hawkesbury-Nepean valley in living memory. The last severe flood was in 1867.

***Figure 22** Hawkesbury River flooding, Wiseman's Ferry*

Land uses need to be compatible with the available warning time and the ability to retreat to adjacent higher land.

The lack of experience inevitably results in a false sense of security in the community and will inevitably lead to a reluctance to evacuate, (Figure 23). People's unwillingness to believe the flood warnings and not act upon the emergency service's instruction to evacuate, was demonstrated in the 2001 flood in Grafton when only 10% of the population left the city during the nine hours of the evacuation. A follow up study found that notwithstanding the fact that Grafton has had a long history of frequent flooding, residents had very little appreciation of the flood threat. For the most part, they did not accept the possible need to evacuate and had no understanding of the evacuation strategy. (Pfister 2002).

It can be assumed that people will be reluctant to evacuate without seeing rising floodwaters to act as a trigger.

Increase in the number of households

The Hawkesbury-Nepean valley already contains sizeable towns with growing populations that will need to be evacuated in the limited time available before evacuation routes become inundated by rapidly rising floodwater.

It is critical that any factor of safety currently available to the SES is not eroded by new development, which would significantly increase the numbers of people needing to be evacuated from these flood islands.

Household numbers increase through new greenfield sites being developed– e.g. Bligh Park, Windsor Downs and Penrith Lakes Environs as well as incremental growth arising from multiple infill developments and replacement of older single houses on larger lots with town houses, villas or dual occupancies. Notwithstanding the flood threat, incremental growth has continued in the Hawkesbury-Nepean valley since the HNFMS was adopted in 1998, although no new areas have been released in areas classed as flood islands in that period.

***Figure 23** Rescue becomes essential*

Flood warning is difficult to provide in areas remote from larger centres. People may be unwilling or unable to evacuate in time before being trapped in their homes.

Table 2 illustrates the population change between 1981 and 2001 in selected Hawkesbury suburbs which lie either wholly or partially below the level of the PMF. The areas that become flood islands and require evacuation if the flood is predicted to reach the 1 in 100 AEP level or higher are highlighted in red.

From an evacuation planning perspective, the increase in the number of households and the increase in the number of cars per household which will be used for the evacuation is as important as the increase in absolute population numbers. This is because if there are more households to be individually warned and hence more vehicles to evacuate, there will inevitably be adverse impacts on the timing of the evacuation and the ability of the designated evacuation routes to carry all the extra vehicles in the limited time available.

Although evacuation becomes necessary because of rapidly rising and potentially deep Hawkesbury-Nepean riverine flooding, local catchment flooding often occurs earlier in a flood event.
This localised flooding is exacerbated by generally flat terrain and poor drainage and has the potential to cut the evacuation routes. Over $56 million has been spent or allocated to upgrade regional evacuation routes as part of the Hawkesbury-Nepean Floodplain Management Strategy to serve existing communities, (Figure 24).

Local evacuation routes

People need to be able to get from their home or workplace to the regional routes using existing local roads. These local evacuation roads also need to be identified, assessed and upgraded if necessary to ensure that they remain open to traffic for the duration of the evacuation. This is the responsibility of council and is an essential part of a local floodplain risk management plan.

Table 2 *Population Growth by selected Hawkesbury localities, which are wholly or partially below the Hawkesbury-Nepean PMF 1981-2001*

Locality	1981	1991	2001	Change 1981-2001 (%)
Agnes Banks	139	298	405	191
Bligh Park	0	3766	6058	n/a
Ebenezer	460	840	1041	126
Freeman's Reach	1559	2005	2200	41
Hobartville	3598	3186	2717	-24
Lower Portland	156	269	377	142
McGraths Hill	967	2087	2428	151
Mulgrave	355	410	238	-33
North Richmond	3085	3871	4352	41
Pitt Town	1058	1367	1579	49
Richmond	4084	4031	4604	13
Richmond Lowlands	673	915	653	-3
RAAF	1023	883	426	-58
Sackville	173	321	410	137
South Windsor	3750	5028	6507	74
Vineyard	696	1002	1035	49
Wilberforce	1671	2458	2607	56
Windsor	1986	1869	1864	-6
Windsor Downs	0	0	1285	n/a
Total	25433	34606	40786	60

Due to Collection District boundary changes between 1981 and 2001 this table should be used as an indicator only.
Adapted from: Hawkesbury Social Atlas 2003.

Wholly below the PMF   Partially below the PMF

Local evacuation roads need to be identified, assessed and upgraded if necessary to ensure that they remain open to traffic for the duration of the evacuation.

This is the responsibility of council and is an essential part of a local floodplain risk management plan.

Figure 24 *Windsor Flood Evacuation Route – artist's impression*

The new second road crossing across South Creek costing over $50 million will provide a higher-level evacuation route for Windsor residents and improve day-to-day traffic flow. The provision of evacuation routes as part of the Hawkesbury-Nepean Floodplain Management Strategy has been challenging and expensive because it required upgrading of an existing road network, which is low lying and susceptible to the early stage of mainstream backwater flooding and frequent cutting by local storms.

(Photo Source: RTA)

Subdivision of flood prone land that does not become a flood island may be acceptable, if an increase in households would not present a risk to the evacuation of both existing residents and new occupants. In new subdivisions the local road layout should include continuously rising evacuation routes to facilitate car-based evacuation to land beyond the floodplain.

It is common practice in new subdivisions for any natural undulations in ground level to be levelled as part of the site works. When flooding is a potential problem, this can increase the hazard by removing any natural high points, which could provide temporary refuges. If low-lying dips are created or roads are not designed to rise continuously, residents can be trapped when local floodwaters rise, cutting their only means of road exit from the site. Detailed guidance in this regard is available in *"Designing Safer Subdivisions – Guidance on Subdivision Design in Flood prone areas."*

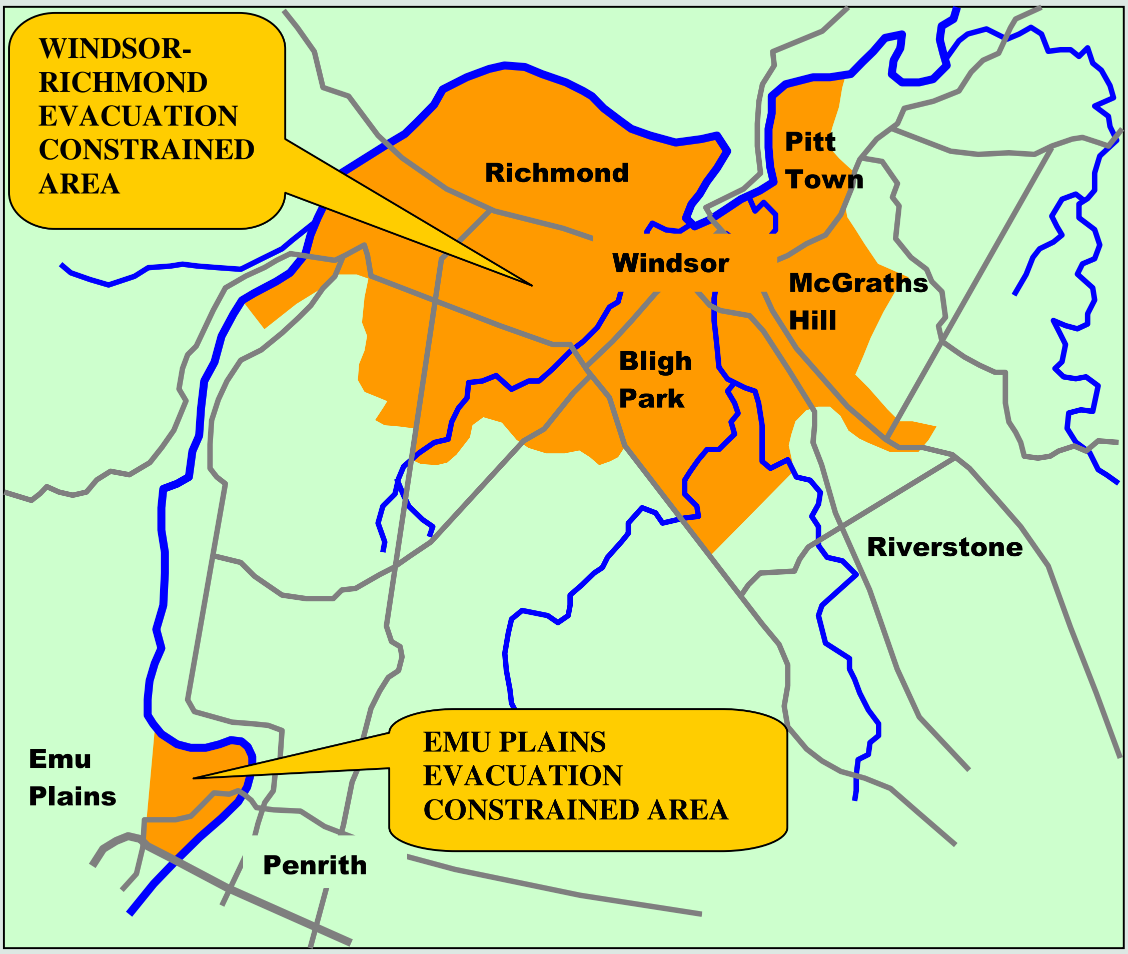
Implications for New Development

When planning new development on flood prone land, evacuation needs should be identified and provision made to ensure that occupants of the development will be able to reach the safety of higher land beyond the extent of the Hawkesbury-Nepean PMF. For some areas of the Hawkesbury-Nepean floodplains, the need for flood evacuation is likely to remain a constraint to new development due to the increase in the number of households requiring evacuation and the potential for isolation and then inundation of the low flood islands, (Figure 25).

For HNFMS emergency planning and route upgrade purposes a figure of 1.8 vehicles per household was derived from census data. This figure continues to be considered a reasonable figure for planning purposes in this area of Western Sydney.

Local catchment flooding has the potential to close evacuation routes ahead of mainstream Hawkesbury-Nepean flooding. To ensure routes remain passable, upgrades to existing roads

Figure 25 *Evacuation Constrained Areas*



Evacuation should be factored into local and regional planning to ensure both the safety of future and existing residents.

have included raising pavement levels, and/or improving drainage to accommodate a 1 in 500 AEP local flood event plus a 0.3 m freeboard for culverts and bridge embankments and 0.5 m clearance for bridge openings.

This is a much higher standard than the 1 in 100 AEP normally adopted for major cross-drainage. It is important that drainage infrastructure receives on-going maintenance to ensure that the structures operate as designed. It should be remembered that design flows can increase over time through increasing urbanisation. An on-going audit program could ensure that evacuation routes remain effective.

Upgrades to existing roads have included:

- raising pavement levels, and/or
- improving drainage to accommodate a 1 in 500 AEP local flood event.

Road infrastructure with sufficient capacity and protection from inundation by local flooding is just one element to be considered in planning for evacuation routes. Other critical elements include:

- The ability to make accurate flood height predictions early in a flood event;
- Flood behaviour, rate of rise, peak of flood, expected duration of the flood etc;

- How early a decision is made to call an evacuation;
- The time required to mobilise the SES and other emergency services in response to this decision;
- The time required to warn all the population;
- The time for the population to respond;
- The level of flood awareness and preparedness in the community; and
- Inclusion of adequate factors of safety in all time lines.

All these factors have inherent uncertainties, which affect the time it will take to carry out an evacuation. Much of the success of an evacuation depends on the operational strength of the emergency services and the robustness of the flood plans under which they conduct emergency operations.

However, it should be recognised that having better road infrastructure cannot eliminate the uncertainties inherent in the flood prediction process, flood warnings and the emergency operation itself. Indeed, having road infrastructure in place can only go so far in helping individuals who choose to ignore timely warnings to evacuate. Nonetheless, road infrastructure can, to a certain extent, provide more time for the evacuation to take place and with a higher level of confidence than would otherwise be the case.

This can only be satisfactorily achieved with provision of sufficient redundancy in the road system to allow for lack of warning, breakdowns or accidents. Conflict between merging streams of evacuation traffic needs to be considered to avoid causing unacceptable delays or queues of traffic, which may result in the tail of the queue being trapped on the floodplain. This could lead to chaos and potential loss of lives.

It is important for residents of the flood islands to have unimpeded access along local roads to the regional evacuation routes. Councils and the SES work together to identify and upgrade local routes. For new subdivisions it is critical that landform modifications and road layout facilitates rather than not hinders evacuation. Readers are referred to *"Designing Safer Subdivisions – Guidance on Subdivision Design in Flood prone areas."* for detailed information about how better subdivision design can result in safe access enabling residents to reach regional evacuation routes.

How Can Evacuation Infrastructure be Provided?

The cost of providing essential infrastructure required for new development is generally borne by the developer.

Identifying the evacuation requirements arising from an increase in households and assessing the practicality and feasibility of providing adequate evacuation routes, is an essential part of any rezoning or large-scale residential development proposal on the floodplain. Care should be taken to ensure that the evacuation of new residents from the floodplain does not adversely impact on any evacuation strategy already in place for existing floodplain communities. If new development would result in traffic conflict on existing evacuation routes resulting in evacuees being trapped in areas below the PMF unable to drive out in the time available, then alternative evacuation routes should be found for the new development.

> The provision of additional homes on the floodplain should be accompanied by measures to ensure the safe evacuation of the residents that will not compromise the evacuation of existing residents.

Funding sources include traditional methods such as direct works by a developer or section 94 Developer Contributions levied by councils through a section 94 Contributions Plan or Development Agreement. In cases where the impact of development flows across Council boundaries, as may happen when evacuation routes are required, joint contribution plans may be prepared to ensure infrastructure can be provided in all affected local government areas.

Development Agreements have been a means to ensure developers contribute to essential public infrastructure when land is being rezoned and have been used for major development sites in Western Sydney.

Legislative changes, *(Environmental Planning and Assessment Act (Development Contributions) Act 2005),* have seen the introduction of voluntary planning agreements under which a planning authority (including councils, the Minister for Planning, development corporations or other specified public authority) may enter into an agreement with a developer to obtain contributions for a public purpose. A public purpose includes the provision of infrastructure.

SECTION III

REDUCING THE RISK TO BUILDINGS AND PROPERTY

6 THE IMPACTS OF FLOODING ON HOUSEHOLDS

The focus of the guidelines is on residential development. The rationale for emphasising risk reduction for residential development stems from the untenable social and financial consequences for householders, which will arise from severe flood events, which although rare, will occur. The Subdivision and Building Guidelines provide additional and detailed practical information to assist planners, builders and developers when planning, designing and building specific development projects.

Non-residential land uses and development types such as commercial, industrial, recreational and community infrastructure involve distinct spatial and development criteria, which are not the same criteria as residential development but are nonetheless critical if overall flood losses are to be reduced. These are discussed in Chapter 11.

All property on flood prone land is at risk of structural and/or content damages or loss arising from:

- Contact with water which may also be polluted;
- Inundation, and particularly prolonged inundation, from varying water levels, which may also be polluted or contain debris;
- Fast flowing floodwater to varying depths, which may contain debris.

Occupiers of flood prone property are subject to personal risk and need to be able to either self evacuate or evacuate with help. Ideally, occupiers would also be able to move items of value either upstairs or to another place before the flood arrives. More information regarding evacuation can be found in Chapter 5.

As discussed in Chapter 4, flood risk comprises a combination of:

- frequency of flooding which includes probability and exposure;
- hazard; and
- vulnerability or the consequences of flooding.

All three elements need to be addressed when planning for flood prone areas. There are different means to modify one or more of these three elements to reduce the overall risk for different types of land uses.

Frequency of Flooding

Flood modification measures are not practical to mitigate Hawkesbury-Nepean flooding except on a very local scale for low level flooding. As such, nothing can realistically be done to reduce the probability of flooding in the Hawkesbury-Nepean valley. Building design modifications including elevated floor levels, a higher flood planning level (FPL) for habitable floors, or a higher location can reduce the chance of the building being inundated. However, it should be noted that a deeper freeboard (thus achieving a higher FPL) does not reduce the probability of the flood, it merely protects the property from over floor flooding in the design flood by allowing for uncertainties in flood modelling etc. More information on freeboard can be found in Chapter 8 and in Appendix B.

Flood Hazard

Flood hazard includes how deep the water can get, bearing in mind that this increases in rarer floods. If deep water (over 1.5 m) results from a flood with a probability only slightly rarer than the design flood then the hazard is much greater than if that same water depth is achieved only in the extremely rare probable maximum flood (PMF). In lower lying parts of the floodplain, a site will be flooded more often. In rarer floods, the hazard is greater because the water depths are so great and exposure to floodwaters can be lengthy.

In some parts of the floodplain the hazard includes high velocity in floods with a probability only slightly rarer than the design flood. High velocity results in damage to buildings and vehicles and creates dangerous conditions for people who remain in the flooded area.

Isolation creates hazardous situations as floodwaters rise around islands of higher ground, trapping occupants. Isolation is primarily seen as a hazard to people, especially where isolation can precede total inundation in rare floods, as is the case in major urban areas in the Hawkesbury-Nepean valley. However, some property damage on flood islands is also inevitable if water levels continue to rise.

Reduction of the hazard may be achieved through constructed barriers or flood-responsive development forms – such as commercial buildings with high concrete walls, which would act as a barrier to reduce the velocity and protect other buildings.

Vulnerability and the Consequences of Flooding

The consequences of flooding must be included in the consideration of flood risk. Some land uses and some occupiers are more vulnerable than others. The level of vulnerability of the likely occupiers should be addressed when determining the distribution of land uses. By structurally enhancing buildings and choosing dwellings designed with flooding in mind, the consequences of flooding (i.e. the damages to buildings caused by depth and velocity) can be reduced. Detailed information on flood aware design can be found in *"Reducing vulnerability of buildings to flood damage – Guidance on building in flood prone areas"*.

Social Implications

The most vulnerable elements of a flood-affected community are its residents. It is the impacts of flood hazard on households, with particular reference to the Hawkesbury-Nepean, which is discussed in this chapter.

Intangible and Tangible Damages

The social implications of flooding on peoples' lives are not limited to the critically important issues of personal safety in a flood event that are discussed in Chapter 5. The consequences of severe flooding are many and varied and some cannot be readily quantified. These are referred to as intangible damages, whilst damages which can be quantified, are referred to as tangible damages.

Health impacts

There are few data on the long-term health impacts of flooding. Studies in both the United Kingdom and Australia have revealed that heightened psychological stress played a part in causing an increase in visits to medical practitioners and hospital admissions, and in the United Kingdom, even an increase in deaths. The studies noted that death and destruction are not necessary to cause major community disaster with consequent adverse health effects. The studies compared visits by flood victims in the year following a flood to visits by people who had not been flood affected. Health risks arising from exposure to moulds, toxins and contaminants in homes during the clean up period are a cause of concern to householders. Emotional trauma, depression and feelings of isolation continue long after the water has receded. Having to organise repairs, clean up and claim any relief payments can be stressful, although this can be alleviated by good social support during the recovery period. One study found that 15-20% of people affected by a natural disaster has symptoms of post-traumatic stress disorder, (reported in Ohl and Tapsell, 2000). Providing care to victims can be hampered by the health care facilities and providers themselves being adversely impacted in the same flood event. In NSW the Department of Health has a disaster plan in place for health emergencies such as Hawkesbury-Nepean flooding.

Financial impacts

Tangible and intangible losses arising from flood damage to property have impacts on affected households' financial health and hence their overall wellbeing. A family home is usually the most expensive purchase in a person's life. For the majority of families it is both their principal asset and is often associated with their largest debt. Whilst many other incidents, such as fire, earthquake and storms are covered in general home insurance policies available in Australia, flood is specifically excluded or included only with extreme limitations. (More information on this can be found in Chapter 7). This problem is compounded by the unfortunate fact that many households are unaware that they are not covered for riverine flooding in their household policies, even though insurers are required to specify exclusions to the cover they offer. This leaves householders particularly vulnerable to losses due to flooding.

> In the Hawkesbury-Nepean floodplain, deep floodwater can occur in relatively frequent floods. A 1 in 300 AEP flood event would reach the height of the ceiling of a single storey house built at the 1 in 100 AEP FPL in established urban areas in the floodplain. Water to the ceiling would result in loss of personal possessions and damage to contents, fittings as well as the structure of the house. The result would be severe trauma to affected households.
>
> Two-storey housing can reduce contents damage and losses by providing higher-level temporary storage during flood events.

Intangible damages are difficult to quantify but are recognised to be greater than tangible damages such as property damage. Some of the consequences of severe flooding on households are listed here:

- The home may be unfit to live in for a lengthy period, or in a worse case scenario may even need demolition, requiring residents to find and pay for long-term temporary accommodation, probably located well away from the flood-affected suburb.
- Temporary relocation may disrupt education, require different commuting patterns, potentially require another vehicle and disrupt local social networks.
- Mortgage commitments on the damaged property would continue.
- Repair costs typically escalate after widespread damage-causing events due to supply and demand factors. Delays in sourcing building materials, equipment and labour are common.
- Locally based jobs may be lost or workers laid off, as businesses would be adversely affected by the same flood event that affected residential areas, resulting in a reduction in household income.
- Borrowing capacity may be impaired by loss or damage to a principal asset i.e. the dwelling house.
- Financial hardship is recognised cause of stress and family breakdown.
- Loss of equity value in the family home due to reduction in property value immediately following the flood, (albeit this is likely to be only a temporary reduction). This has implications for borrowing capacity and may limit the choices for relocation.
- Limited warning times for evacuation means that fewer personal possessions can be removed out of harm's way. The loss of personal belongings, including mementos and items of no monetary value, is traumatic and can have long-term repercussions on individuals' well being and health.

The financial stresses which households would experience post-flood, would only be marginally relieved by State and Federal disaster relief payments, which are limited and aimed at providing for basic essentials only.

Annual Average Damages

The social consequences of flooding which potentially affect all floodplain occupants are usually ignored or at best glossed over in many floodplain risk management studies. Instead, the emphasis is placed on the economics of a proposal using a cost benefit approach, which balances the economic advantages of the development (e.g. providing more houses, employment opportunities, higher and best use of land, etc) against the anticipated damages using the Annual Average Damages (AAD) method. AAD is the average damage per year that would occur in a particular development situation from flooding over a very long period of time, (Figure 26). AAD can only include tangible damages, i.e. those that can be quantified. It is a useful means of assessing the costs of flood mitigation works e.g. the construction of a levee. The cost of the levee can be compared with the difference between the AAD pre-levee and the AAD post-levee to see if the works are a worthwhile means of reducing damages.

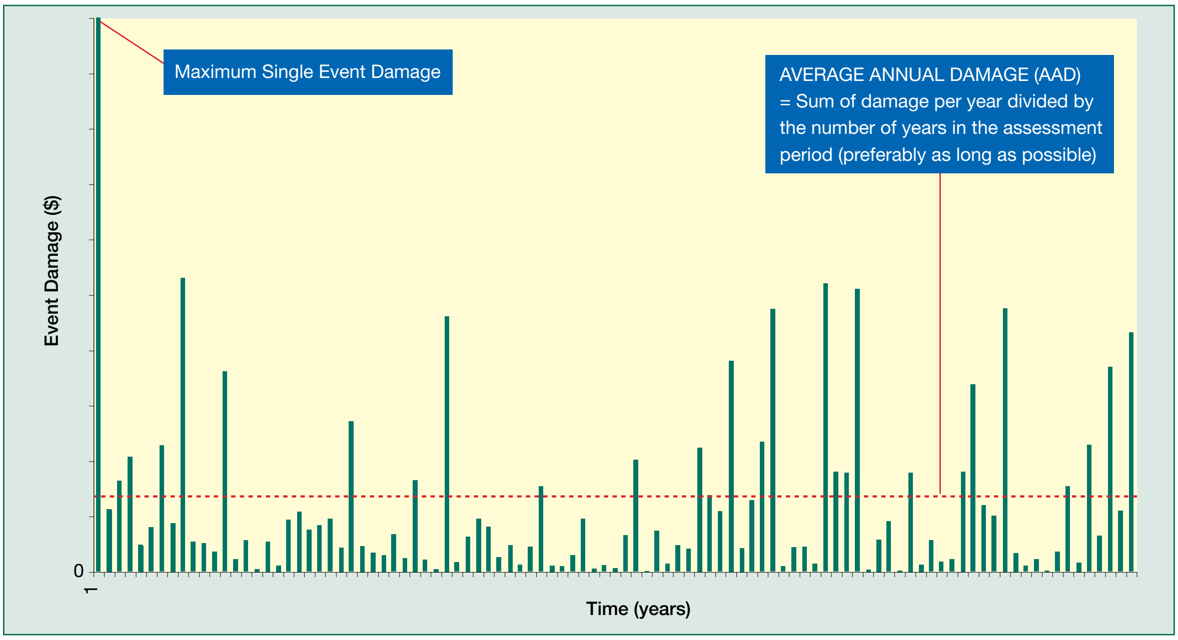
However, AAD is an unsuitable tool for assessing whether a new development should go ahead on flood prone land where the floods have an AEP that is less than 1 in 100. AAD is also unsuitable as a means to determine what, if any development and building controls that would reduce flood risk should be applied. This is because the results of calculating AAD are skewed by the fact that rare floods are just that – rare. By averaging the result over a very long time period, and by multiplying by a probability of less than one, the resulting dollar value per household per year is inevitably low.

For the Hawkesbury-Nepean valley, a structural house damage AAD figure of around $300 p.a. has been calculated. However, $300 cannot be used to assess the impacts on flood-affected households. Flood losses are not spread out evenly or incurred every year. A householder is not met with a bill of $300 every year. If that were the case, it would be an unwelcome, but still manageable impost for most house-owners. Instead a householder receives a repair and clean-up bill potentially one to two hundred times that amount, should it be unfortunate enough to experience a severe flood. There is no practical way an individual household can effectively self-insure for an event which has no certainty about when it will occur – it could occur in the first year of occupancy, it could occur twice in any one year, or it may never occur in that particular householder's life. Householders are therefore faced with the dilemma of how to cope financially with a flood when it occurs unexpectedly. Funds will be needed to assist recovery not only in the short term but also in the long term especially if additional loans have to be taken out to repair flood damaged property and replace household and personal effects.

> An individual household cannot effectively self-insure for an event that has no certainty about when it will occur.

It is worth remembering that developers together with those making the decision to permit housing on land subject to flood risk are themselves not necessarily the ones who will bear the consequences of a flood when it occurs. That burden may have to be borne solely by householders, landowners and businesses that own or occupy the development at the time of the flood. Given the absence of flood insurance, this burden can neither be distributed over time or transferred to a wider group, namely insurance companies. However, even though governments at all levels in Australia have traditionally responded with financial assistance to flood-affected communities, a reliance on scarce public funds to provide disaster relief and

Figure 26 *Randomly occurring Flood Damage as Annual Average Damage (AAD)*



public goodwill, is hardly a responsible approach and should not provide a rationale for promoting growth in high hazard floodplains.

The Use of Multi-Attribute Decision Analysis

Cost benefit analysis traditionally has a broadly based goal of achieving maximum economic efficiency, which will benefit society as a whole. It is often used to assist in making expenditure decisions and has been used to evaluate whether flood mitigation works, land filling etc are economically worthwhile given the amount of flood risk reduction which the works can achieve. This approach ignores equity issues and the lack of nexus between gainers and losers, given that the gainers (i.e. those able to develop flood prone land) are rarely the ones to compensate the losers (i.e. those suffering subsequent flood losses). There is also a separation in time between gains and losses given the infrequency of major flooding.

A tool that could be considered when looking at how to justify decisions that would limit residential property damages, is multi-attribute decision analysis.

This introduces social considerations into the economic cost benefit approach and is more complex than a straightforward cost benefit analysis as it includes other interested parties e.g. householders, society etc. It is recognised that it is quite difficult to quantify social factors. It does however, enable decisions to be made which have regard to equity. Policies, which do not address the impacts on individual groups, in effect usurp the policy maker's authority to make such judgements.

Table G1 in the Floodplain Development Manual (2005) provides an example of a floodplain risk management option assessment matrix which can be used to assist in this process.

The questions that should be considered when making decisions for land use planning on flood prone land are:

- Who will bear the cost of (be disadvantaged by) any increase in the cost of structural enhancement to a new house to take into consideration the flood risk? *(First home buyers).*
- Who will benefit from any increase in the cost of building new housing to that higher flood-tolerant standard? *(Builders' profits increased if margins remain the same; banks may benefit from larger mortgages; councils would receive higher DA fees).*
- In the absence of general household flood insurance who will bear the cost of damages after a flood i.e. who will be disadvantaged? *(Home owner at the time of the flood).*
- Who benefits from flood damages? *(Suppliers of building materials and the building industry due to higher demand in recovery period).*
- Who benefits from having structurally enhanced housing built to flood-aware designs which would result in less damage, fewer repair costs, shorter recovery period? *(First and subsequent owners and occupiers of new housing).*

Householders will always be the most vulnerable to flood losses, especially if they are not able to obtain insurance. Social welfare or natural disaster payments are a cost to the government of the day and only partially make up for any losses. Addressing potential flood losses at the planning and building stage of residential development – and recognising that this may incur additional costs, is one method of equitably reducing costs when a flood occurs. Whilst construction costs are generally passed on to the first purchaser, it should be recognised that they are only one component of the total purchase price of a new dwelling which also includes land costs, fees and charges. The fact that the entity (company or individual) which incurs the expense in the first place may not be same as the entity (householder) which reaps the benefit is an inevitable outcome of social justice policies.

Comparisons can reasonably be made with policies applying to areas subject to other natural hazards e.g. bushfire and cyclone. There, authorities have imposed more rigorous standards on new residential buildings. The measures have tended to become mandatory only after major events triggered a demand for property protection to reduce losses.

What are Homeowners' Attitudes to Natural Hazard?

A study was designed to deliver a reliable understanding of the current and likely future communities' views on building in areas of natural hazard. The results of this study, "Analysis of Community Attitudes to Flood Related Risks", carried out for the HNFMS by Gutteridge Haskins and Davey and Cox Consulting in 2001, provided key information about:

- Attitudes of current and future communities of the Hawkesbury-Nepean Valley regarding natural hazards;
- What kind and level of personal losses are 'acceptable or unacceptable' to them; and
- How much and under what conditions they are willing to pay for measures aimed at reducing the risk and impact of such losses.

The study area focused on areas lying below the level of the Hawkesbury-Nepean PMF level in Penrith, Hawkesbury, Blacktown, Baulkham Hills, Hornsby and Gosford local government areas.

Using questionnaire and interview techniques, information was collected from 1,640 households randomly selected to represent five different population groups including:

- First home buyers living in the area;
- Second home buyers living in the area;
- The population most likely to migrate into the area, referred to as the migrant sample group;
- A population outside the area with a high level of awareness of natural hazards; and
- A reference group drawn from a population with no recent experience of natural disasters.

The specific issues explored with each person surveyed were:

- Their current level of insurance and protection against burglary, fire and other hazards;
- Their opinions on risk reduction strategies (planning and building controls);
- Their willingness to pay for improved protection against the impact of natural hazards;
- Their ability to pay for natural hazard damage; and
- Their attitude to flood insurance.

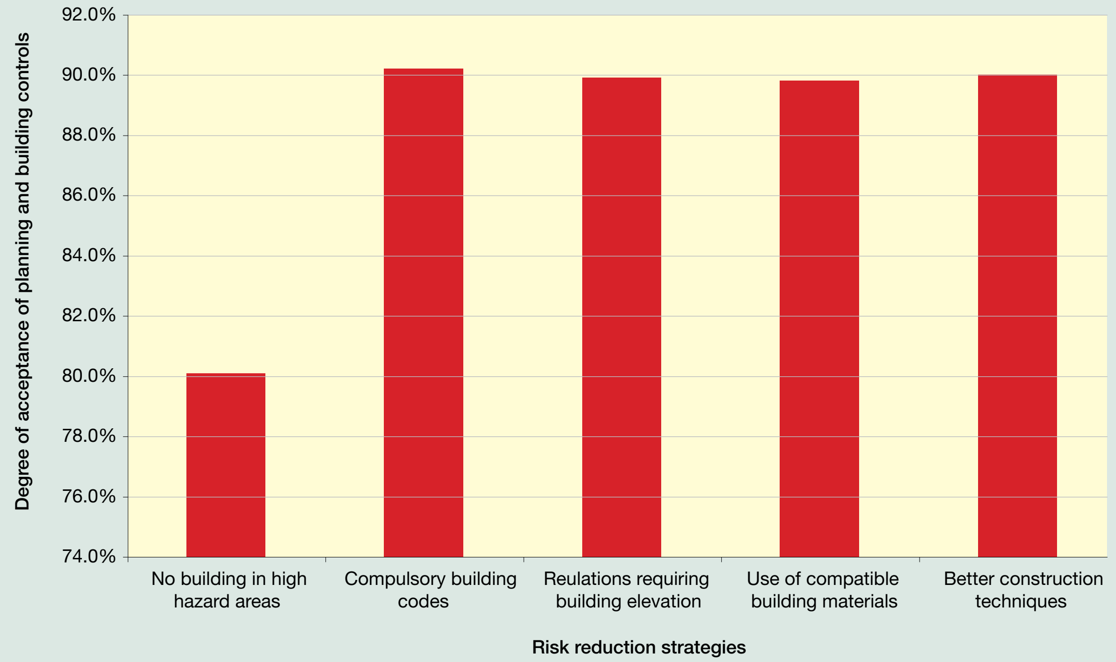
By comparing and contrasting the responses with a Focus Group, a detailed picture of the attitudes to flood-related risks of the current and possible future population of the floodplain was constructed.

Overview of Findings

'Risk reduction strategies' was a term used to describe a range of controls that could limit development in the floodplain and set design and construction standards for buildings to reduce the likelihood of major flood damage. Five specific risk reduction strategies were discussed with study participants. Around 90% of respondents supported four out of the five of the strategies discussed even though they also recognised that their introduction would mean increased housing costs, (Figure 27). Many respondents noted a belief that responsible authorities, such as councils, would make sure that appropriate controls were in place in areas known to be prone to natural hazards.

The results suggest that those who live in the study area may have an expectation that State and local government would already be aware of the hazard and are responding to it with appropriate development controls and building codes. There is an assumption and reliance that those in authority will exercise their duty of care to protect people and property when reaching decisions on development and buildings in areas of known natural hazards.

Figure 27 *Community support for planning and building controls to limit damages to homes and personal assets*



This graph illustrates the high degree of acceptance, which emerged from the Community Attitude Survey, for a range of planning and building controls to limit damages.

Apart from losses to home contents, the potential for significant structural damage to dwellings is difficult for most householders to fully understand.

Willingness to pay for improved hazard protection

Most respondents were willing to pay more for a new house, if this would protect the building against major structural damage in the event of a natural disaster. All except the first homebuyer group were willing to pay up to an additional 10% on their housing costs, (Table 3).

Q. How much are people willing to pay for a home built to withstand major structural damage from a natural disaster?

A. With the exception of first time home buyers, the median additional amount on the house price that a household is willing to pay is $20,000 i.e. 10% more on a $200,000 house.

(2001 figures)

In considering this finding it is important to note that almost 35% of those who have had experience of a natural hazard say they would not purchase a home in a hazard-prone area. There were much lower numbers of respondents from the study area and from the likely migration group who said they would not purchase a home in a hazard-prone area. Some of the possible interpretations are:

- Once people have experienced a natural disaster they are more wary of putting themselves in the same position again;
- First and second homebuyers in the study area and people likely to migrate into the area did not, at the time of the survey, have a realistic understanding of the potential effects of a natural disaster; and
- First homebuyers in the study area are initially focused on setting up their homes. They are not willing (or perhaps are unable) to consider any additional spending priorities and were generally willing to pay only an additional 5%.

Table 3 *Additional amount willing to pay on $200,000 house price to protect building against major structural damage*

	First home buyers living in area	Second home buyers living in area	Migrant sample group	Hazard aware sample group	Reference sample group
$1,000 to $5,000	30.1%	11.2%	9.5%	5.2%	12.5%
$5,100 to $10,000	19.4%	19.4%	16.6%	14.0%	16.0%
$10,100 to $20,000	20.1%	36.7%	36.4%	34.3%	31.9%
$20,100 to $40,000	9.7%	15.3%	10.6%	12.8%	15.2%
$40,100 to $100,000	20.8%	17.3%	26.9%	33.7%	24.3%
Median 'Willingness-to-pay' amount	$12,000	$20,000	$20,000	$20,000	$20,000

These findings suggest that in the event of a flood people may be shocked by the impacts and feel aggrieved that they had not been informed about what to expect, in terms of an individual's risk potential.

Ability to pay for hazard damage

Respondents generally said that they had a fairly limited financial capacity to cope with the impact of a natural hazard, (Figure 28).

> If a flood event occurred in the Hawkesbury-Nepean valley under present conditions, the majority of those affected would be unable to pay for even limited damage to their homes from their own resources.
>
> Householders would require substantial financial assistance to recover from a flood.

Attitude to flood insurance

Most second homebuyer households and most of those likely to move into the area, reported that they were willing to pay quite high increases in house and content insurance to be covered for flood-related risks. First homebuyers generally reported being less willing to pay increased costs for these insurances.

> Around three-quarters of those living in the study area are willing to purchase flood insurance, if it were available.

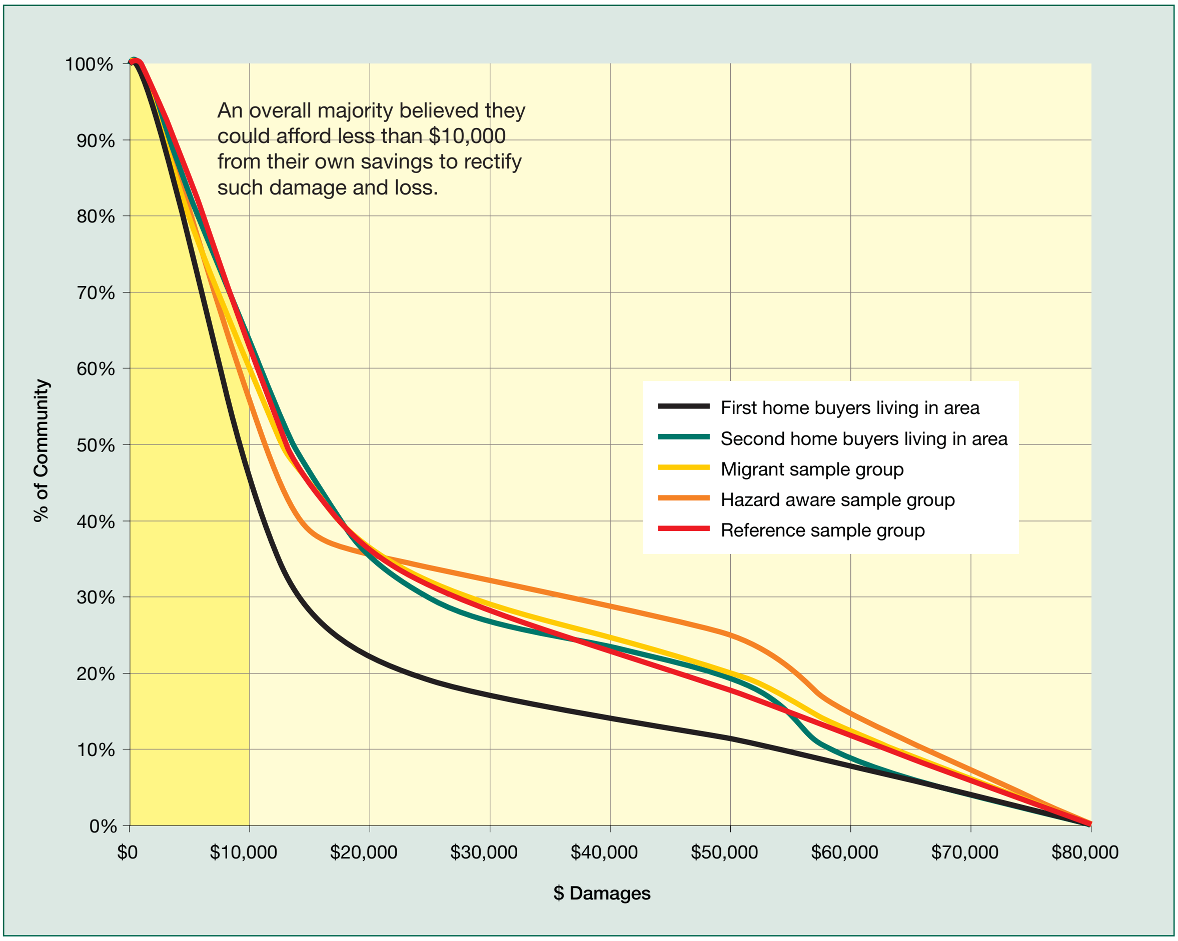
Building Insurance Premiums

Over 50% of all sample groups were willing to pay up to $200 for building flood insurance premiums. For the Hazard Aware sample group, this rose to almost 70%, (Table 4). This level of flood insurance premiums is high when compared with average house insurance premiums, though for most income groups of homeowners, it would be a relatively affordable amount.

Home Contents Insurance Premiums

For home contents flood insurance premiums, a similar picture emerged. Over 50% of all sample groups were willing to pay up to $200, (Table 5). Again this was almost 70% for the Hazard Aware sample group.

Figure 28 *Ability to finance loss from own resources*



The findings shown in Tables 4 and 5 demonstrate a very clear conclusion that most homeowners are willing to pay relatively significant proportional increases in their existing house and contents insurance premiums for increased peace of mind. An annual premium of up to $200 each for house and for contents would therefore appear to be relatively affordable to most income groups.

Conclusions

Overall, the survey found that attitudes to risk vary amongst households depending on a range of factors including previous experience of hazard events, social characteristics and lifecycle priorities. Those likely to move into the study area and the second homebuyer group now living in the area are "risk-averse". That is, they are willing to pay reasonably high amounts for the kind of risk mitigation and protection measures that could be implemented through structural building and development controls. First homebuyers are willing to pay somewhat less.

The study found that:

- Homebuyers living in the study area indicated that they have a limited capacity to finance flood losses from their own resources;
- The community expects responsible authorities to know about likely natural hazards and to ensure adequate community protection from potential damages arising from these natural hazards; and
- Householders are generally willing to pay for protection measures so long as they are well informed of both the risks they face and the likely effectiveness of the measures being proposed.

6

Table 4 *Flood Insurance – Percentage willing to pay for building flood insurance premiums*

	First home buyers living in area	Second home buyers living in area	Migrant sample group	Hazard aware sample group	Reference sample group
$1 – $99	16.7%	18.6%	21.6%	34.5%	26.2%
$100 – $199	33.1%	30.7%	34.3%	33.1%	32.9%
$200 – $299	18.2%	23.4%	20.5%	12.9%	13.9%
$300 – $399	7.4%	7.3%	5.5%	3.6%	6.7%
$400 – $499	4.2%	2.7%	1.5%	1.4%	3.3%
$500 or above	20.3%	17.3%	16.7%	14.3%	16.9%
	100.0%	100.0%	100.0%	100.0%	100.0%
Less than $200	49.8%	49.3%	55.9%	67.7%	59.1%
Less than $300	68.0%	72.7%	76.4%	80.5%	73.0%

These findings would support a view that under the building codes and development plans and policies now applying in the valley, people who can least afford the consequences are carrying financial risks about which they are not adequately informed.

Further, there are grounds to expect that if councils and other authorities introduce controls in order to discharge their duty of care, the community will be prepared to accept them and any reasonable, associated financial consequences.

The Community Attitude survey concluded

The potential benefits of introducing appropriate controls with an accompanying community education and consultation program would:

- far outweigh any costs of taking this action; and
- enable councils and authorities to discharge their duty of care.

What Are The Financial Implications of Flood Losses for Householders?

Households have the potential to suffer unsustainable levels of loss of property and livelihood when affected by major or severe Hawkesbury-Nepean flooding. The short-term consequences of flooding are generally well catered for in the emergency services' recovery plans and through immediate and urgent assistance to individuals and families from natural disaster relief measures. However, the long-term consequences of flooding on the lives, well being and financial circumstances of individual households are often overlooked, or at best only given token consideration. In the absence of domestic flood insurance and minimal payouts under State and National Disaster Relief, financial losses will have to be borne by individuals. These losses have the potential to cause severe financial distress and hardship, often manifesting itself in social and domestic problems. These guidelines promote the means to reduce the increase in these losses through better land use planning on floodplains and through recommending that new houses be built to better tolerate flooding. It would

Table 5 Flood Insurance – Percentage willing to pay for home contents flood insurance premiums

	First home buyers living in area	Second home buyers living in area	Migrant sample group	Hazard aware sample group	Reference sample group
$1 – $99	22.3%	24.0%	27.2%	40.5%	28.1%
$100 – $199	31.1%	30.6%	34.0%	28.6%	33.2%
$200 – $299	17.6%	22.7%	17.8%	11.3%	16.2%
$300 – $399	8.4%	7.1%	3.4%	6.7%	6.3%
$400 – $499	4.1%	3.1%	0.7%	1.5%	2.1%
$500 or above	16.5%	12.5%	16.9%	11.3%	14.1%
	100.0%	100.0%	100.0%	100.0%	100.0%
Less than $200	53.4%	54.6%	61.2%	69.1%	61.3%
Less than $300	71.0%	77.3%	79.0%	80.4%	77.5%

be in the interests of the community to adopt such measures.

A study entitled "Household Financial Flood Risk Investigation" was carried out for the Hawkesbury-Nepean Floodplain Management Strategy by Sue Clarke and Leonie Tickle of Macquarie University (May 2001). The study focussed on the financial effects of flooding on representative owner-occupier households. Housing ownership figures indicate that 68% of all occupied private dwellings in Western Sydney are either owned or being purchased (Figure 29).

The investigation aimed to go beyond the concept of Annual Average Damages (AAD) which is the usual measure used to quantify flood damage where average costs spread over the long-term are derived, usually for economic comparison analysis. However, they are not related in any way to a householder's ability to pay or to the time taken to recover from such a financial loss. In reality, the financial effects on owners and occupiers from single or multiple flood events include:

- Direct financial loss, e.g. damage to buildings and possessions;
- Consequential financial loss, e.g. loss of future earnings; and
- Impact for future borrowings.

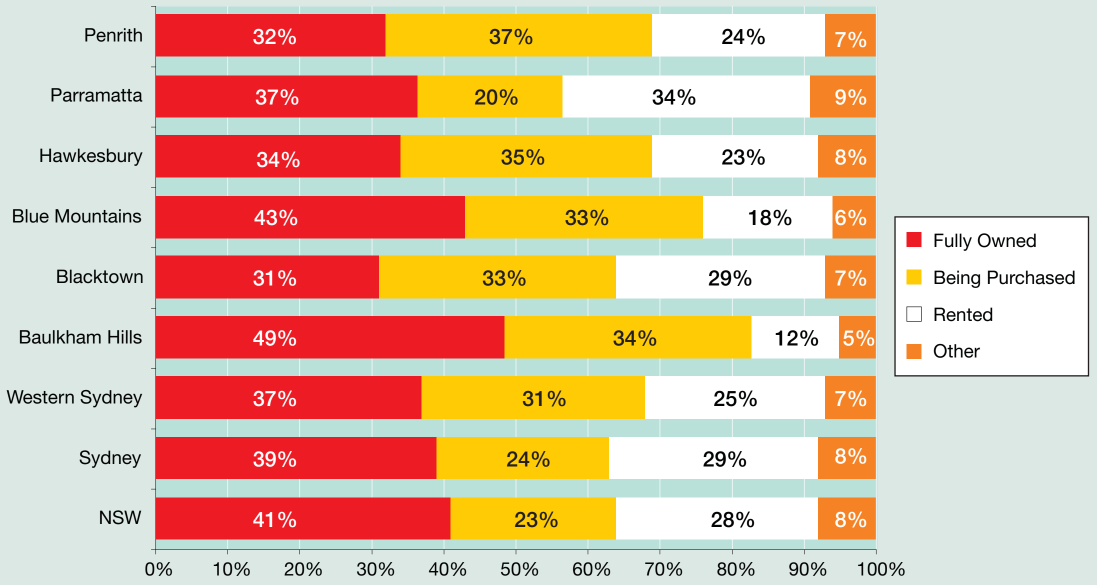
The size and impact of these financial effects depends on the following physical and financial variables:

- Flood severity;
- Non-housing physical assets at risk (e.g. home contents);
- Current income and projected future income;
- Income sources (e.g. dependence on local employment);
- Total financial and other assets;
- Indebtedness;
- Capacity to recoup losses sustained (e.g. dependent on age and employment prospects).

Recovering from Losses

The report provided objective measures of varied owner-occupier householders' ability to recover from the financial impact of a Hawkesbury-Nepean

Figure 29 *Occupied dwellings by tenure type*



Housing ownership figures indicate that 68% of all occupied private dwellings in Western Sydney are either owned or being purchased. (Source: Hawkesbury Social Atlas, Hawkesbury City Council 2003)

flood which occurred five years after buying the house, taking into account the physical and financial variables listed above. A meaningful estimate of the financial risk associated with flooding was developed, based on the concept of 'maximum endurable flood' before a particular household experiences severe financial hardship. Severe financial hardship was defined as occurring when income net of tax and mortgage payments falls to 120% of poverty line levels.

Household scenarios were developed to accurately represent the demographic composition of the residents in the Hawkesbury-Nepean floodplain and to provide a reasonable diversity of scenarios. The scenarios are based on demographic data with allowances for other reasonable considerations, such as the fact that those at the lowest end of the income range for a specific suburb are more likely to be renting rather than purchasing their own home. The selected households therefore do not represent the entire population of the region, but rather the home-purchasing population.

Demographic information reveals that whilst most households in most Hawkesbury-Nepean suburbs are families with children, the percentage of lone parent households is generally around 11% with figures as high as 20%-25% in some suburbs.

A major contributor to financial vulnerability to flood damage is a reduction in household income. A flood causing significant damage to local business resulting in loss of continuity of employment opportunities is shown to have a more devastating effect on household financial wellbeing than a flood where damage is restricted to residential properties. This highlights the need for rigorous assessment of flood prone land at both the strategic and local planning stages for residential, commercial or industrial development proposals.

The ability of a household to withstand the financial consequences of flood damage also depends on income levels relative to the size of the mortgage. The study demonstrated that the highest income couple was able to withstand a flood without descending into severe financial hardship and retain comfortable post-retirement income.

Conversely, the lowest income couple is forced into severe financial hardship following a flood causing losses of only 5% of land value, 50% of house value and 25% of contents' value.

The study found that any household taking out a significant mortgage close to retirement is particularly vulnerable to flood losses due to the shortened period before retirement to recover from the financial impact. This was clearly illustrated by the example in the study of a single 50-year old who could endure only maximum flood losses of less than $60,000, assuming no loss of employment. She would be left in dire financial circumstances after retirement, if she failed to save in the intervening years.

There is no way of knowing when a major flood will occur, it could occur immediately after purchasing a house, or there may be multiple floods over several years, limiting any family's ability to recoup losses, or it might never eventuate during that family's occupancy of the floodplain.

A flood-aware community, which had an understanding of the risk of living in a floodplain, would be better able to cope with such uncertainty and risk.

The working single parent household with two children to support is also not in a very secure financial position and is extremely vulnerable to any financial downturn, especially in the short term after purchasing a home. She would experience a high level of vulnerability stemming from the already low level of disposable income after mortgage repayments and other essential household expenses. A flood resulting in no loss of land value, 30% of house value and 15% of the contents (a total loss of $54,000 in 2001 dollars) would leave the household in severe financial hardship for the two years immediately following the flood. This household would be unable to sustain any further substantial flood losses arising from another flood in close succession or cope if the losses occurred very close to retirement age.

Conclusion

To conclude, those younger households with more resources to draw upon such as savings and two secure salaries could withstand financial losses better than the more vulnerable members of society such as those on lower incomes, single income/average income households or those near or at retirement age. It is for this vulnerable sector of the community that affordable housing is targeted. This brings into question the appropriateness of locating affordable housing on land that is subject to potentially damaging floods, given that the occupants may be financially very vulnerable and thus least able to sustain any losses.

Affordable housing is targeted at lower income households who would be least able to sustain flood losses.

Those who are already economically and socially disadvantaged are particularly vulnerable to the hardship caused by flood damage to their homes and possessions. There are means of reducing their financial exposure to flood losses such as by more appropriate siting of affordable housing on less hazardous sites and by adopting building controls to make new dwellings, including affordable housing dwelling types, more flood resistant. Together, these two precautionary measures would reduce the likelihood of households who can least afford it being exposed to unsustainable financial losses from flood events.

7 FLOOD INSURANCE

The Role of Flood Insurance

Insurance is a means of spreading risk through the community – "a means by which the losses of a few are distributed over the many" (Dinsdale and McMurdie 1973). In Australia, insurance policies for residential property damage generally include natural hazards such as cyclones, fire, hail, storms and earthquake but specifically exclude cover for floods.

The general absence of residential flood insurance (with only a few exceptions) in Australia reflects a historic perspective that considers mainstream floods as being more risky than earthquakes and cyclones – both of which are standard inclusions in home and contents insurance. Modern property insurance companies have developed from mutual fire insurance groups where a relatively large number of small risks were covered by premiums paid by a large pool of those insured. They developed a risk averse culture, which is reflected in the current conservative approach to hazards that could give rise to catastrophic losses.

As with households, flood insurance for small businesses and agriculture has not been available in NSW. In contrast, most medium to large industries and commercial enterprises have flood insurance, including cover for loss of profits. Comprehensive motor vehicle policies usually include flood damage. (Leigh, Taplin and Walker 1997).

Whilst most house and contents insurance policies exclude cover for flood damage, they provide cover for stormwater or rainwater damage which is defined differently from flood damage.

Insurers distinguish between damage caused by water flowing from a surcharging water drain (insured) and damage produced by the overflow from a natural watercourse (not insured).

Some insurers now offer very limited cover against flash flooding for example when damage occurs within 24 hours of the rain that caused the flood. However, most people who take out building and contents policies are not covered for

Figure 30a *Domestic insurance policies do not cover floods*

Detail of Fairfield City Council's flood icon, Prospect Park, Fairfield (More information can be found in Chapter 13).

the type of mainstream flooding that can occur in the Hawkesbury-Nepean valley, (Figure 30).

Regrettably, many people are unaware of the distinctions made between flood and storm damage in their insurance policies and neither do they necessarily have access to localised information about the risk of floods. A significant proportion of house owners incorrectly believe they have full cover for flood losses. (Smith and Handmer 2002). The Australian Securities and Investment Commission (ASIC) notes that these problems may also be common to small businesses as well as individual households. The potentially devastating effect of floods mean that the consequences of being ill informed are typically more serious than they might be in other insurance matters (ASIC 2000).

Whilst there is no indication at the time of writing that flood insurance will become generally available, there is debate about how it can be offered to address flood risk. A system where the burden is spread across all those with policies rather than being borne solely by those at risk of flooding is likely to be the most equitable and affordable. Before cover can be considered, there needs to be adequate and consistent flood hazard information upon which to assess the risk together with a commitment to manage floodplains in a sustainable manner in order to reduce the risk and minimise any increase in damages.

This was confirmed in the report entitled 'Insurance Industry Perspective on Flood Losses" (Blong 2000) undertaken for the Hawkesbury-Nepean Strategy by the Natural Hazard Research Centre at Macquarie University. Blong assessed the insurance industry's view on covering flood losses using a questionnaire, and found that the industry generally is seen to favour voluntary flood insurance rated on an individual property basis. It also found scope for a community-rating scheme based on local government areas.

His report concluded that policy changes were imminent with major direct insurers offering some sort of flood cover, although it was doubted that companies had sufficient information about anticipated flood damage to set realistic premiums, 'redline' a flood level or establish policy conditions. Since 2000 however, the insurance industry has been diverted by other matters which have had a higher profile than the flood issue, including corporate collapse and legislative and tax changes.

No one chooses to be flooded. In the absence of availability of flood insurance, householders are left to bear the brunt of the consequences caused by flooding. Even if insurance were available, it would not be a panacea. In the United Kingdom, there are many low-lying properties in both urban and rural areas which are liable to frequent flooding. Flood insurance has been included in general household insurance for over 40 years but it has not resulted in less flood damage, less trauma or until recently, necessarily better planning controls for flood prone land. The total flood and storm damage bill to insurers following the United Kingdom floods in autumn 2000 was approximately the equivalent of AU$3.25 billion which included AU$2.15 billion in domestic property losses (A.B.I. 2001). Indeed, following repeated floods, insurers are now ceasing to insure affected properties until the government ensures that better flood mitigation strategies are in place to prevent the risk escalating as new development on flood prone land continues.

Blong found that in Australia there also needs to be a partnership between the insurance industry and the government, based on goodwill, before the insurance industry views flood damage mitigation strategies favourably and recognises the commitment of all levels of government to flood risk reduction. However, the insurance industry is made up of companies who have differing objectives, each operating in a commercial-in-confidence environment which does not result in a sharing of information or a common approach.

Flood insurance would however, go some way to providing some security to communities living in the Hawkesbury-Nepean floodplain who are not subject to frequent floods but to rare floods with attendant losses which are potentially catastrophic. The Hawkesbury-Nepean Floodplain Management Strategy survey "Analysis of Community Attitudes to Flood Related Risks" (HNFMS 2001) found that house buyers were willing to pay more for home and contents insurance in order to be covered for a foreseeable natural hazard. A further finding from the Community Attitudes survey was that householders were willing to pay more for a house built to withstand the hazard. Both first and second time homebuyers wanted 'peace of mind'. (More information on this survey can be found in Chapter 6).

It is important to note that even if it were to be available, flood insurance would not prevent the risk or reduce the total loss. It enables the losses to be shared (by all those insured) and distributed over time (through the payment of annual premiums), thus reducing the socio-economic impact of the disaster. (Leigh, Taplin and Walker 1997).

Implications for planning for flood prone land

Unlike other natural hazards such as bushfire and earthquakes, flood insurance for residential properties is generally unavailable. Although insurance is only one element of managing the risk, the lack of insurance places a greater emphasis on avoidance to reduce the risk to individuals and a greater onus on authorities to act responsibly when planning for flood prone land, given that the risk is foreseeable and lack of insurance cover makes households all the more vulnerable to the consequences of flooding.

By implementing the guidance given in these Guidelines, the risk can be rendered more manageable. In that way, the inevitable increase in property damages in the Hawkesbury-Nepean floodplain, which would otherwise occur, could be averted.

Figure 30b *Flooding can cause catastrophic damage*

8 DETERMINING FLOOD PLANNING LEVELS

What is a Flood Planning Level?

A flood planning level (FPL) is made up of both:

- a level derived from a flood which has a certain likelihood of occurrence and is selected for planning purposes; and
- a freeboard to allow for uncertainties in flood modelling and other variable parameters such as afflux, wave action and climate change.

It serves to prevent a developed site from being flooded too frequently and can prevent damage from occurring up to the selected flood level.

Flood planning level = selected flood level + freeboard (Usually expressed in metres AHD)

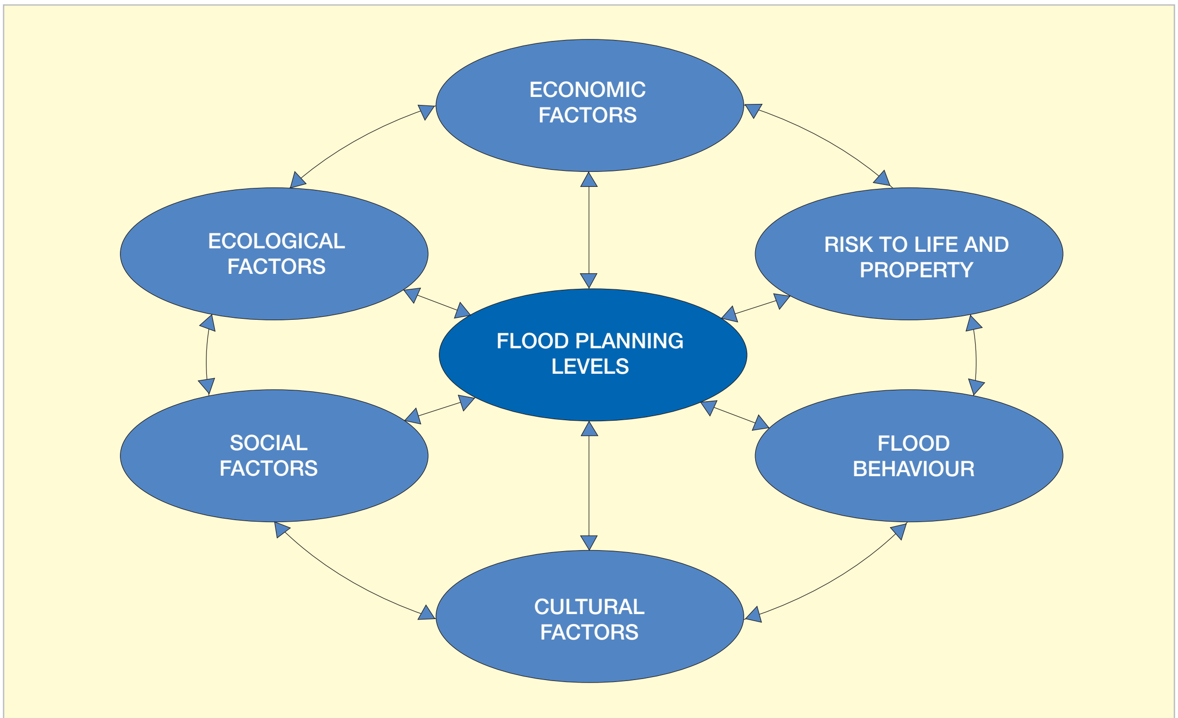
The process for determining the FPLs should be made through the floodplain risk management process as detailed in the NSW Government's Floodplain Development Manual (2005).
The factors illustrated in Figure 31 are:

- Flood behaviour
- Risk to life and property
- Economic and financial factors
- Social factors
- Cultural factors
- Ecological factors

In some floodplains where the hazards posed by floods rarer than the 1 in 100 AEP flood are severe – as in the case of the Hawkesbury-Nepean, a range of FPLs for different types of land uses may be justified. This approach can provide an adequate reduction in risk and avoids utilising measures which may be either too stringent and restrictive or at other extreme, weak and ineffective.

Councils are encouraged to prepare local floodplain risk management studies and plans with a view to adopting appropriate responses to the flood risk. Selecting appropriate flood planning levels (FPL) for the construction of new development is fundamental to managing the risk to buildings on floodplains and is an integral part of the local floodplain risk management process.

Figure 31 *Important factors in selecting flood planning levels*



(Source: Floodplain Development Manual 2005)

The NSW Government's Floodplain Development Manual (2005) includes the following definition of Flood Planning Levels:

'Flood planning levels are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. FPLs supersede the "standard flood event" in the 1986 manual'.

Any FPL, which is less than the PMF, does not represent the limit of flood prone land.

The 1 in 100 AEP or 1% design flood level is widely used both in Australia and overseas as the basis for the FPL for residential development, and thus it could be argued that it is a reasonable frequency which an owner or occupier might experience flooding of a house site. However, the critical question is not only how often the site might flood but also what the consequences are and how severe they would be. This will depend on how much higher the rarer floods can rise above the FPL. The potential for exceptional losses in larger floods indicates how vulnerable a property would be to flood damage and can be used as an indication of property risk exposure. If this level of risk exposure above the FPL is relatively high and is a concern, then additional measures may need to be adopted in order to reduce that property's risk exposure.

It is common practice in Australia and elsewhere where natural hazards are prevalent, to reduce the vulnerability of buildings to the forces of nature by requiring a range of structural enhancements and / or appropriate building locations or designs. This is the case for sites where there is a high risk of damage from cyclones, earthquakes and bushfires. In contrast, the sole means to reduce the impacts of flooding on buildings has been a reliance on a minimum floor level standard i.e. an FPL. This only controls the frequency of flooding i.e. how often losses (damage to a dwelling and contents) might be incurred; it does not address the hazard associated with floods that exceed the FPL. Low-lying locations below the FPL are generally not considered suitable for new residential development.

Whilst the FPL is currently the principal control to limit damage to new development, there is potential to reduce losses in rarer floods through additional building controls relating to materials, construction methods, house design and siting. For other natural hazards, this approach is already codified in regulations. There is potential for households to benefit from significantly reduced contents losses by straightforward measures such as incorporating an upper storey into the dwelling. This provides an opportunity for movable items to be stored upstairs out of the reach of all but the most severe floods. The FPL can also be accompanied by controls to limit the vulnerability of different land uses, essential infrastructure or flood protection works. These additional measures are often overlooked as practical measures to reduce the risk.

Property modification measures include:

- land use planning provisions, which may limit new development in certain risk areas; and
- development and building controls.

Response modification measures include:

- identifying, upgrading or constructing evacuation routes;
- raising public awareness; and
- response planning etc.

In some floodplains (but not in the Hawkesbury-Nepean context), levees may be an option in conjunction with a FPL for habitable floor levels to mitigate flooding and provide some protection to a whole town or neighbourhood. Best practice indicates that having a levee in place should not simply result in a lower FPL being adopted behind the levee. Levees cannot be guaranteed never to fail and the same rigour should be used to set FPLs for development protected by a levee as on unprotected flood prone land.

Choosing the Design Flood

Choosing the appropriate design flood as the basis for setting the FPL should be based on the degree of risk i.e. a combination of:

- the consequences;
- how often flooding might occur; and
- the exposure to the risk.

Unless the PMF is chosen as the design flood, there is always a possibility of flooding and associated consequences. The NSW Flood Prone Land Policy (2005) recognises that with few exceptions, it is neither feasible or socially or economically justifiable to adopt the PMF as the basis for a FPL. The risk associated with flooding between the FPL and the PMF is referred to as continuing risk. Property built to a FPL based on a design flood, which is lower than the PMF, plus freeboard, will incur flood damage in actual floods when the water level exceeds the level estimated for the design flood. Whilst continuing risk presents itself less frequently, it nonetheless exists and must be managed. Even risks, which have a high degree of improbability, can constitute a foreseeable risk. There is an expectation that the greater the potential damage or harm from this risk, the greater standard of care which should be exercised when considering measures to manage and reduce this risk.

The Flood Prone Land Policy (2005) states that a return interval for the design flood for typical residential development would generally be based on the 1 in 100 AEP event plus a 0.5m freeboard. In recognition of the fact that floods larger than the 1 in 100 AEP event do occur, the policy does not prevent a larger flood to be chosen as the design flood where it can be clearly demonstrated that the situation is exceptional. Councils are able to adopt levels lower than the 1 in 100 AEP level for commercial and industrial development event provided careful consideration is given to the safety of workers, clients, etc. To provide protection for new buildings in floodplains, the Manual (2005) advocates consideration is given to a building's structural adequacy for events equal to or greater than the design flood.

There is no 'standard' or 'right' answer as to what level of risk may be socially acceptable or tolerable. It is worth noting that the community accepts different levels of risk for different natural hazards and accepts a relatively high level of risk for flooding compared to bushfire, earthquake and cyclones.

The 1 in 100 AEP flood level is the most commonly adopted flood level in both Australia and overseas, including the USA, as being a minimum for residential development. The 1 in 100 AEP flood event is considered indicative of a 'big flood' with potentially disastrous consequences. It is one that has an even chance of being experienced at least once in a 70-year lifetime, (Table 6 and Figure 32).

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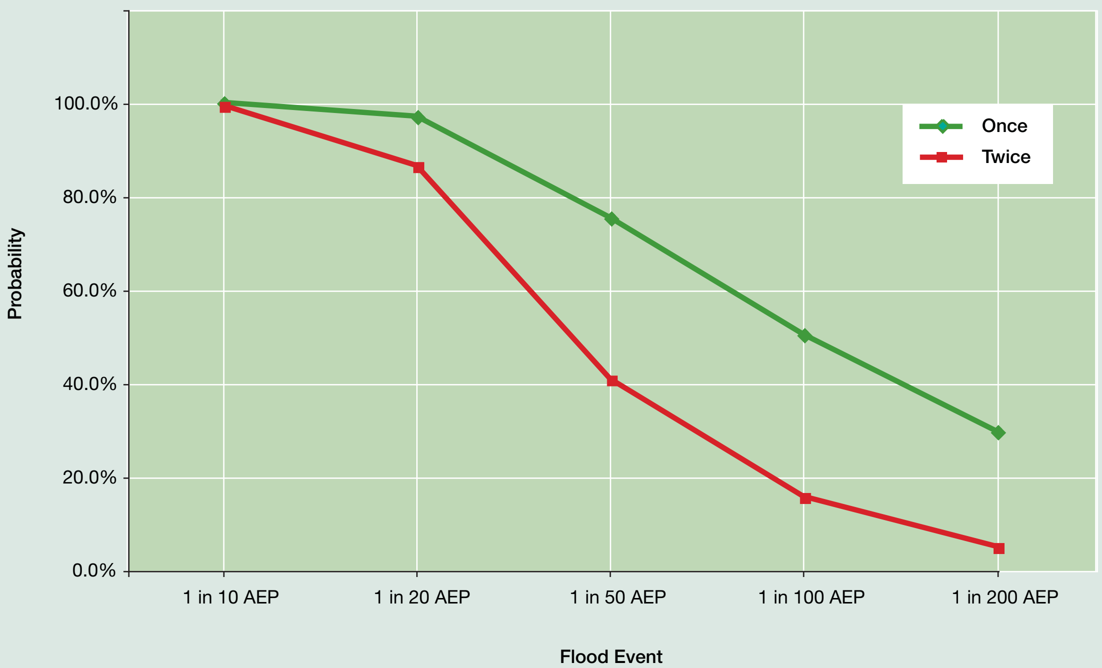
Table 6 *The probability of experiencing a flood of a given size in a lifetime of 70 years*

Size of flood	Chance of occurrence in any year (ARI/AEP)	Probability of experiencing the given flood in a lifetime (70 years)	
		At least once	At least twice
1 in 10	10%	99.9%	99.3%
1 in 20	5%	97.0%	86.4%
1 in 50	2%	75.3%	40.8%
1 in 100	1%	50.3%	15.6%
1 in 200	0.5%	29.5%	4.9%

(Source: NSW Floodplain Development Manual 2005)

Figure 32 *Probability of experiencing a given flood in a 70-year lifetime*



This graph shows the chance of experiencing two 1 in 100 AEP floods in a lifetime (i.e. 17% probability) is significantly less then experiencing one (i.e. 50% probability).

In most floodplains the 1 in 100 AEP design flood will provide an acceptable level of protection against floods occurring, although there are contemporary overseas examples of a rarer flood being chosen. For example, in Scotland built development cannot occur in a functional flood plain which is identified as land affected by the 1 in 200 AEP flood (Scottish Planning Policy 7: Planning and Flooding 2004). In England and Wales, the 1 in 200 AEP flood has been adopted for land affected by tidal and coastal flooding and the 1 in 100 AEP for riverine flooding. There are examples of considerably higher standards being used for flood mitigation. In the Netherlands the accepted design event along the Rhine and Ijssel rivers is the 1 in 1250 AEP flood and along the Maas, where flooding is a lesser problem, the 1 in 250 AEP flood is used to reduce urban flooding.

Within Australia there are several examples of the 1 in 200 AEP flood event being adopted for planning purposes. Inverell council has adopted this higher standard for the Macintyre River.

The 1 in 200 event has also been adopted on the Torrens River in Adelaide. There have also been cases where the PMF was considered an appropriate standard for planning purposes because the difference between the 1% flood and the PMF was minimal and the flood risk could be readily eliminated with negligible implications.

In urban areas the 1 in 100 AEP or 1% design flood has commonly been adopted as the standard for the FPL, although this decision has not always been taken with a clear understanding of the potential damages caused by rarer floods. However, significant floods are not particularly rare. In the Hawkesbury-Nepean floodplain, where the flood range can be exceptionally great, a FPL for residential development based on the1% flood, is only likely to result in an ‘acceptable’ level of risk if it is also accompanied by a suite of other measures such as building controls which can reduce property losses in the event of rarer floods and adequate evacuation procedures to safeguard life.

The flood range and the consequences of rare floods are exceptional in the Hawkesbury-Nepean valley. The design flood levels along the river exhibit large variations between the flood planning level (100 year flood level plus 0.5m freeboard in Penrith and the 100 year level in Windsor) and floods that are not much rarer, (Table 7). For example in Penrith there is a 0.8m difference between the 1 in 100 year level and the 1 in 200 year flood. In Windsor the difference is 1.4 metres. If the flood of 1867 occurred today, with Warragamba Dam in place, the water would reach about 26.8 metres at Penrith and about 19.1 metres at Windsor. Over-floor flooding to such depths can cause major damage to traditional brick veneer dwellings and their contents. (More information on this can be found in Chapters 9 and 10 and in the Building Guidelines “Reducing Vulnerability of buildings to flood damage – Guidance on building in flood prone areas”).

Table 7 *Windsor and Penrith Design Flood Levels*

Flood	Victoria Bridge Penrith (m AHD)	Windsor Bridge Windsor (m AHD)
10 year	21.6	12.3
20 year	23.4	13.7
50 year	24.9	15.7
100 year	26.1	17.3
200 year	26.9	18.7
500 year	27.5	20.2
1000 year	28.6	21.8
PMF	32.2	26.4

(These levels relate to flooding post Warragamba Dam with auxiliary spillway in place)

Damages from a flood that has a 1 in 200 chance per year of occurrence can result in damages 30 times greater than a flood with a 1 in 10 chance per year of occurrence. It is therefore prudent to apply other flood-specific development and building controls in addition to setting a FPL to manage the risk from bigger floods. This warrants a suite of controls to reduce the risk in floods rarer than the 1 in 100 AEP flood. Managing flood risks for new development relies on implementing land use planning, development and building controls. Risk can be reduced to more acceptable levels by having a combination of FPLs for different land uses, two storey dwelling houses and dwellings built to flood aware design standards. Such controls can reduce property damage and provide for safe egress in times of flood. Care needs to be exercised to ensure that measures undertaken in one location do not have adverse affects on the flooding of other areas of the floodplain.

There is no reason why different design floods cannot be adopted for the FPLs for different land uses where an additional level of protection is deemed necessary for social or economic reasons. This is discussed further in Chapter 11.

Determining Freeboard

The following pages provide an introduction to the factors involved in determining freeboard but readers who require more information are directed to Appendix B for a more detailed explanation.

What is freeboard?

Freeboard is a factor of safety typically used in relation to the setting of flood planning levels (FPL), floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted FPL and the flood used to determine the FPL. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels, wave action, afflux and climate change. Freeboard is included in the flood planning level, (Figure 33).

Note: freeboard in this context does not include an allowance for over-floor flooding caused by overland flow in local storm events. Local drainage problems can be minimised by ensuring the finished floor levels are a minimum height above finished ground levels.

The 2005 Manual advocates a freeboard of 0.5 metre for residential floor levels above the selected flood level. It is a standard commonly used throughout the State.

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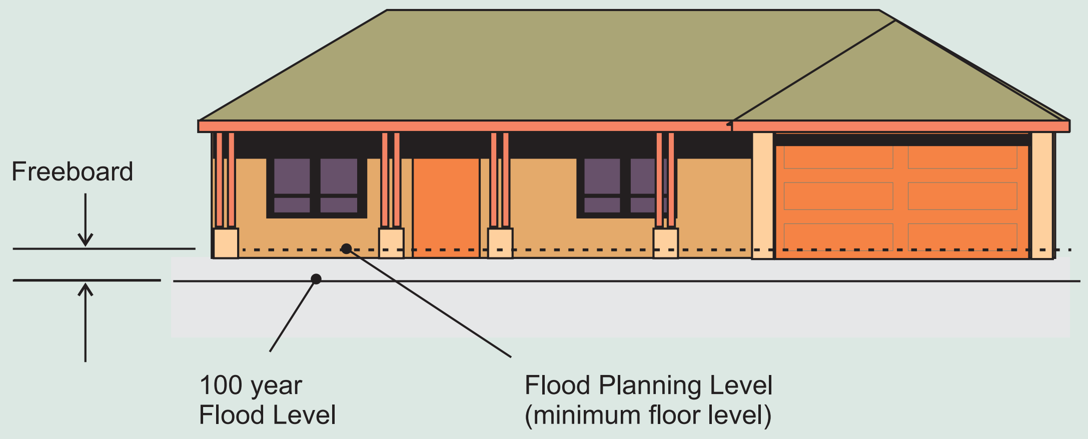
Figure 33 *Freeboard*



Freeboard is the difference in height between the adopted FPL and the flood used to determine the FPL

In most floodplains, a freeboard of 0.5 metre will provide an adequate factor of safety for residential development but a floodplain risk management study may identify cost-effective benefits from having a higher figure.

The purpose of a freeboard is to allow for uncertainties. It provides a reasonable level of confidence that a property built at the FPL is protected against the design flood. It is not intended to give protection against rarer (higher level) floods. If protection against more severe floods is demanded, then a different design flood should be chosen, rather than a deeper freeboard.

Freeboard in the Hawkesbury-Nepean context

Given that the Hawkesbury-Nepean valley is subject to flood risk that is considerably higher than many other NSW floodplains, the Guidelines provide advice on determining if a variation to a 0.5m freeboard is warranted when setting FPLs for:

- the floor levels of dwelling houses and other occupied buildings;
- public infrastructure e.g. roads and railways; and
- drainage works,

in order to provide a factor of safety which is reasonable and appropriate for this floodplain.

Consideration of uncertainties in determining freeboard

A freeboard provides an all-encompassing factor of safety to compensate for uncertainties that exist in:

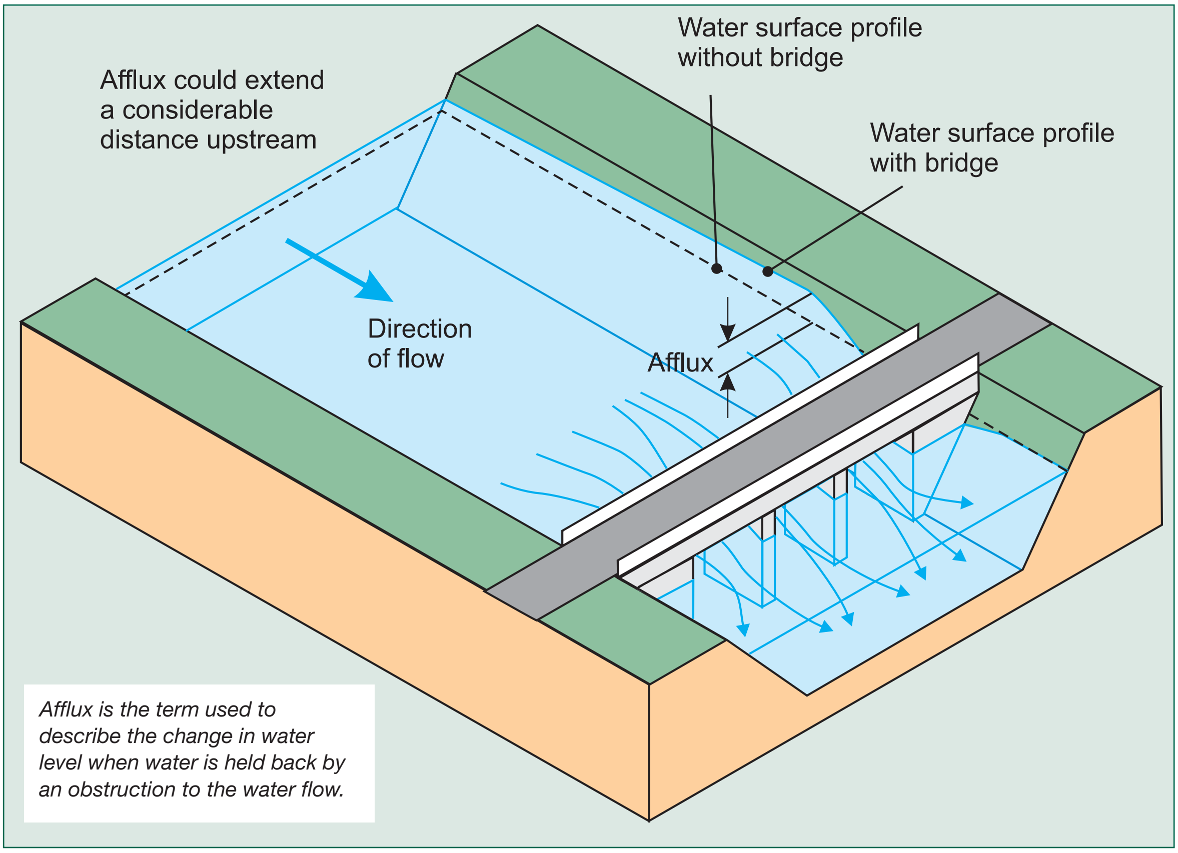
- the flood model estimation, or

confidence in the estimation of the various components which affect flood protection, namely:

- wave action,
- afflux (see Figure 34), and
- climate change.

This approach reflects the impossibility of quantifying either the associated increase in flood levels or the chance of two or more of the components occurring at the same time. It recognises that a rigorous review of an allowance for each of the components would be unlikely to be credible. The approach taken here has been to assess whether there is any rationale for moving away from the commonly adopted 0.5 metre standard. Each of the uncertainties listed above needs to be considered. A short introduction for each uncertainty is provided here, with more detail in Appendix B.

***Figure 34** Afflux*



Flood model estimates

In a flood study, the behaviour for the full range of floods up to the probable maximum flood (PMF) is comprehensively investigated. A flood study incorporates flood models and determines flood levels, the extent of flooding and velocities. Historical flood data can increase the reliability and credibility of flood estimates. There are however, inherent uncertainties in flood modelling; they include:

- amount and accuracy of the information and its interpretation;
- types of models and methodology adopted.

Variations in the topography of the floodplain affect the reliability of estimates of design flood levels.

Appendix C contains a detailed checklist of flood modelling uncertainties.

It is not good practice to use the outputs from a flood study and floodplain risk management plan prepared for one specific catchment and apply them without further assessment to another catchment, even in the same council area. Each river's floodplain has unique characteristics that need to be addressed independently.

In the Hawkesbury-Nepean valley there is no reason to suggest that a greater than normal freeboard allowance should be made for uncertainties in flood model estimation.

This is because the Hawkesbury-Nepean floodplain has recently been subject to very extensive and robust internationally endorsed modelling process, especially in the more settled parts. This is in contrast to some other floodplains, where there may be less rigorous modelling available.

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Wave Action

Flood models do not include any wave action. Waves add uncertainty to the determination of peak water levels. This increase in peak water level generates additional forces acting on structures. Thus waves have the potential to cause damage to levees and exposed buildings built at the design flood level. The impact of waves is very site-dependent and varies with weather conditions.

Extensive areas of floodwaters, or fetch, including areas adjacent to large lakes and estuaries, can generate quite large waves. The wake of emergency boats, vehicles and the down draught from emergency operations' helicopters can also generate waves.

Where waves are believed to be inevitable, they should be included in the flood study and allowed for in the design flood level.

The open expanse of many areas subject to Hawkesbury-Nepean backwater flooding makes wind generated waves a real threat. The independence of the variables relating to waves favours a conservative approach when determining wave allowance in freeboard.

Afflux

Afflux is the term used for the change in water level when water is held back by an obstruction to the water flow in the conveyance areas. Immediately downstream of the obstacle, levels may be reduced as a result of an obstruction, whilst upstream the levels may rise. Velocities can be affected by afflux as can the extent of the floodwaters. Obstacles to flow include narrowing of the floodplain, buildings, dense vegetation, culverts, bridges, blocked drains or filling of the floodplain. (Figures 34, 35 and 36).

Development in flood storage areas is inappropriate if it results in a loss of storage or creates an afflux downstream.

Afflux varies locally and particularly once a site is developed. Freeboard can be used to account for this local afflux. Ideally, finished landforms and a likely future development scenario need to be known to understand how to include afflux in the freeboard calculation.

Figure 35 *Small culvert openings in highly urbanised areas are easily blocked by debris*

Extensive culvert blocking during the August 1998 Wollongong floods resulted in flood levels with a recurrence interval of greater than a 200 year event being reached despite the rainfall event which caused the floods being equivalent to a 100 year event.

Figure 36 *Debris can partially block larger waterways*

Wollongong, after the August 1998 floods

Regional afflux (i.e. due to broad scale planned development on a greenfield site) should already be factored into a flood level determination through the flood modelling process. Freeboard is not the appropriate floodplain risk management tool for addressing any uncertainty associated with regional afflux.

Notwithstanding the inclusion of afflux in the flood level determination, there is an inevitable cumulative impact on the floodplain arising from a multitude of small decisions and the ultimate development scenario is often not known early in the development process.

A normal allowance for afflux in freeboard would be generally satisfactory for the Hawkesbury-Nepean floodplain.

Climate change

Recent research in Australia suggests that all forms of flooding will increase as a result of climate change. Smith has suggested that a 1 in 100 AEP Hawkesbury-Nepean flood today will progressively change and may be regarded as a 1 in 50 AEP event by 2070, (Smith 2001).

Increased storm surge and sea level rises are a predicted consequence of climate change. In low-lying coastal floodplains, tides affect flooding and should be assessed.

Long-term natural variability in Australian rainfall and run-off has been recognised as adding complexity to future flood scenarios. However, it implies that historical flood data may not be a reliable source in predicting future floods.

Determining a precise component figure for climate change is not feasible, given the scientific uncertainty with the current predictions and limited regionally applicable studies for the Hawkesbury-Nepean catchment. However, to avoid damage to buildings which can be expected to be in use for many decades to come, incorporating a higher allowance for climate change in the freeboard would seem appropriate and be in keeping with the precautionary principle.

Determining variations to a 0.5 metre freeboard

Appendix B provides additional information to assist in understanding how freeboard components combine or act independently. It may be necessary to vary freeboard allowances or adopt differing freeboards for particular land uses and development types in differing locations. The components that make up freeboard should be assessed to justify any necessary variation in the commonly used standard of 0.5 metres.

Given flood risks in the Hawkesbury-Nepean are known to be exceptional, ignoring the uncertainties would not represent best management practice according to State and Commonwealth guidelines. Duty of care obligations may then be viewed as not having been properly exercised.

Achieving freeboard through filling or building design modifications

Filling should not result in any net change to the storage capacity of the floodplain for a flood with the same return interval as that selected for planning purposes.

There are merits in incorporating freeboard into finished ground levels, the building form or other structures. However, there are emergency management implications in elevating habitable floor levels above the ground level as in a Queenslander style of dwelling or where only non-habitable rooms such as laundries, bathrooms, garages or unenclosed storage areas are on the ground floor, (Figure 37). Experience has shown that people tend to become complacent and are tempted to retreat upstairs in the house rather than evacuate early in a flood event.

Urban design considerations are important when deciding if the finished ground level should incorporate the freeboard. Infill development should have respect for neighbouring developments and the streetscape. Issues for consideration include floor heights, final building form and mass, loss of amenity from overlooking, overshadowing etc. Compromise may be necessary in such circumstances but the flood risk should not be casually dismissed.

Wave action can be effectively mitigated by filling or landform shaping, although in some locations this may not be either a practical or desirable option due to other constraints.

There are environmental considerations in filling or raising the ground level with fill. This also

Figure 37 *Elevated dwelling isolated by floodwaters*

Elevated houses can have emergency management implications in rising floods as occupants may not evacuate in time. (Cattai, 1978).

applies when the fill is to be sourced locally to provide compensatory flood storage. Planning instruments may impose restrictions on filling. The Department of Environment and Conservation (DEC) also regulates the filling of land. The range of environmental issues relating to filling includes:

- the fill material: source, means of transport, type of material(s), potential for contamination, acid sulphate soils, salinity, importation of weeds;
- adverse impacts on local water quality due to leaching, erosion and sedimentation and the need for managed control measures;
- impacts on local drainage and/or local flood behaviour;
- adverse impacts on biodiversity and ecological systems; and
- geotechnical considerations such as stability of finished ground.

Alternatives to choosing a higher freeboard

If a higher level of protection is required, say for land uses which are more vulnerable to the consequences of flooding, a preferred floodplain risk management approach is to select a rarer flood rather than a larger freeboard. A merit-based approach enables consideration of flood characteristics including the magnitude of the flood range, depths, velocities, warning time available and social, economic and environmental considerations.

Essential infrastructure located on flood prone land may include components, which are particularly susceptible to damage by floodwater. Having a conservative component-specific freeboard and elevating such items will reduce the risk, facilitate recovery and enable a quicker restoration of essential services.

A successful practical means to protect against waves for commercial development has been adopted in Inverell where toughened glass has been used to protect shop windows, rather than attempt to retrofit property with a higher freeboard.

Ability to adjust protection

The scope to correct or adjust for the degree of uncertainty to meet the selected level of protection should be factored into the determination of the freeboard. For example, in some catchments flood mitigation works are cost-effective and a levee can protect against the design flood. However, even property protected by a levee, requires an adequate freeboard. If extra protection is necessary, raising or otherwise modifying a levee system may be a practical solution.

In contrast, in wide coastal floodplains or where flooding might also be affected by coincident high tides, it is difficult to mitigate flooding. If flood levels are later reviewed and found to have been underestimated, there is the potential for damaging consequences because retrofitting an already developed area to correct for ‘under protection’ can be extremely difficult. In such situations, choosing a larger, more cautious freeboard is a sensible approach to provide protection.

There may be valid economic, social or practical access reasons why a higher, more conservative freeboard cannot be adopted. In such circumstances it is necessary to acknowledge that it will result in a reduced chance of protection against the selected flood. For example, where the FPL is based on a 1 in 100 AEP flood, the effective standard of protection may only equate to a 1 in 80 AEP flood.

How freeboard can assist in evacuation

A freeboard could also be incorporated into new flood evacuation routes to ensure they can remain open during the time required for evacuation. A freeboard could be applied to new railways to both protect the infrastructure from damage and to enable the line to remain open longer in a flood event, particularly if rail has a nominated role in any emergency evacuation plan. New road and rail designs should also ensure that no adverse impacts would occur elsewhere due to afflux. This may be avoided by additional waterway openings in elevated structures.

Elevating the route above the level of flood-related waves and/or incorporating wave barriers to deflect waves from the carriageway can provide additional protection for evacuation infrastructure.

Need for Review

A floodplain risk management plan should be robust enough to cope with worse than anticipated climate change effects over a 30 year time frame and needs to be subject to periodical review in order to respond to emerging, credible information. There will always remain a need to review new data as it becomes available (e.g. results of new flood studies, significant flood events or new modelling techniques) to ensure that the adopted freeboard continues to provide protection to the required standard.

Cumulative impacts of new development need to be assessed and if necessary flood levels adjusted. A review timetable should be programmed into the floodplain risk management plan to ensure it remains valid.

The Precautionary Principle

The NSW State Government promotes sustainability in new development. Sustainability principles include the precautionary principle, which states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of this principle, public and private decisions should be guided by a careful assessment of the risk-weighted consequences of various options.

In keeping with these principles, the NSW Government's Flood Prone Land Policy aims to promote a merit-based assessment for flood prone development, commensurate with the flood risk whilst addressing social, economic and ecological factors.

Determining variations to a 0.5 metre freeboard

When determining a freeboard, it is necessary to understand how freeboard components should be combined and how they act independently. Joint probabilities reduce the chance of occurrence. There is an extremely remote chance that in a flood event each uncertainty factor will be at its maximum value and a similarly remote chance of each being at its minimum value. Thus, a freeboard where each is maximised and then added cumulatively would be overly conservative.

It is common to have only one freeboard in a local government area, but a higher freeboard can provide better protection for vulnerable land uses or in specific locations where flood hazard is greater.

Freeboard components should each be assessed independently and if necessary variations in the standard 0.5 metre justified. Each component may not apply in all locations e.g. in restricted urban floodplains wind-generated waves may not be an issue, but afflux from debris blockages may be.

In some circumstances, an alternative approach can be to factor in wave action, local afflux and climate change into the estimation of the design flood levels, rather than leaving such matters to be factored into an all-encompassing freeboard.

Documenting how a freeboard has been determined can assist in demonstrating duty of care.

Conclusion

When determining FPLs which include freeboard, the uncertainties of the modelling used to estimate flood levels and the uncertainties associated with wave action, afflux and climate change have to be given credence and weight. It is however, recognised that the final freeboard can never be derived with mathematical certainty.

A conservative approach to the assessment of freeboard, which includes a scientifically credible upper limit allowance for the climate change component, is advocated. However, if new flood modelling is being undertaken for a flood study, rather than using existing results, an alternative approach may be to include climate change in the design flood levels rather than including it in the freeboard figure.

It is commonly assumed that because a freeboard results in a higher ground floor level, it reduces the chance (or probability) of a property being flooded. This is not the case. A freeboard will help protect a property from inundation by floodwaters that reach the estimated level of the selected flood.

Having a freeboard is a way of ensuring the desired level of protection is reliably met when the uncertainties come into play.

> Freeboard is integral to protecting property from the selected flood event.

9 METHODOLOGY FOR DETERMINING FLOOD RISK MANAGEMENT BANDS

This chapter explains how to determine and apply flood risk bands in so far as the *risk to buildings* is concerned.

Introduction

Flood damages to buildings are traditionally managed by reducing the likelihood of over the floor flooding occurring. This is done through the adoption of minimum floor levels – typically the 1 in 100 AEP flood level plus a half metre freeboard. In the majority of floodplains this measure alone would reduce the damage to the building to equate to a low risk rating. However, where there is a significant range of flood levels between the 1 in 100 AEP flood and the probable maximum flood (PMF), as there is in the Hawkesbury-Nepean, a minimum floor level control is insufficient to reduce the flood damage risk to a low level. Therefore it may be necessary to consider other controls to reduce the risk rating. Flood risk management bands can provide the basis for defining areas where additional controls are required to manage damage. They form the basis for applying differing residential building and development controls to new development on the floodplain, tailored to suit the variations in flood hazard across the floodplain.

A summary of how the chapter is structured is given in the text box below.

Summary

What are flood risk bands?

The concept of rating risk is explained. Risk ratings enable appropriate development and building controls to be identified which in turn go some way to equalising the flood risk to new development in the floodplain.

Methodology to determine flood risk management bands

A series of steps are identified:

Step 1 – Hazard from depth – identify and assess the flood hazard using Flood Study outputs.

Step 2 – Consequences – assess potential losses and damages.

Step 3 – Likelihood of losses – assess how often losses might occur.

Step 4 – Severity of losses – assess the severity of the losses.

Step 5 – Measuring risk – measure the risk using a concept of relative risk.

Step 6 – Rating risk – convert the measurements of risk to give risk ratings.

Step 7 – Comparing risk levels – use the risk ratings to assess the implications of deeper flooding and compare risk levels.

Step 8 – Controlling and reducing flood risk.

Setting Risk Bands

- Setting the first risk band above the residential flood planning level or FPL (1 in 100 AEP plus freeboard).
- Second risk band above the residential FPL.
- Third risk band above the residential FPL.
- Risk bands for the flood planning areas below the residential FPL.

Mapping Flood Risk Bands

Guidance is provided on mapping flood risk bands.

9

What Are Flood Risk Bands?

Each risk band is defined by an order of 'like' risk gradings. These risk gradings are categorised according to the severity of the consequences. The severity of the consequences is expressed as

- the magnitude of the financial cost of damages and losses arising from flooding as a dollar figure;
- how the consequences compare with other floodplain locations; and
- the likelihood or frequency of losses of these magnitudes, i.e. how often and how long individual households and their assets would be exposed to the hazard.

Note the frequency of flooding is principally dependent on the behaviour of flooding at the site, whereas exposure is a measure of how often the floodplain is used by an individual e.g. intermittently or continuously and whether this is over a short period or a lifetime. The higher the exposure, the greater the chances of an individual experiencing the related hazard event.

In the case of residential development, it can be taken that homeowners have a high continuous exposure because their major assets are located on a permanent, long-term basis on the floodplain.

The risk bands can be described as Low, Medium, High or Extreme. Each would reflect the level of financial risk from the loss of the house and contents losses which would occur if there were no additional flood-aware building controls applied to new dwellings on land lying above the FPL but below the level of the PMF.

The methodology put forward here can help determine flood-related management tools such as land use zonings and building and development controls specifically for nominated flood risk bands up to the PMF. These floodplain development management tools may include:

- selecting one or more flood planning levels (FPL) to specify floor levels,
- land use types,
- building styles, designs, components and materials etc.

The aim would be to control flood risks arising from occupation of the floodplain which may result in financial harm to individual households. This could be achieved by keeping the cost of the flood losses and recovery to a level which could be endured by those households exposed to the flood risks.

How can land use planning reduce risk to buildings?

- FPLs can reduce the probability of a building being inundated
- Selective allocation of land uses can reduce vulnerability
- Flood-responsive housing design and construction can result in reducing damages to manageable levels for households.

Where flood probabilities are very low, the flood hazard and the ensuing risk may be sufficiently low such that imposing controls on land uses or buildings may be unwarranted as depths and velocities in those very rare floods may result in relatively little damage. This of course is not always the case.

- Although no building controls may be necessary in low flood risk areas, there remains a continuing flood risk.
- It is critical that residents and property owners in all flood prone areas are made aware of the flood risk through on-going public awareness strategies.
- All occupants should have access to evacuation routes continuously rising out of the floodplain.

All floodplains are unique and an approach which is appropriate to one area, is not necessarily going to give the best risk reduction in another. In adopting risk management bands, a council should identify the flood risks inherent in each floodplain and determine the bands that are warranted. In locations where there is very little flood range, choosing even the PMF as the basis for the FPL may be justified in order to give full protection against all floods and effectively eliminate risk because the cost and trade off may be negligible. However, in the Hawkesbury-Nepean floodplain the flood range is so significant and the floodplain so extensive, as to warrant a more sophisticated and more flexible approach, which would allow some appropriate development on the floodplain yet at the same time provide an equitable response to the risk. Having several bands would provide risk reduction and go some way to equalising levels of risk.

Methodology to Determine Flood Risk Management Bands

Introduction

A methodology to derive flood risk management bands for residential development is provided here. It comprises a series of sequential steps, which can be applied to any floodplain that is being proposed for development in order to manage flood risks to that new development. The methodology is concerned with property damage and does not address the hazards posed by flooding to the occupants of new development. This important aspect of risk management is discussed in Section II of the Guidelines.

The methodology is based on the correlation between a reduction in the likelihood of flooding and the depth of flooding, with a reduction in property damages. On higher land within the floodplain, the flood probability and hence the flood risk diminishes. Land that lies between the level of the 1 in 1000 AEP flood and the very rare PMF has an extremely low probability of flooding. Flood-related residential building controls may not be warranted because of the reduced risk in this band.

Each flood risk management band has a set of associated building controls, which, if applied to new housing, can go some way to equalising the risk of damage across the floodplain. The figures are derived from damages (losses to a standard house) and flood probability.

Step 1 Hazard from Depth

Identify and assess the flood hazard using Flood Study outputs and, if available the Flood Hazard Definition tool.

Flood hazard in the context of defining flood risk management band methodology includes

- water depths and/or velocities or combinations of depth and velocity; and
- the rate at which floodwater rises and therefore how much warning time is available.

A Flood Study identifies the hydraulic categories (floodway, flood storage and flood fringe) and hazard categories (high or low) for flood prone land. A detailed explanation of a Flood Study can be found in Appendix F of the Floodplain Development Manual (2005).

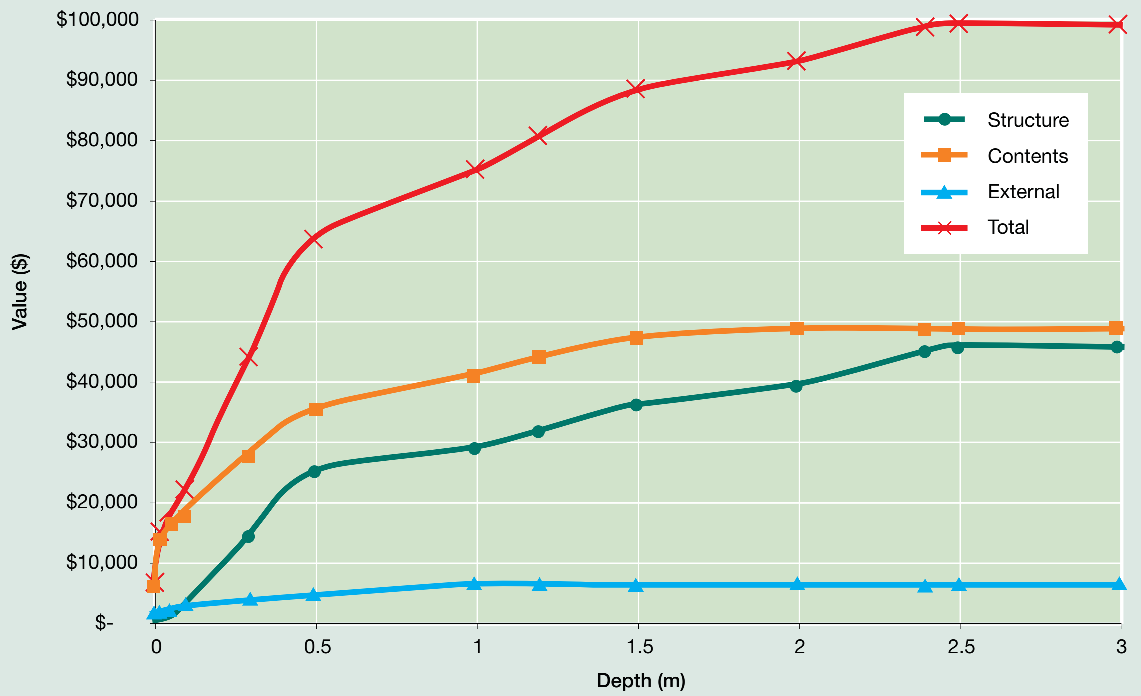
Step 2 Consequences

Assess potential losses and damages.

To simplify the methodology for determining risk management bands, consequences can be defined as losses and damages to residential property due to water depths alone. This includes damages to the building structure, fit out and fittings, appliances, contents, portable property and property external to the dwelling. Some building materials, construction methods and house design are more vulnerable to suffering flood losses than others because of susceptibility to water damage or the forces of moving water.

The stage damage relationship[1] for new houses of similar size floor and living areas, is generally applicable from one floodplain to another in NSW. This is because houses in the State tend to be of similar design and use similar building materials. However the damage sustained at various depths over the floor can vary significantly between the types of building construction e.g. brick veneer or full masonry and whether they are single or multi-storey.

Figure 38 *Damage in dollars for a single storey house versus depth in metres*



Notes:

1. *Amounts shown for damage to the structure refer to the cost of repair / replacement of components which are normally fixed to the building. This includes wall linings, skirtings / architraves, windows, ceilings, kitchens and fixed electrical appliances, bathrooms, laundry and door furniture. This should not be confused with structural damage which is a different class or category of damage and has serious implications as to whether the building can continue to be safely occupied or must be demolished and rebuilt if damage is extensive. Structural damage refers to the weakening or failure of load bearing components which together support the building and its contents. This includes the foundations, floor systems, wall frames and roof trusses. The damage values shown in the figures do not include this class of damage.*
2. *Should structural damage result in significant failure of key structural components, then replacement of the house at a cost exceeding $150,000 may be necessary. If contents losses are included, the total replacement costs may exceed $200,000.*

[1] *The term 'stage damage relationship' is used to describe the relationship between the damage to property and the height of the floodwater that causes that damage. For example for a house with a floor level at 17.6 metres AHD, flooding at 18 metres AHD would give a water depth over the floor of 0.4 metres. A water depth of 0.4 metres could result in $54,000 damages to a contemporary brick veneer house and contents.*

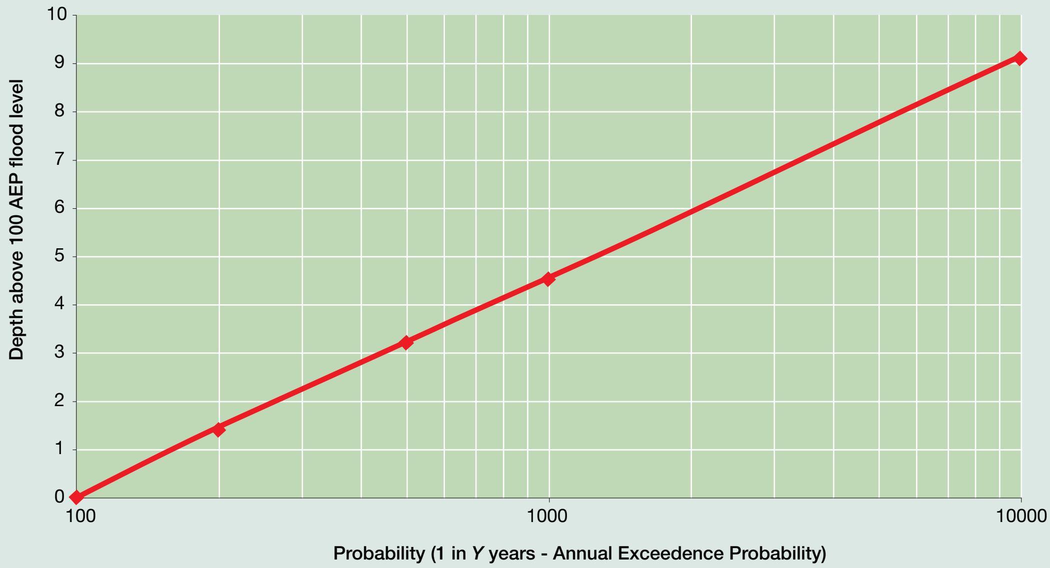
Step 3 Likelihood of Losses

Assess the likelihood of losses occurring.

For a flood hazard, the likelihood of occurrence can be determined from a flood frequency analysis using historical records or from a Flood Study using rainfall data.

The frequency of occurrence (e.g. 1 in 100 AEP) is a statistical expression which a flood affected community (or council) may choose to interpret in subjective terms (e.g. likely to occur) to assist in making decisions on risk management, (Table 8).

Figure 39 *Depth in metres versus probability of the flood*



While depth increases in a larger flood, the probability of the flood occurring decreases.

Note: This figure relates to Windsor – the range in flood depths varies at different locations throughout the floodplain

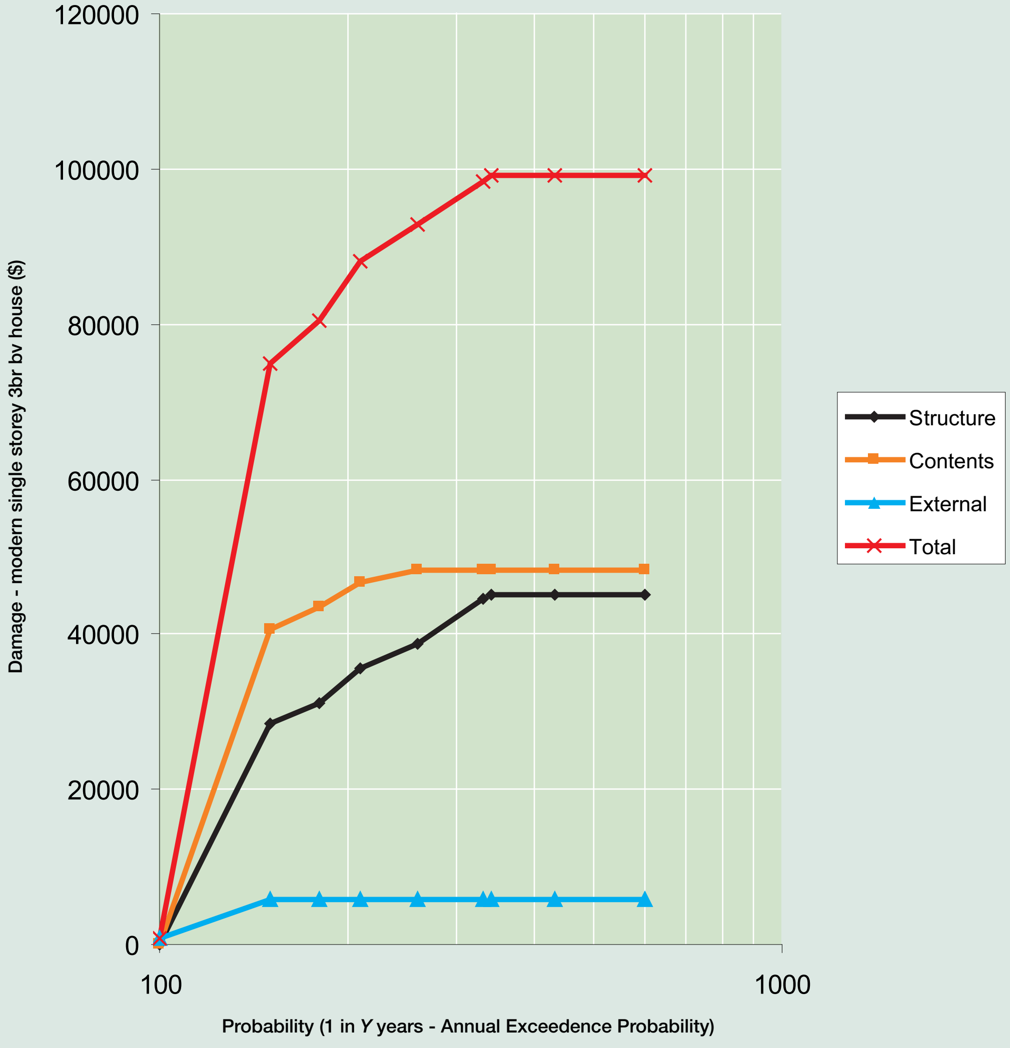
Table 8 *Assessing Likelihood*

Frequency of occurrence	Likelihood	Description of Threat Event
Below 1:50 AEP	Almost certain	Has occurred many times and expected to occur again within decades.
1:51 to 1:100 AEP	Likely	More than 50% chance of experiencing this event in a lifetime and widely accepted that it will probably occur.
1:101 AEP to Flood of Record	Possible	Has occurred in recent history and can occur again.
Flood of record to 1:1000 AEP	Unlikely	Conceivable that it could occur. Flood studies confirm that potential depths continue to pose a high hazard.
1:1001 to 1:10,000 AEP	Rare	May occur in exceptional circumstances.
1:10,001 AEP to PMF	Improbable	Too infrequent to have implications for residential damage calculations.

The likelihood of the losses occurring is dependent on how often the flood, which causes a certain amount of damage, occurs. As the 1 in 100 AEP or 1% flood event is commonly accepted as the basis of the FPL, damage only occurs when this flood is exceeded. In some floodplains, floods not much rarer than the 1% flood can result in very deep water which can result in considerable damage to property built at the FPL.

The relationship between how much damage a certain size flood causes and how often it can occur is therefore very site specific. It can be derived by combining the damage-depth curve with the probability-depth curve for the location. (Figure 40).

***Figure 40** Damage in dollars for a single storey house versus probability of a flood*



Note: The damage – probability relationship is site specific and influenced by the potential depth of flooding. It relates to a 3-bedroom, brick veneer single storey house in Windsor

Step 4 Severity of Losses

Assess the severity of the losses, guided by the information in Table 9.

Damages range from minor losses in more frequent floods, mainly outside the dwelling or to garage contents to extensive damage to the building structure in deeper floods. The cost of these losses ranges from insignificant to catastrophic.

***Table 9** Assessment of the severity of property losses[1,2]*

Scale Of Loss	Description Of Loss
Insignificant <$5000	• Flooding limited to outside the dwelling, only external property damaged e.g. – gardens, – fences, – garage contents.
Minor $5001-$10,000	• Very shallow over floor flooding. • Damage mostly limited to – carpets, – furniture which is moisture absorbent placed at ground floor level, – fixtures and fittings e.g. built-in cupboards. • Replacement possible through savings.
Moderate $10,001-$25,000	• Relatively shallow flooding, less than 0.3 metre deep. • Damage limited to contents which cannot be raised or moved away; can be replaced over time. • Repairs not critical and dwelling habitable with only clean-up.
Major $25,001-$50,000	• Considerable damage likely to: – building itself e.g. walls, – electrical services, – fixtures such as kitchens and ovens, – white goods, furnishings and furniture. • Extensive repairs, replacement and clean-up essential requiring high costs and lengthy recovery over several months before house is made habitable.
Catastrophic $50,001 – $150,000 plus	• Extensive damage to building structure possibly resulting in total loss – $150,000, • Loss of all household contents not previously removed from the site – around $50,000* plus, • Serious, sudden, unexpected, uninsurable financial loss. *(based on average contents of $80,000)

Notes:

1. *The nature of losses included in Table 9 are indicative of a traditional single storey brick veneer house.*
2. *With a flood aware two storey house the scale of loss for a given depth of flooding will be less than for a traditional single storey brick veneer – slab on ground house. For example, at 0.5 metre depth of flooding damage to the structure of the two storey flood aware house will be around $12,000 less.*

9

Step 5 Measuring Risk

Measure the risk using the concept of relative risk.

The risk can be measured using a concept of relative risk. Table 10 calculates the maximum relative risk for a flood range by multiplying the magnitude of damage in an event by how often that event is likely to occur (e.g. 0.5 relative risk in the table equates to $5,000 x 1/10,000 – i.e. the highest probability limit for that range). Note that in smaller flood events the lower amount of damage can be offset by the greater likelihood of the occurrence of those smaller floods.

***Table 10** Relative Risk*

Frequency or likelihood of flooding AEP	Relative Risk				
	$5,000 damages	$10,000 damages	$25,000 damages	$50,000 damages	>$200,000 damages
1 in 10,000 to PMF	0.5	1	2.5	5	20
1 in 1,001 to 10,000	5	10	25	50	200
1 in 201 to 1,000	25	50	125	250	1000
1 in 101 to 200	50	100	250	500	2000
1 in 50 to 100	100	200	500	1000	4000
1 in 20 to 50	250	500	1250	2500	10,000

Step 6 Risk Rating Matrix

Convert the measurements of risk in Step 5 (Table 10) to give risk ratings

***Table 11** Risk Ratings*

Frequency or likelihood of flooding AEP Damages	$5,000 Insignificant	$10,000 Minor	$25,000 Moderate	$50,000 Major	$200,000 Catastrophic
1 in 10,000 to PMF	Very low	Very low	Very low	Very low	Low
1 in 1,001 to 10,000	Very low	Low	Low	Low	Medium
1 in 201 to 1,000	Low	Low	Low	Medium	High
1 in 101 to 200	Low	Low	Medium	High	Extreme
1 in 50 to 100	Low	Medium	High	High	Extreme
<1 in 50	Medium	High	Extreme	Extreme	Very extreme

***Table 12** Explanation of Risk Ratings in Table 11*

Risk Rating	Relative risk	Acceptability of risk level
Very low	0-10	Acceptable due either to relatively low losses or very low probability, or both.
Low	11-150	
Medium	151-250	Consequences severe but bearable and infrequent enough to be regarded as acceptable.
High	251-1000	Very serious and unacceptable, exceeds community expectations. As a result requires controls to reduce or prevent these losses occurring.
Extreme	1001-5000	
Very Extreme	>5000	

Note: Table 12 has been prepared based on findings on community expectations and what level of damage individuals and households can withstand. This information was derived from the Analysis of Community Attitudes to Flood Related Risks (Cox and Gutteridge Haskins and Davey, 2001) and the Household Financial Flood Risk Investigation (Clarke and Tickle, 2001) undertaken as part of the Hawkesbury-Nepean Floodplain Management Strategy.

The table of risk ratings (Table 11) is a risk matrix. It can be used for:

- allowing comparison of the spread in risk levels for various flood events selected for flood planning levels (FPL). Selecting a flood with a lesser likelihood for the FPL can decrease the relative risk. For example, for damages up to $25,000 relative risk decreases from ‘extreme’ for a frequency of greater than 1 in 50 AEP flood to ‘very low’ when it is rarer than 1 in 10,000 AEP;
- for a particular planning level, indicates how the scale of risk, and thus losses, increases from insignificant to catastrophic through each level of consequence;
- identifying how effective (or ineffective) a number of risk bands or development controls can be as a tool to manage risk. For example, adopting a 1 in 100 AEP for the FPL reduces flood risk overall but does not eliminate high and extreme risks because high value damages of major and catastrophic severity are still a possibility;
- recognising risks which are too high and unacceptable so that a risk management strategy can be devised to control and reduce such risk.

Step 7 Comparing Risk Levels

Use the risk ratings to assess the implications of deeper flooding and compare risk levels

The implications of deeper flooding

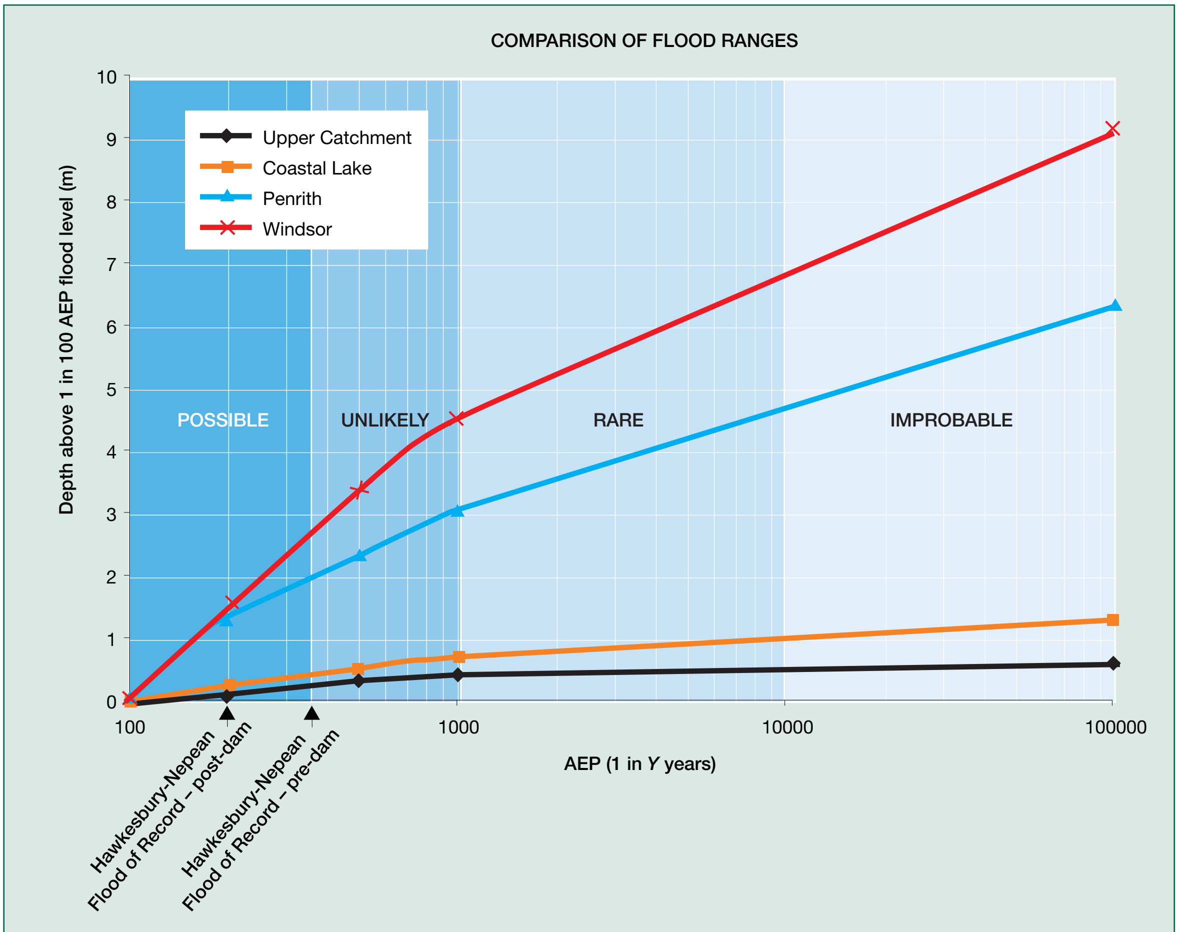
Whilst the stage damage relationship for particular types of houses is not generally floodplain-specific, there can be major differences between floodplains in the level of flood risk due to how deep the water gets and how often property can be flooded. A comparison of flood ranges above the commonly used FPL based on the 1 in 100 AEP flood illustrates these differences in depth.

As can be seen in Figure 41, these rarer floods inundate houses in the Hawkesbury-Nepean area (curves for Penrith and Windsor) at much greater depths than in other catchments. The rate of increase in the damages is quite sensitive up to mid-wall height or around 1 – 1.5 metres. In a single storey house, a substantial proportion of the structure and almost all of the contents and fixtures are affected by water at this depth. As a result of the greater depth of flooding, the flood risk for these rarer flood events in the Hawkesbury-Nepean is many times greater than in other catchments.

For floodplains where the flood range is small, flooding will not be deep enough to threaten total loss of contents and house destruction. As well, the higher damages are only associated with rare (less than 1 in 1000 chance) or improbable (less than 1 in 10,000 chance) flood events.

Providing the dwelling survives a severe flood, the damage amount in Hawkesbury-Nepean flooding can be two to three times higher than elsewhere

Figure 41 *Comparison of flood ranges*



for similar frequency flood events. Furthermore, if the risk of damage to the critical structural systems of a house in the Hawkesbury-Nepean floodplain is not prevented from occurring, then total destruction is possible once flood levels rise 1 metre above the floor. Losses can then increase dramatically to over $200,000. (Note this is a conservative figure based on a modest house costing $150,000 to replace, including site clean up and new house construction, and contents value of around $50,000). The relative risk figure (Table 10) would then exceed 1000 – a figure almost ten times higher than that for floodplains where there is potential for only shallow flooding.

Comparison with community expectations

It can be seen from the previous steps, proper risk assessment involves considering risk over various levels of consequences (i.e. how much damage) and how often each level might occur. The objective of risk management is then to achieve a balance between these potential losses and their likelihood so that the risk ratings remain in the categories low to medium rather than high to extreme. Hence, high frequency events may be tolerated provided the resultant losses are minor. However, at the other extreme, a high loss event (such as one causing catastrophic losses exceeding $200,000) will only be endured if there is a very remote chance of the threat occurring, i.e. is a low risk event.

The risk matrix illustrates that for possible events between 1:100 AEP to the flood of record (i.e. post dam level) , the risk ratings include “High Risk” and “Extreme Risk”. Based on levels of community tolerance, these are considered excessive.

The survey conducted by Cox Consulting and Gutteridge Haskins and Davey – Analysis of Community Attitudes to Flood Related Risks, (HNFMS 2001), indicated that homeowners believed they had fairly limited financial capacity to cope with the impact of a natural hazard, being able to afford less than $10,000 from their own savings to rectify damage and losses. However, most floods would cause damage exceeding that amount. For example, relatively shallow flooding in houses of less than 100 – 200 mm would result in total flood losses of up to $25,000. About 90% of these losses would involve damage to contents such as carpets and furniture at floor-level. This amount of damage, whilst high and undoubtedly inconvenient and the cause of distress may not be an insurmountable financial burden on the majority of homeowners. It may be cushioned by the fact that the contents which are likely to be damaged have a limited life due to wear and tear and need to be replaced normally over time. Hence a more realistic upper threshold for ‘tolerable’ losses might be closer to $25,000.

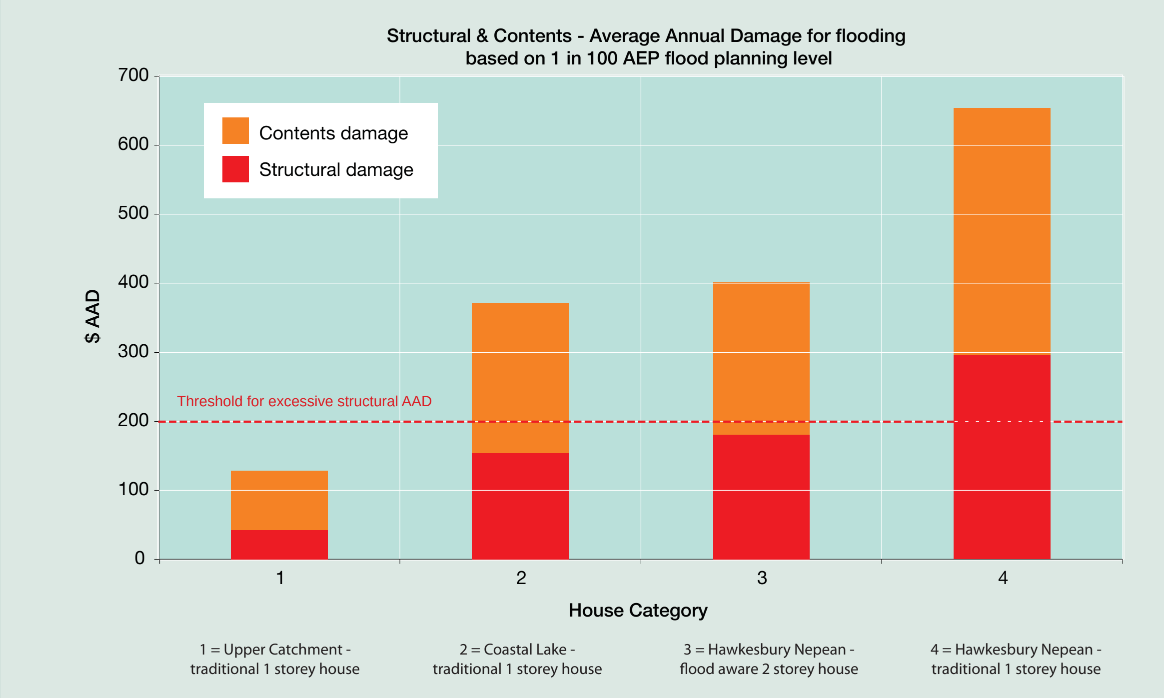
For shallow flooding of around 100 mm deep water, damage to the building itself should be only minor, costing between $2500 and $5000. Damages increase markedly as the water becomes deeper as more expensive components become affected by floodwaters. By the time water reaches a depth of 1.5 metres, about 70% of the structural damage will have been incurred, (Figure 38).

Affordability of Flood Risk

The difference in level of risk at different locations can also be seen by comparing the damage potential and typical annual average damage (AAD) figures as derived for these Guidelines, (Figure 42).

The AAD figures give an indication of the cost living on the floodplain if it were possible to spread losses evenly over the long term. The AAD values should be low enough to ensure the benefits to floodplain occupants outweigh the losses in financial terms. For developments located above the FPL based on the 1 in 100 AEP flood, this is usually the case. For the upper catchment and coastal lake examples, the AAD values for structural house damage are in the order of $50 and $150 respectively.
In comparison, the Hawkesbury-Nepean structural house damage AAD values for a traditional single storey house are higher at around $300, (Figure 42).

***Figure 42** Comparative structural and contents Annual Average Damages in different catchments*



Another way of viewing the issue is to examine whether the community would consider the risk affordable. This can be gauged by the premiums the insurance industry would be likely to charge for covering flood risk and whether they are reasonable. High premiums reflect a high risk and vice versa. If the risks are too high, as reflected by high premiums, the public tend to avoid or are discouraged from purchasing that high risk asset because the premiums are seen as unaffordable.

If the insurance industry were to be attracted to covering flood losses, it should be remembered that the premiums charged to homeowners on the floodplain would include not only the relevant AAD value, but also administrative costs, profit margin, stamp duty etc.

It is important that these premiums are affordable and sufficiently attractive to draw in large numbers of policyholders to ensure a scheme is viable and worthwhile financially. The Community Attitude survey (Cox and GHD 2001) indicated that around 50 to 60% of the respondents were willing to pay up to $200 more for their insurance premiums if flood damage was covered. This amount to cover flood hazard would be in addition to the existing building cover insurance. This increase would appear to be relatively affordable.

Using this information, it suggests that the AAD figures should be at least below $200 p.a. However, the Hawkesbury-Nepean floodplain AADs for traditional one-storey housing are substantially higher at $300 indicating that risk may be excessive. This gives a strong case for introducing measures to reduce the vulnerability of buildings flood damage in order to reduce the AAD values.

Close examination of the stage-damage relationship and the AAD values shows that *contents* damage can be higher than *structural* damage and therefore may be presumed to be of greater concern. In reality however, the impact of contents losses, although traumatic, is not as critical as structural damage. The approaches taken by householders to reinstating building damage and replacing their damaged household contents are also likely to be different. When insurance is unavailable and savings are limited, then priority would normally need to be given to making the house structurally safe, secure, weatherproof and habitable in the shortest possible time. These measures include replacing unsafe electricity supply components, replacing broken windows and doors, repairing damaged walls and preventing further deterioration to the house structure. If savings are insufficient for essential repairs, borrowing may be required.

There is more choice in replacing contents than in repairing the structure. However, compromises may be needed, based on such factors as:

- what household items are essential and have to be replaced or repaired immediately to support a return to the home;
- what can be replaced gradually over the short/medium or longer term;
- the householder's ability to pay for replacement items in the absence of insurance pay-outs and the means tested, and limited disaster recovery grants available from the government;
- the quality of the replacement item; and
- whether the item is worth repairing (considering its age and condition), or replacing.

If savings are not sufficient then replacement of some contents may be foregone rather than borrowings increased.

Step 8 Controlling and Reducing Flood Risk

The risk ratings in Table 11 are presented in Figure 43 as a risk matrix, i.e. the risk of damage to a traditional single storey brick veneer, slab on ground house. Having established the risk matrix concept the remaining goal is to determine what can be done to reduce those risks which are too high to be ignored and cannot be accepted without some controls for their reduction and effective management.

In a land use planning and development control context, risk reduction can involve a combination of measures for a range of options as shown in the text box below.

Isolation of risk	preventing development in high threat and unsafe areas.
Elimination of risk	countering flood hazard impacts in residential areas through suitable building design and development layout.
Control of the risk	using elevation to reduce exposure to frequent flooding or controlling types of land uses depending on the flood hazard vulnerability.
Substitution	using flood compatible building materials and construction methods.
Protection of occupants	ensuring provision for evacuation and other emergency management measures where the flood hazard is a threat to people.

Careful application of a combination of measures for any of the above options influences to what level of risk the development will be exposed.

Figure 43 *Risk Analysis for Structural Damage to a traditional brick veneer single storey house*

Risk analysis for structural damage to residential development in floodplains
based on a traditional single storey, brick veneer, slab on ground house

Floor level range	Likelihood of above floor flooding	Chance of experiencing in a life time	Structural damage consequences				
			Insignificant < $1,000	Minor d < 0.1m $1,000 - $5,000	Moderate d > 0.1 & < 0.5m $5,000 - $25,000	Major d > 0.5 &< 1.0m $25,000 - $50,000	Catastrophic loss of house $150,000 plus
1:10,000 AEP to PMF	Improbable	0.7% - 0.07%	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
1:1,000 to 1:10,000 AEP	Rare	7% - 0.7%	Low Risk	Low Risk	Low Risk	Low Risk	Medium Risk
Flood of record to 1:1,000 AEP	Unlikely	30% - 7%	Low Risk	Low Risk	Low Risk	Medium Risk	High Risk
1:100 AEP to flood of record	Possible	50% - 30%	Low Risk	Low Risk	Medium Risk	High Risk	Extreme Risk
1:50 to 1:100 AEP	Likely	75% - 50%	Low Risk	Medium Risk	High Risk	Extreme Risk	Extreme Risk
Below 1:50 AEP	Almost Certain	100% - 75%	Medium Risk	High Risk	Extreme Risk	Extreme Risk	Extreme Risk

Note: This figure reflects the most serious impact on the individual/household i.e. significant structural damage or the total loss of the house. Although the loss of any contents has financial implications, contents can be progressively replaced over time. There is more choice in replacing contents than in repairing the building structure. Furthermore, some contents losses may be foregone if the borrowing capacity is limited. On the other hand structural damage must be rectified to a satisfactory minimum standard before a dwelling can be considered safe enough to reoccupy.

Setting Risk Bands

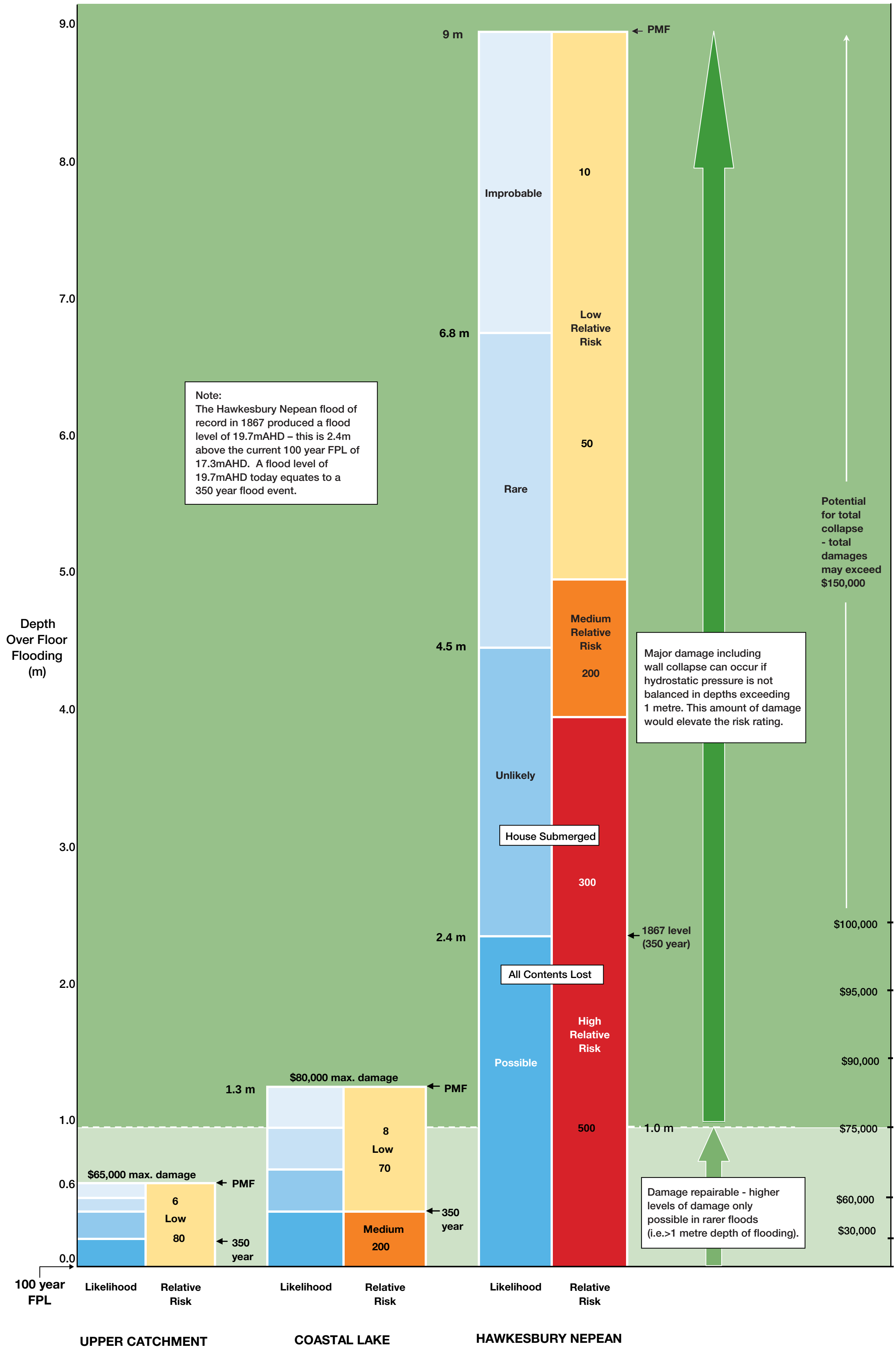
The flood risk changes progressively across a floodplain with risks decreasing with every increase in the floodplain elevation. At higher elevations, some measures will no longer be necessary because flooding will either not be deep enough to cause severe consequences or be frequent enough to be a concern.

The number of risk bands required depends on the gradation of risk, the benefits gained from the measures and the cost and practicability of their implementation. Specific controls on land uses, development and buildings would then be applicable to each of the bands.

Setting the First Risk Band

The first risk band is based on the FPL for residential development, i.e. above the 1 in 100 AEP flood level which is the most commonly applied measure throughout NSW. The setting of flood planning levels prevents development being flooded too frequently. If the 1 in 100 AEP flood is adopted for the minimum FPL then all flood risks to the building below this elevation will generally be avoided (although in elevated buildings the below-floor area would be vulnerable to damage). This includes a large proportion of risks with a high to extreme rating, (Table 11).

Figure 44 Risk comparison for a modern single storey brick veneer house in different catchments



However, as discussed previously, even above the 1 in 100 AEP flood in the lower Hawkesbury-Nepean floodplain, there is still the possibility of major and catastrophic damage to buildings in rarer floods which mean high and extreme risks remain present. These risks are hardly present in the upper catchment and coastal lake scenarios, because structural damage will barely exceed $25,000 to $30,000, (Figure 44).

The major factor which can bring about losses of a catastrophic proportion is the large water forces from deep flood levels and high velocity flows causing the walls to collapse. This can be controlled by the adoption of a strategy of wet proofing and the application of an N rating system to resist higher forces from moving floodwaters. (Chapter 10 gives more information on the N Rating system and other measures, which can be adopted to protect buildings against flood damage). This measure will largely reduce risks in the right hand column of the risk analysis in Figure 43.

A further reduction in flood risk can be gained by adopting a two-storey flood aware house design. This can potentially halve both the structural damage and the contents damage particularly for flood events below the first floor level. This also offers a more economic solution to reducing structural damage, (Figure 47).

The breakdown of damages under 'structures' includes some items that are fixtures e.g. kitchens, bathroom cabinets and permanently installed cooking appliances. These are not structural, i.e. they are not load bearing components, but have been included here for consistency as they are normally included in home buildings insurance policies.

With a flood aware design, damage to the structural components could be significantly reduced and confined to repairing affected parts of electricity supply, cleaning and repainting lower ground walls and replacing broken windows and doors. This would cost less than $10,000 and be regarded as low risk. A conventional single storey house would involve repairs costing around $30,000 (excluding kitchen) and would be "High Risk".

***Figure 45** Risk Analysis for structural damage to a traditional single storey brick veneer house with options to reduce the damage*

Risk analysis for structural damage to residential development in floodplains
Based on a traditional single storey brick veneer - slab on ground house

Floor level range	Likelihood of above floor flooding	Chance of experiencing in a life time	Structural damage consequences				
			Insignificant < $1,000	Minor d< 0.1m $1,000 - $5,000	Moderate d> 0.1 & < 0.5m $5,000 - $25,000	Major d > 0.5& < 1.0m $25,000 - $50,000	Catastrophic loss of house $150,000 plus
1:10,000 AEP to PMF	Improbable	0.7% - 0.07%	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
1:1,000 to 1:10,000 AEP	Rare	7% - 0.7%	Low Risk	Low Risk	Low Risk	Low Risk	Medium Risk
Flood of record to 1:1,000 AEP	Unlikely	30% - 7%	Low Risk	Low Risk	Low Risk ($25,000 upper floor)	Medium Risk	High Risk
1:100 AEP to flood of record	Possible	50% - 30%	Low Risk	Low Risk	Medium Risk ($20,000 ground floor)	High Risk	Extreme Risk
1:50 to. 1:100 AEP	Likely	75% - 50%	Low Risk	Medium Risk	High Risk	Extreme Risk	Extreme Risk
Below 1:50 AEP	Almost Certain	100% - 75%	Medium Risk	High Risk	Extreme Risk	Extreme Risk	Extreme Risk
Avoid Residential Development below 1:100 AEP level						Control by adopting 2 floor levels	Control by wet flood proofing and "N" Rating System

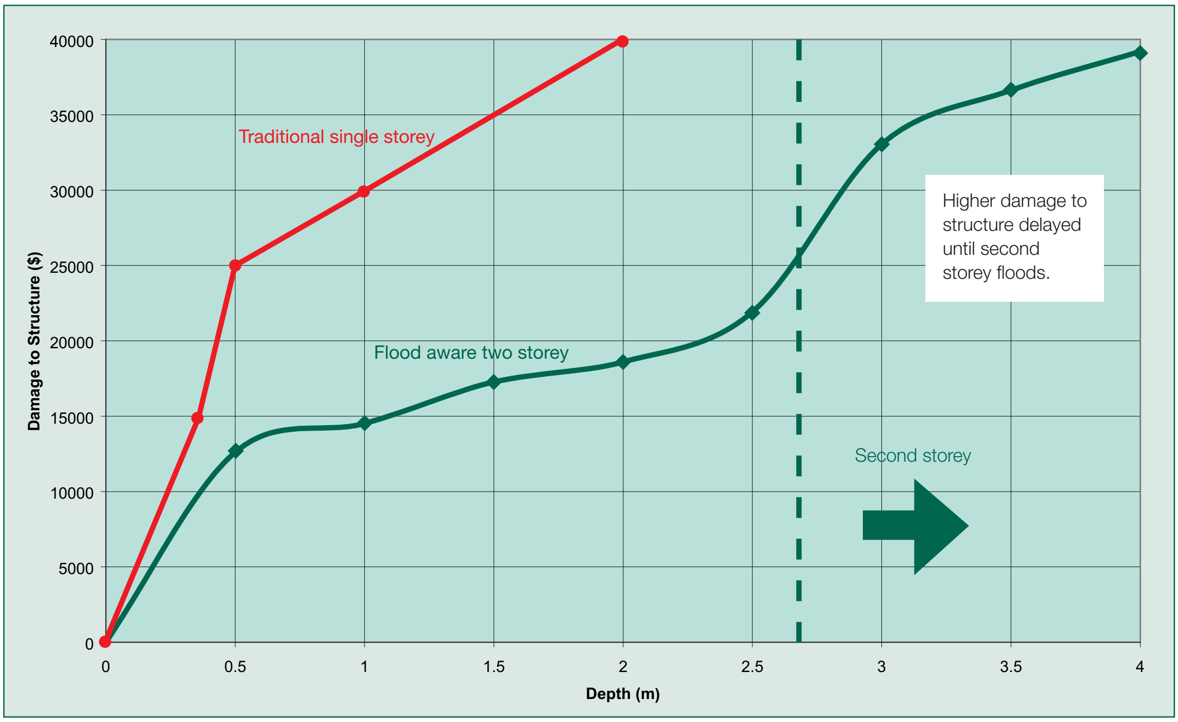
In regard to contents damage, the risk matrix shows contents losses of around $25,000 on the lower floor. If some higher value contents can be moved to the upper storey then a further reduction in losses.

Throughout the risk management process, the measures considered should be practical as well as cost effective. Those suggested for the lower risk band (1 in 100 AEP to flood of record), would meet these requirements. From the Community Attitude survey results, (Cox and GHD 2001), it is clear any measures should also be acceptable to the public and meet their expectation from a cost viewpoint in delivering better levels of protection.

A further solution could also be to raise the FPL to above the 1 in 100 AEP flood. Whilst this would also maintain "Medium Risk" or "Low Risk" ratings, it has the disadvantage that it would also sterilise extensive areas of the floodplain from residential development and alienate communities in existing urban areas.

To evaluate the risk reduction benefits (particularly to structural damage) of changing to flood aware two storey houses at the 1:100 AEP FPL or above,

Figure 46 *Reduced house structure damage in dollars with a two storey flood aware house*



it is necessary to account for the depth damage relationship for such housing. Figure 46 shows the damage versus depth of flooding relationship for a two storey house with an equivalent total floor area as the traditional single storey house.

From Figure 38 it can be seen that the damage to the house structure for a 1.5 metre deep flooding over the floor is around $35,000 for a traditional single storey house. The relative risk for this amount of damage is up to 350 for a 1:100 AEP floor level. This equates to a "High Risk" rating. In contrast, Figure 46 indicates that the structure damage would decrease to around $17,000 for a two storey flood aware house for similar depths of flooding. The risk rating for such a house is "Medium Risk" (i.e. risk rating = 170), which is far more desirable than a "High Risk" rating with twice the level of losses.

Using Figure 46 it is possible to derive a "Risk Analysis for Structural damage to a two storey flood aware house", as shown on Figure 47. As evident from Figure 47, two storey flood aware houses built above the 1:100 AEP flood level would generally have a more acceptable "Low Risk" rating. It is only the houses with ground floor levels close to the 1:100 AEP level that have a "Medium Risk" rating when deeper flooding at 2.4 metres inundation occurs above the ground floor level.

Second Risk Band above the residential FPL

For the next flood range i.e. between the flood of record to 1 in 1000 AEP, risk could be restricted to "Medium Risk" and "Low Risk" ratings provided suitable building materials are used e.g. suspended timber floors and structural wall frame bracings. This involves careful selection of suitable materials with the cost the differences of better performing materials being only marginal.

The consequences of not including these measures at the outset, could mean that in the event of flood damage, the replacement of those specific components may also involve removal and replacement of wall linings, skirtings and architraves which would add a further $10,000 cost.

Figure 47 *Risk Analysis for structural damage to a flood aware designed two-storey house*

Risk Analysis for Structural Damage to Residential Development in Floodplains based on a flood aware designed two storey house					
Floor Level Range	Likelihood Of Above Floor Flooding	Chance Of Experiencing In A Life Time	**STRUCTURAL DAMAGE CONSEQUENCE**		
			INSIGNIFICANT < $1,000	MINOR $1,000-$5,000	MODERATE $5,000-$25,000
1:10,000 AEP to PMF	IMPROBABLE	0.7% - 0.07%	Low Risk	Low Risk	Low Risk
1:1,000 to 1:10,000 AEP	RARE	7% - 0.7%	Low Risk	Low Risk	Low Risk
Flood of record to 1:1,000 AEP	UNLIKELY	30% - 7%	Low Risk	Low Risk	Low Risk ($25,000 upper floor)
1:100 AEP to flood of record	POSSIBLE	50% - 30%	Low Risk	Low Risk	Medium Risk ($20,000 ground floor)

The benefits of these measures could therefore justify a flood risk band within this flood range.

A single storey dwelling flood aware can have a reduction in risk in this band if flood aware design is adopted.

Third Risk Band above the residential FPL

Above the 1 in 1000 AEP flood level, the risk ratings are all "Low Risk" and therefore may not warrant building protection measures. This flood range which extends up to the PMF, could constitute an upper risk band which includes measures to control inappropriate land uses and protect critical infrastructure rather than protect property. These matters are discussed further in Chapter 11.

Risk bands for the flood planning area (land below the residential FPL)

The frequency of flooding on land below the 1 in 100 AEP flood level confirms the practice of restricting all residential development to land at or above that level, even if the risk is shown as "Low Risk" or "Medium Risk" in Figure 45.

Overall, to control the full gradation of the risk in the Hawkesbury-Nepean floodplain, up to two more flood risk bands should also be applied for non-residential land uses at levels below the FPL adopted for residential development. One of these lower bands could include commercial and industrial land uses with no residential component.

It is recognised that within each flood risk band there will be a gradation of risk. However, by the application of common controls within each band, new development would have its flood risk reduced to a level which is tolerable for the band as a whole.

Identification of flood risk bands should be undertaken as part of a council's Floodplain Risk Management Plan process. This process includes undertaking flood studies to determine the exposure of the land to flood hazard and flood behaviour. Historical flood data and existing flood studies can assist in this regard, as can the Flood Hazard Definition Tool provided to councils through the HNFMS.

Table 13 gives an indication as to how flood risk bands may be described and the areas of flood probability to which they may be applied. Not all floodplains will warrant application of this number of bands.

***Table 13** Flood Risk Bands*

Flood planning area	Flood risk band
Land lying below the 1 in 50 AEP flood event.	Flood risk band A
Land at or above the 1 in 50 AEP but below the 1 in 100 AEP.	Flood risk band B
Land at or above the 1 in 100 AEP but below the 1 in 200 AEP or flood of record which ever is the higher.	Flood risk band C
Land at or above the 1 in 200 AEP or flood of record whichever is the higher, but below the 1 in 1000 AEP.	Flood risk band D
Land at or above the 1 in 1000 AEP up to the probable maximum flood.	Flood risk band E

Flood planning levels can be used to determine more than just floor levels. How flood planning levels can be applied to a range of elements in order to reduce the risk to new floodplain housing is given in the hypothetical case study at the end of this chapter on pages 101 and 102.

Mapping the Flood Risk Bands

Zone boundaries and development applications are generally aligned to cadastral boundaries. It is unlikely that flood risk will conveniently coincide with such boundaries. Therefore, for ease of implementation, especially in urban areas where lot sizes tend to be smaller, and given the scale of mapping available, it may be preferable to align risk band boundaries with cadastral boundaries. This would avoid any one lot being subjected to multiple risk band controls. Ideally, the higher and not the lower risk band should be applied to the whole of the lot, in order not to compromise the level of risk reduction.

However, in rural areas where lots are larger and may contain significant variations in ground level (and hence flood risk), having more than one risk band within a property may be appropriate.

It would enable development to be located on those parts of the lot where the risk is lowest, thus reducing the potential for damages.

It is common for environmental planning instruments to include a provision which compensates for the scale of mapping, such as

"Development which is permissible in one zone but prohibited in the adjacent zone, may be permissible in the zone where it is prohibited if it is carried out within [insert distance as per local policy decision] of the zone boundary provided zone objectives are not prejudiced."

A similar provision could be applied to flood risk band boundaries provided the applicant could demonstrate that the flood risk was acceptable for the proposed use.

RISK BAND CASE STUDY

Site description

> Flood prone land adjacent to the river. The site floods in mainstream floods just slightly larger than the 1 in 100 AEP event. Entire site is completely inundated in a 1 in 500 AEP event when part of site is subject to low to moderate velocities.

> Land is filled to level of 1 in 100 AEP flood but cannot practically be raised higher because of existing adjacent development.

> No physical structures such as a levee or barrier can mitigate depths in floods bigger than the 1 in 100 AEP event.

> Greater depths of flood inundation above the 1 in 100 AEP than in many other areas and typical of those from mainstream Hawkesbury Nepean River flooding in the possible to improbable flood event range (i.e. 1.4 metres depth for a 1 in 200 AEP flood event and greater than 6 metres for a PMF type event).

> Potential for hazardous flow velocities in lower areas of the site. These velocities may have the potential to cause structural damage to a brick veneer house.

Reducing risk to achieve the objectives of the Flood Prone Land Policy

The following risk management strategy offers a more comprehensive risk management approach to the traditional approach of having only a single FPL for residential floor levels, no flood related building controls and no recognition of the consequences of larger floods:

FLOOD RISK BAND C

> Select the 1 in 100 AEP flood level (1%) plus a freeboard of 0.5 metres as the flood planning level **FPL–1** below which no residential development would be permitted. **FPL–1** would be the minimum residential floor level.

- All dwellings to be two-storey flood aware design as described in the 'Guidance on Building in Flood Prone Areas' to reduce damages due to water depth.

Rationale: choosing a higher FPL as the basis for development requires filling with associated environmental impacts and other costs and is limited by need to maintain levels compatible with adjoining land and existing development. Two-storey flood aware design can further reduce flood risks.

FLOOD RISK BAND D

> Set a second **FPL–2** at the 1 in 200 AEP flood level (0.5%) or flood of record plus freeboard of 0.5 metres:

- All dwellings within this band to have a minimum of 50% of their habitable floor space at or above this higher **FPL–2**. Note the difference between the 1 in 100 AEP and the 1 in 200 AEP flood level is no greater than one storey.

Rationale: to reduce the probability of flooding for a substantial proportion of habitable floor space and to reduce contents damage to minimise financial losses and assist recovery.

- All dwellings within this band to be of flood aware design as described in the 'Guidance on Building in Flood Prone Areas' to reduce damages due to water depth.

9

Rationale: to diminish the chances of structural failure to buildings and to reduce damages, including failure to non-structural elements in the event of inundation.

Flood aware two-storey dwellings at FPL-1 in bands B, C and D. Single storey dwellings only at or above FPL-2 in band D or band E.

FLOOD RISK BAND E

> Set a third **FPL–3** at the 1 in 1000 AEP flood level plus freeboard of 0.5 metres.

Rationale: given the low likelihood of flooding the risk of structural damage etc is low. As a result the need for flood aware design is less critical.

ALL FLOOD RISK BANDS

> All dwellings in areas subject to moving floodwaters, to be designed and constructed of suitable materials to an N rating to adequately protect against flood damages caused by high velocity up to the flood of record .

Rationale: to protect building against structural damage/total failure in the event of moving floodwaters.

> Determine a site-specific evacuation route planning level, which would rise continuously from all occupied properties to land above the PMF.

Rationale: to ensure all occupants can safely evacuate by vehicle away from rising floodwaters before exit routes are cut by rising flood water.

> All land below the PMF level is flood prone and should be identified as such. The following public awareness and notification methods should apply to all land at or below the PMF:

- Section 149 certificates for all lots on the site to have a notation that the land is subject to Hawkesbury-Nepean flooding up to the PMF (and local flooding if that is the case) and that council policies regarding development of flood liable land apply.

Rationale: to ensure that all purchasers of property on flood prone land up to the PMF are able to make informed choices.

- The on-going dissemination of flood awareness material to all occupants and owners of property on the site.

  Rationale: to ensure that all occupiers and owners are included in on going public awareness/education programs.

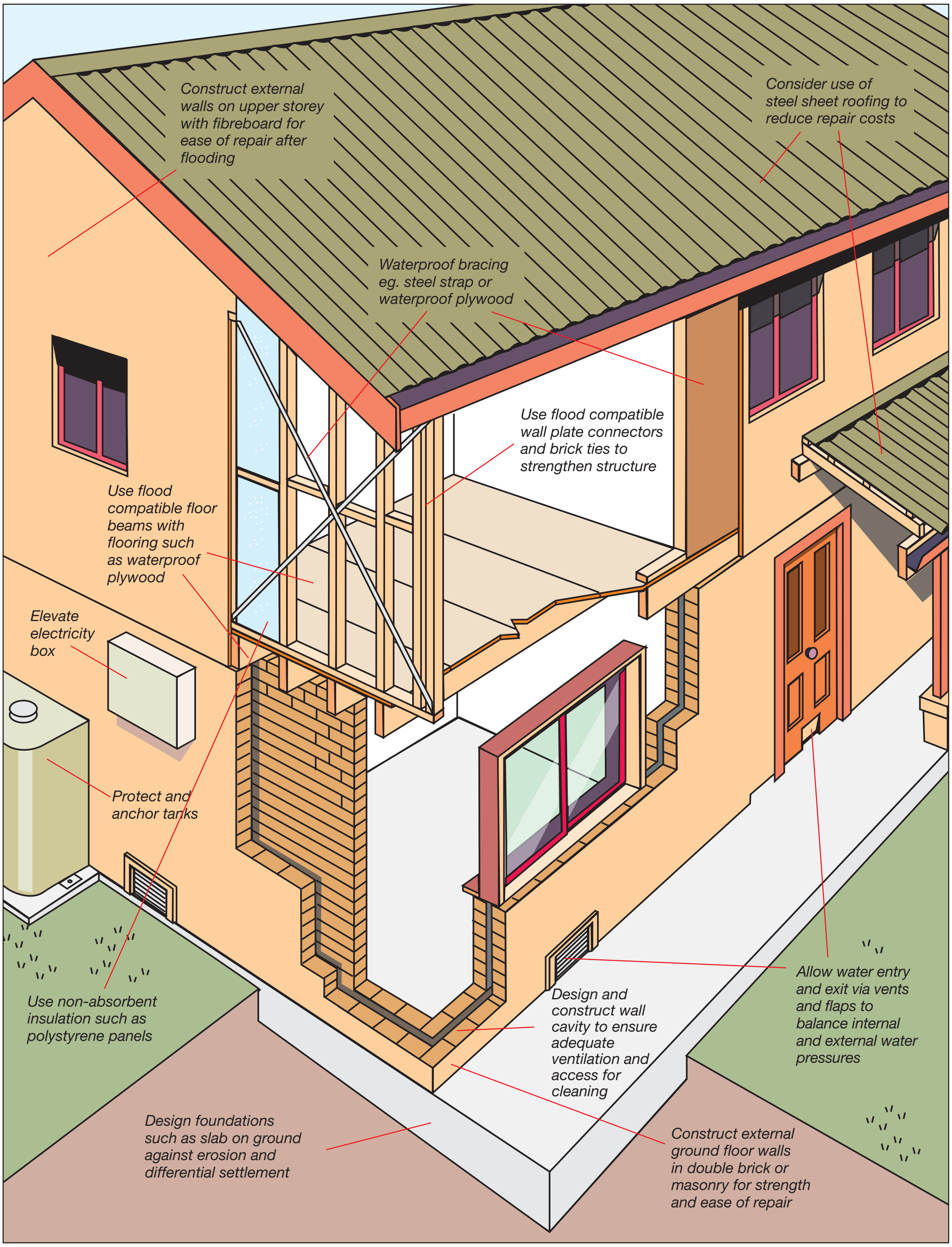
10

REDUCING THE RISK THROUGH FLOOD AWARE RESIDENTIAL DEVELOPMENT

How House Design, Construction and Materials Can Reduce the Flood Risk

Alternative housing types, incorporating materials and construction methods that are more flood-tolerant can significantly reduce vulnerability to flood damage and thus the level of risk borne by householders, (Figure 48). The Building Guidelines "Reducing vulnerability of buildings to flood damage – Guidance on Building in Flood prone Areas" provides detailed information as to how to achieve flood risk reduction in residential dwellings and is summarised here.

Figure 48 *A flood aware designed house suited to both high and low hazard areas*



How to Reduce Damages Arising from Depth

One, two or more storeys

A single storey brick veneer house built to current standards, together with its contents, is the most vulnerable type of housing to suffer flood damage. Simple alternatives such as having two (or more) storeys can provide opportunities for householders to protect contents on an upper floor where the probability of incurring flood losses is much lower. However, unless flood conditions are taken into account in the design and construction of dwelling houses so that they are able to resist flooding, structural damage will mean that expensive and lengthy repairs are inevitable. This prolongs the recovery period, with resultant social and economic implications. Flood aware housing design includes a range of measures, some of which are highly recommended whilst others are not essential but would result in reduced damages and facilitate the clean-up period. The Building Guidelines differentiate between measures, which are:

- critical to ensuring structural soundness;
- worthwhile in minimising damage and assist in the clean-up; and
- more related to furnishings and fittings and are clearly a matter of personal choice.

Increased density

Medium and high-density forms of residential development, which make use of prefabricated or tilt-up concrete panels or full brick construction, offer good alternatives for higher flood risk areas. This form of housing construction can reduce the risk of structural damage. It can achieve comparable yield on a smaller footprint thus avoiding the higher risk parts of a site such as those with high velocity or greater chance of flooding. The construction techniques and materials used for medium and high density forms of housing have lower susceptibility to damage than stud framed dwellings and as upper level units are higher, they have a much-reduced chance of being flooded so reducing the risk of contents damage. (Figures 49 and 50).

How to Reduce Damages Arising from Velocity

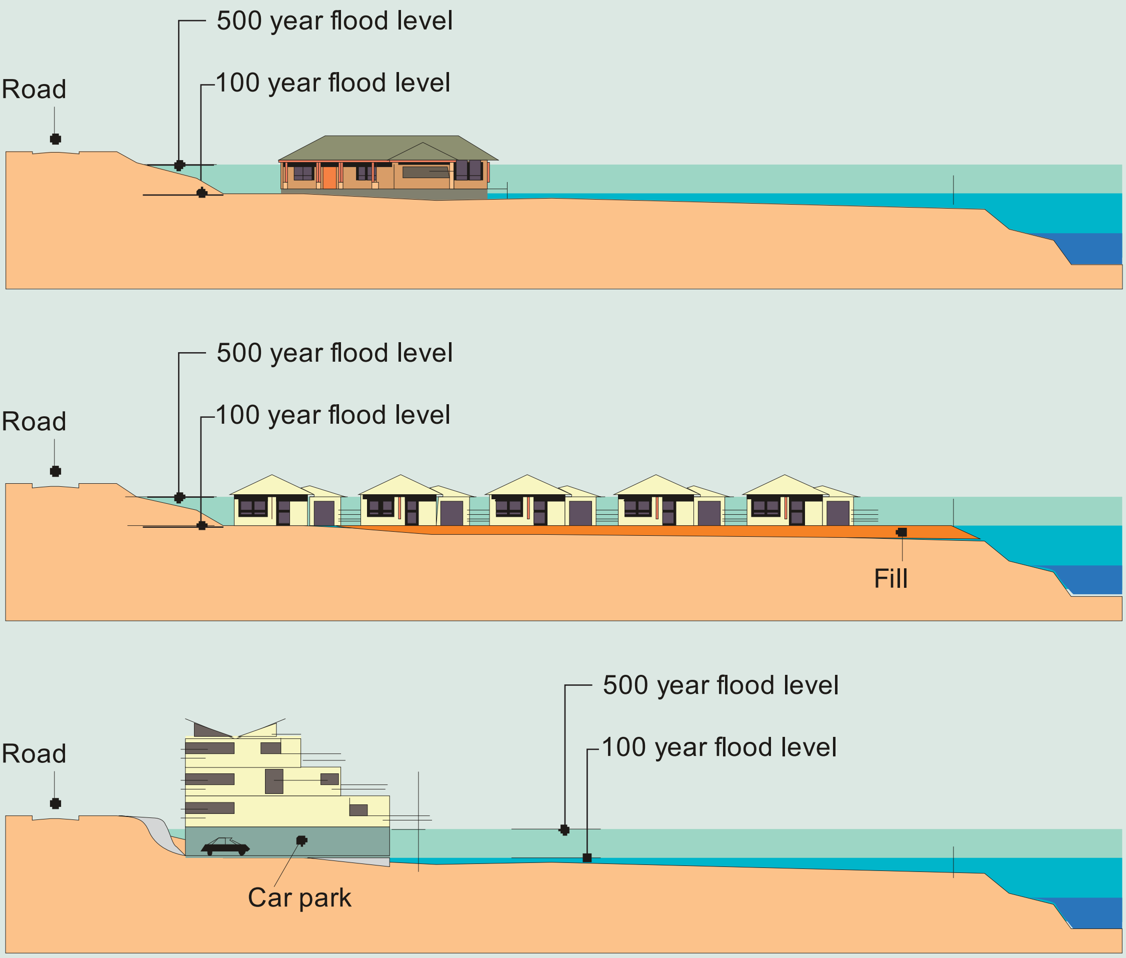
Flood hazard is made up a combination of several factors including water depth and velocity. As shown in the previous chapter, in the Hawkesbury-Nepean floodplain, the potential flood depths between the 1 in 100 AEP flood level and the PMF can result in houses having floodwater over the ceiling or even their rooftops.

Figure 49 *Medium density housing has advantages in flood prone areas*

Medium density housing can make use of concrete and block work construction and have a lower susceptibility to water damage than brick veneer construction.

10

***Figure 50** Alternative site layout can reduce risk*



Multi unit housing on the higher part of a site can achieve comparable yield and yet reduce the risk of flood damages to dwellings compared to a traditional subdivision layout of single storey brick veneer dwelling houses across site.

Whilst water depth is a widespread hazard, high velocities are generally found nearer to the river or where the floodplain is narrower. Velocities from mainstream flooding are generally lower in flood storage areas such as Riverstone, Bligh Park and McGraths Hill. However, near Penrith and downstream of Sackville, there is the potential for dwellings to be exposed to fast moving floodwaters and to damaging velocities. Forces from local velocities around a building may require additional measures to limit damage to an acceptable and manageable level.

Protecting buildings against natural hazards

Commonwealth and State Government recognise that flooding is the most costly, yet most manageable, natural hazard. There are benefits in introducing building codes for protecting structures against flooding, comparable to those already in place for other natural hazards such as bushfire, cyclones and earthquakes. The Building Guidelines advise how to improve the reliability of the structural design of dwelling houses under low flow conditions. This approach recognises the tendency for velocities to increase around houses due to the blocking of flood flow paths by the development itself, which reduces flood conveyance areas.

> Areas subject to high velocity floodwaters in a 1 in 100 AEP flood are not suitable for new residential development.

Areas where houses are likely to be subjected to the more frequent and/or higher velocity flooding where there is the potential for significant damage should be avoided for new residential development. These areas have a higher potential damage from debris loads and foundation erosion as well as being more hazardous for residents and emergency operations in flood events. Development is not encouraged in areas where there is the potential for significant velocity in a 1 in 100 AEP flood. However, it should be recognised that for some sites, floodway conditions may develop in rarer floods and velocities may be hazardous. If hazardous velocities can occur then the suitability of the land for residential development should be questioned.

An approach developed by CSIRO in Melbourne equates water velocity to wind velocity so that established and familiar wind design methods (in AS 4055 Wind Loads for Housing) can be adapted to house design to resist flood velocity. This uses the N rating procedure, with conditions necessary to counter additional problems arising from water immersion. The adopted basic wind/water design relationship indicates that N1 through to N6 ratings generally apply to water velocities of 0.8 to 2.1 metres / second.

The Building Guidelines include a set of design tables based on this approach. The Building Guidelines equate the risk of exposure to structural damage to a house regardless of its elevation on the floodplain, based on risk being a product of consequence and likelihood. If risk is to be reduced, stricter design requirements (i.e. higher N ratings) are required lower down on the floodplain than in the higher, less frequently flooded areas.

An unprotected house is unlikely to resist forces much greater than 0.8 to 1.0 metres / second. Research undertaken for the HNFMS by the University of Newcastle concludes that water flowing at around 1 metres / second up to the eaves of a house could cause failure of brick wall components. Further details of this study can be found in “Reducing vulnerability of buildings to flood damage – Guidance on building in flood prone areas” (the Building Guidelines).

Application of the Building Guidelines for Flood Prone Areas

Traditionally constructed brick veneer houses are particularly vulnerable where velocities greater than 0.8 metres / second will occur. As such, alternative building types are suggested for locations where such velocities could occur in floods up to and including at least the flood of record.

By carefully designing the subdivision layout and appropriately locating buildings, velocities can be controlled and reduced through a site. This may require additional flood modelling to examine a range of realistic post-development conditions under a range of flood probabilities.

Whilst building in high velocity areas is generally not appropriate, the damage arising from velocity can be reduced by building structurally enhanced housing. The Building Guidelines give detailed advice on how to choose a higher N rating which may be more stringent than that required for wind loading in the area in order to achieve protection from floodwater velocities. This method should only be applied to infill, redevelopment or small development sites where only a small number of houses will result. It is not appropriate to presume that hazardous, high velocity sites can be made safer for large-scale new developments through application of this methodology.

> Residential development is vulnerable to high local velocities.

The advice in the Building Guidelines is intended to limit structural damage to dwelling houses i.e. reduce the likelihood of potential damage to the structural components during and after flooding. It relates to the inundation of the dwelling by floodwaters with consideration given to potentially extended periods of immersion.

Suggested Flood Planning Levels (FPL)

Flood planning level =
selected flood level + freeboard

(e.g. FPL in metres AHD =
1 in 100 AEP flood level + 0.5 metre)

To prevent flood damages in frequent floods, a minimum FPL based on the 1 in 100 AEP flood level plus freeboard is appropriate for residential development. However, in the Hawkesbury-Nepean because of the potential for extreme water depths in floods not much rarer than the 1 in 100 AEP flood event, adopting the measures listed below could reduce damages. In the Hawkesbury-Nepean, the flood of record equates to approximately a 1 in 200 AEP event and the depth of floodwater is such that controls to reduce flood damage are warranted. Figure 51 illustrates this approach.

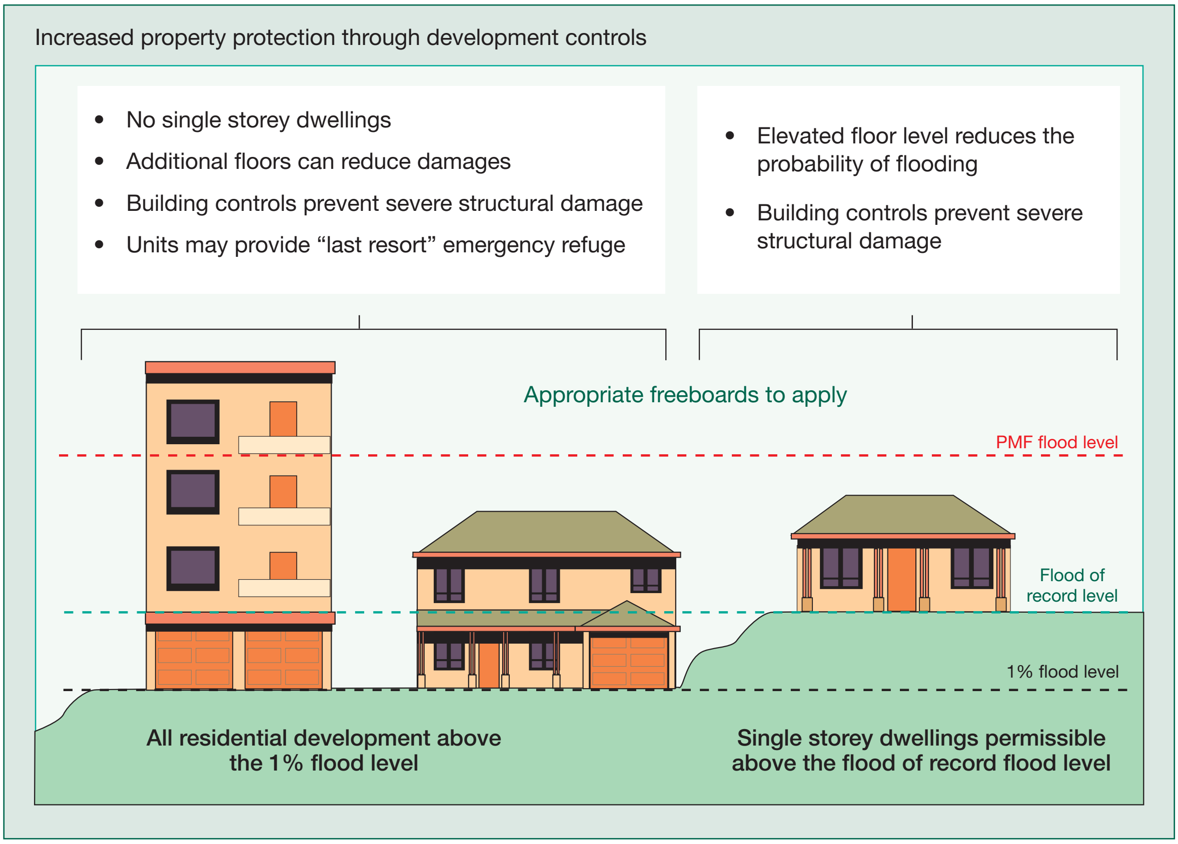
- If single storey dwellings are proposed their lowest habitable floor level should be at or above the 1 in 200 AEP plus freeboard.
- Incorporating the flood aware building measures for the design, materials and construction methods used in housing on flood prone land (Table 14 below).
- For dwellings with a habitable floor level lower than the 1 in 200 AEP flood level, incorporating the following measures can reduce flood damage:

  a) including two or more storeys; and

  b) building all external and load bearing internal walls below the 1 in 200 AEP FPL of masonry construction e.g. double brick, concrete block, concrete panel rather than brick veneer or framed walls with sheet cladding; and

  c) using timber frame walls with sheet cladding only for non load-bearing internal partitions.

***Figure 51** Flood planning levels can be used to reduce the risk to dwellings and contents*



The recommended measures in Table 14 focus primarily on those building components, which have high vulnerability to damage, and are structurally important. The use of traditional components, building methods and design could lead to high post-flood repair costs and unnecessarily prolong the recovery period.

The measures are intended to:

- provide the structure or fabric of the dwelling with adequate strength so that it will not be unacceptably compromised during or following immersion in water;
- reduce the chance of post-flood deterioration of structural components;
- involve minimal deviation from normal construction methods;
- be cost effective; and
- promote the use of materials and design for structural components in order to prevent expensive replacement or repairs.

The measures have been derived to ensure that any additional cost incurred in building a flood aware house is more than compensated for in the savings made when the house is damaged by floodwater. Calculations for a 180 square metre four bedroom dwelling house indicate that adopting a flood aware design costing an additional $17,000, can provide overall flood damage reduction in the order of $50,000 – that is $20,000 for structure and fixtures plus $30,000 for contents, (Figure 52).

Note that all references to the 1 in 200 AEP FPL means the level of the 1 in 200 AEP flood level plus adopted freeboard. Similarly the 1 in 100 AEP FPL is the 1 in 100 AEP flood level plus adopted freeboard. As discussed in Chapter 8, a freeboard is used to allow for uncertainties in flood modelling and other variables such as waves, afflux and climate change. A freeboard protects against flooding in the selected flood event. It does not protect against a rarer flood.

Figure 52 *Financial benefits of flood aware design housing in low and high hazard areas*

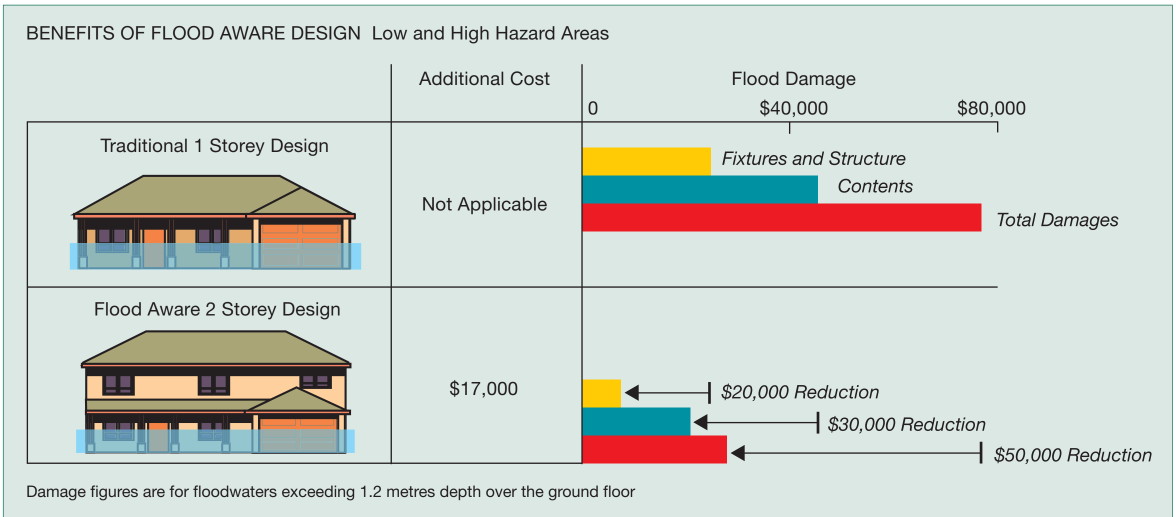


Table 14 *Summary of Flood-Aware Building Measures*

	FLOOD DAMAGE	FLOOD COMPATIBLE MEASURE
Component: FOUNDATIONS		
1	Erosion and soil saturation can result in subsidence and undermining of foundations.	Allow for flood conditions. Support foundations on same stratum. Protect exposed embankments.
Component: FLOORS AT ANY LEVEL		
2	Some types of fabricated beams, e.g. used in the floor, can lose strength after immersion.	Use flood compatible beams, e.g. solid timber or steel section beams, or make allowance for strength loss in design of beams.
3	Standard particleboard sheet flooring can lose significant strength when immersed and can fail especially under concentrated loads.	Use waterproof plywood.
Component: WALLS		
4	Autoclaved aerated concrete (AAC) blocks are very porous and can cause damage to other components when saturated.	For structural purposes, use materials which are dimensionally stable and not weakened by immersion, e.g. clay bricks, concrete blockwork, concrete panels.
5	Hardboard wall frame bracing can lose strength, both inherently and at fixings, when immersed.	Use bracing materials not structurally impaired by immersion e.g. steel straps, fibre-cement or waterproof plywood sheets.
6	Wet plasterboard wall lining is incapable of contributing to wall frame bracing.	Ignore bracing contribution from plasterboard wall lining. Structural bracing to carry full load (No 5 above).
7	Modern houses generally do not provide sufficient water entry points so water levels outside, inside and in the cavities are not equal, causing differential water pressures to deflect the walls, or even cause failure.	Allow water entry via vents and flaps to balance water pressure. Openings need to extend from outside to inside the house via wall cavities.
8	Face-fixed brick ties may pull away from studs under velocity forces or when inside water levels are higher than outside the house.	Use medium or heavy-duty side-fixed brick ties.
9	High water velocity can overload timber frame capacity and connections.	Design according to appropriate N (Wind Code) classification.
Component: INSULATION		
10	External wall frame wrap (e.g. sarking) or panel insulation hinders access to wall cavity for cleaning and post-flood ventilation of the cavity. Batts or loose fill insulation can sag and hold water restricting ventilation and promoting rot and decay or corrosion of frame structure.	Use insulation with minimal absorption that dries quickly e.g. polystyrene panels.
Component: GENERAL		
11	Poor ventilation in cavities e.g. wall and roof, can increase the chance of post-flood deterioration of structural components, especially timber.	Ensure adequate ventilation to cavities. Additional venting may be necessary e.g. in brick veneer walls vents with double the minimum of 7300 mm^2 per lineal metre provided around the base of external walls.
12	Narrow and/or winding staircases may hinder safe movement of contents to the upper floors.	Staircases should be designed to facilitate the relocation of contents from the ground floor to upper floors, e.g. straight, with a minimum 1m clear width, and treads and risers of comfortable proportions.
13	In multi-level housing, evacuation to higher floors within the building may be a preferable alternative to attempting to evacuate to higher ground in flash floods of short duration and limited warning.	Unrestricted internal stair access to refuge areas on upper floors should be available to all occupants and should include appropriate evacuation signage.

Retrofitting Existing Houses

After a flood event there is likely to be community pressure for immediate solutions to retrofit houses to meet higher standards. The cost of retrofitting the existing dwelling stock would be high (15-50% Stewart et al.) and unlikely to be practical.

House raising is one method used in NSW to protect existing houses in high hazard locations. Used on a case-by-case basis, it can be a costly solution, and is not appropriate to every location or to every house type. Following the preparation and adoption of a Floodplain Risk Management Plan (FRMP), a council may instigate a house raising scheme of flood affected properties in consultation with the residents, owners and the Department of Environment and Climate Change. Some government funding may be available. In considering house raising, regard should be had to the impacts on the streetscape, heritage issues, visual impacts, privacy and over shadowing. Residents need to be aware that house raising to achieve a floor level at the flood planning level still leaves the house vulnerable to floods higher than the design flood. By being higher than the surrounding ground level and roads, a raised house can easily become isolated in flood events, potentially trapping the occupants.

When extensions or renovations are planned for flood prone dwellings applying both the measures in the Building Guidelines and the FPL currently in use (if higher than the existing floor level), would give some increased protection to at least part of the dwelling. However, this may not always be practical and councils may prefer to limit the size of new extensions at very low-lying properties.

Voluntary purchase is a measure of last resort where low-lying residential properties are identified as being located in a high hazard zone or are at high risk from flooding. Funded jointly by state and local government, voluntary purchase is a costly option and it is generally adopted by councils as part of the their FRMP only when other measures have been investigated and found to be unacceptable to the community on social, environmental and economic grounds.

Owners can, if they so wish, sell their property to council at an agreed valuation based on the property not being flood affected. It is not compulsory purchase and so there is a possibility that some households may choose to accept the high risk. Upon purchase, the dwellings are generally demolished and the land used for non-residential purposes that are appropriate to the high level of risk.

Existing development will inevitably remain vulnerable to flood damage. The flood risk can be reduced to replacement dwellings on flood prone land if the same standards are applied as for new dwellings i.e. the relevant measures in the Building Guidelines and the FPL currently in use. In certain cases where it is considered that the flood risk to the occupants and the building itself is too severe, a council may be reluctant to permit a replacement dwelling. This is most likely to apply to very low-lying older dwellings on land below the 1 in 100 AEP flood level.

11 REDUCING THE RISK THROUGH LAND USE PLANNING

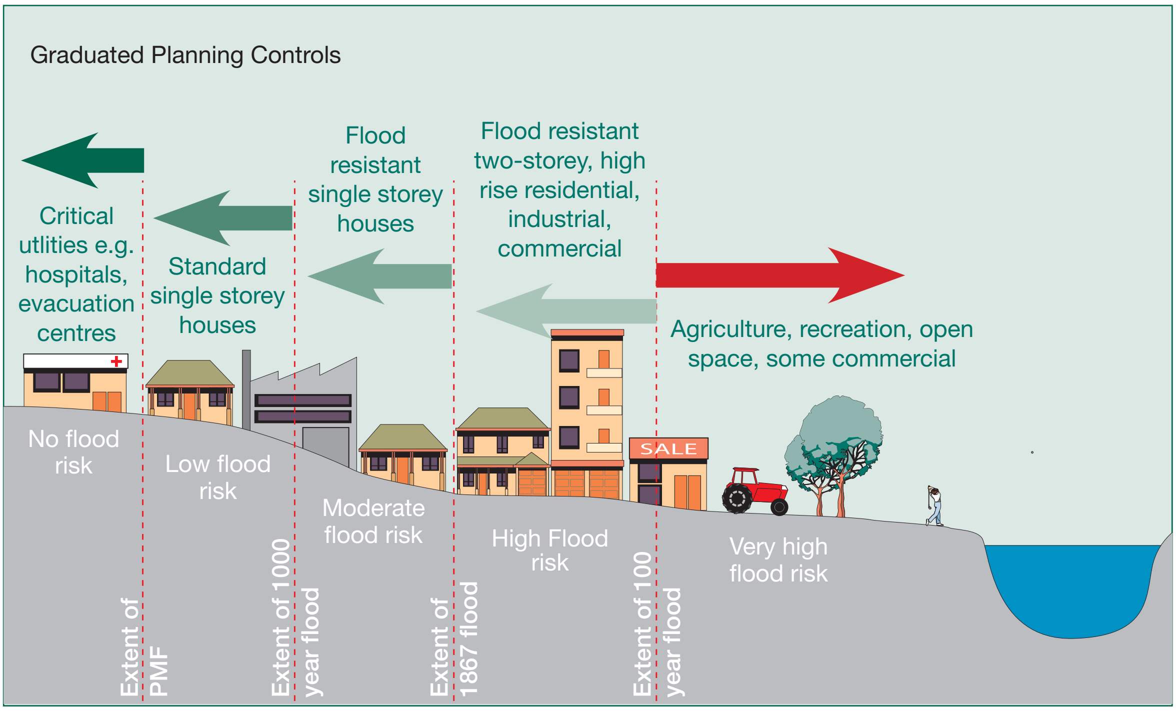
Graduated Planning Controls Using a Planning Matrix

The risk band methodology described in Chapter 9 allows the variation in flood damages risk to be graded and provides a basis for an alternative and more effective approach to managing flood risk by applying graduated controls. The Planning Matrix (Figure 54) is an effective way of presenting these graduated controls. They can then be implemented through environmental planning instruments and development control plans. The matrix method was identified in the Hawkesbury-Nepean Flood Management Advisory Committee's report "Land use Planning and Development Control Measures" (HNFAC 1997) as an appropriate means of implementing the outputs of a floodplain risk management plan through land use planning.

The matrix approach provides the opportunity to recognise that different land uses, densities and forms of development have different vulnerabilities to flood hazard. Land use can be planned in various ways to achieve risk levels which meet the expectations of both existing and future communities. Figure 53 illustrates in a simplified manner, the distribution of land uses within the floodplain using graduated controls. It contrasts the traditional approach of only relying on one FPL to manage the flood risk. As well as responding to flood risk through spatial distribution of land uses, the method also allows for controls in building design and local conditions to manage and minimise the consequences of flooding up to the PMF.

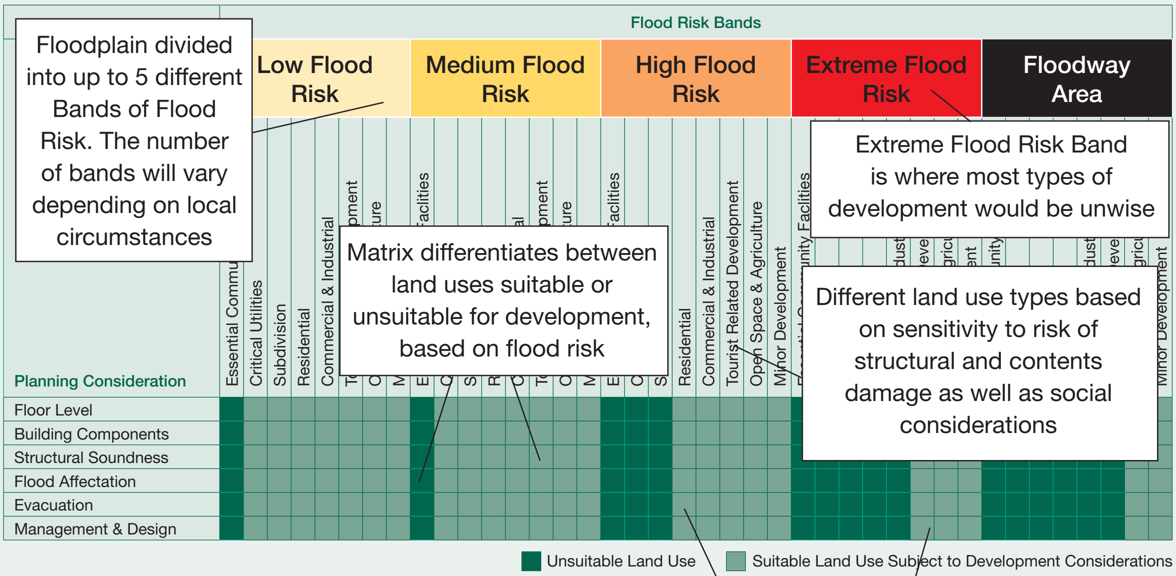
The matrix can specify planning controls, which can be applied across the floodplain for various land use and flood hazard categories. It also provides an opportunity to investigate options which maximise the use of the floodplain with the aim of achieving development expectations, while at the same time managing development and land use distribution in a manner which minimises vulnerability and ultimately, risks. It does this by avoiding the narrow traditional management approach which prohibited specified developments on lower parts of the floodplain.

Figure 53 *Distribution of land uses on the floodplain to reduce risk*



An example of the possible distribution of land uses in the floodplain according to the flood risk offering opportunities for safer occupation of the floodplain and reduced flood damages (note: the number of risks bands may vary between floodplain areas depending on the range in depth of flooding above the flood planning level).

Figure 54 *Risk Band Matrix for planning and development controls*



Note: Numbers which reflect specific controls are inserted into this matrix to provide individual controls dependant on local circumstances in each Council area

Floor Level

1 All Floor Levels to be equal to or greater than the 5% AEP flood plus freeboard
2 Habitable floor levels to be equal to or greater than the 1% AEP flood plus freeboard
3 Habitable floor levels to be equal to or greater than the flood of record plus freeboard
4 Habitable floor levels to be equal to or greater than the 0.1% AEP flood plus freeboard
5 All Floor Levels to be equal to or greater than the PMF flood plus freeboard
6 Floor levels to be as close to the design flood level as practical & no lower than the existi
7 Floor levels of shops to be as close to the design flood level as practical or more than 30 proofed below the design flood level

Building Components & Method

1 The structure to comply with Building Guidelines (section....) below or at the 1% AEP flood plus freeboard
2 The structure to comply with Building Guidelines (section....) below or at the flood of record plus freeboard
3 The structure to comply with Building Guidelines (section....) below or at the 0.1% AEP flood plus freeboard
4 The structure to comply with Building Guidelines (section....) below or at the PMF flood plus freeboard

Structural Soundness

1 The structure to comply with
2 The structure to comply with
3 The structure to comply with
4 The structure to comply with
5 Engineer's report to certify th a 1% AEP flood plus freeboa
6 Engineer's report to certify th a flood of record plus freebo

Specific types of controls need to be applied in certain risk bands to facilitate land uses which are compatible with the flood risk (eg. flood aware two storey house design may be appropriate in High Flood Risk band to reduce structural and contents damage)

Evacuation

1 Evacuation from the site to a ... imes
2 Evacuation from the site to a ... (section.....)
3 Evacuation from the site to be potentially achievable & consistent with Hawkesbury-Nepean Flood Emergency Plan
4 Traffic generation arising from the proposed development must not compromise the ability to evacuate others as provided for by the Hawkesbury-Nepean Flood Emergency Plan

Flood Affectation

1 Engineer's report required to certify that the development will not increase flood affectation elsewhere
2 The impact of the development on flooding elsewhere to be considered

Management and Design

1 Subdivision design to comply with the Subdivision Guidelines(section...)
2 Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with these Guidelines
3 Flood plan required
4 Applicant to demonstrate that area is available to store goods above the 1% AEP flood plus freeboard
5 Applicant to demonstrate that area is available to store goods above the flood of record plus freeboard
6 No external storage of materials below the 1% AEP flood plus freeboard as potentially hazardous during flood

Preparing a Planning Matrix for Graduated Controls

Step 1 Determining Number of Risk Bands

A crucial aspect of establishing a "Planning Matrix" is to determine the number of risk bands. Locations such as the lower Hawkesbury-Nepean floodplains, where the flood depth range is greater than in other areas, require a larger number of risk bands above the flood planning level in order to effectively manage the risk from flooding in an equitable manner across the floodplain or floodplains.

Chapter 9 gives a methodology for dividing the floodplains into different bands with similar levels of risk. The desirable objective from this approach is to achieve a "Low Risk" or at worst "Medium Risk" environment across the entire floodplain to limit damage to more acceptable limits.

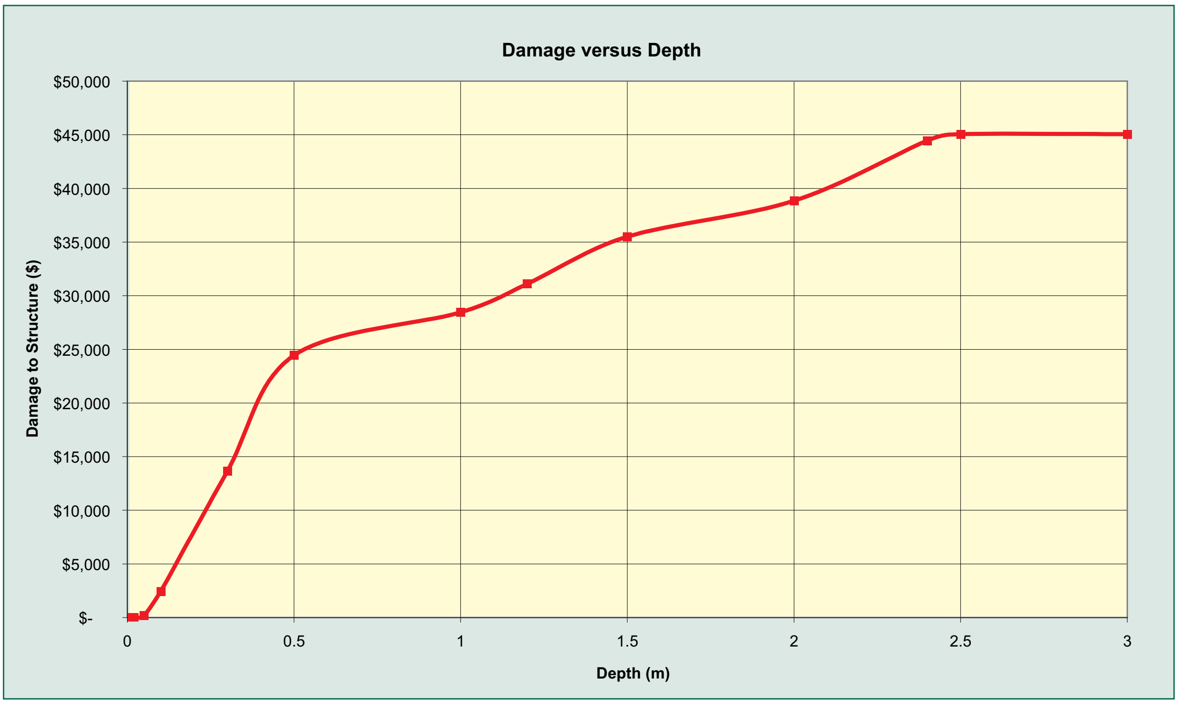
Whilst Chapter 9 presents a three risk band scenario above a 1:100 AEP flood level, determination and ownership of an appropriate risk band configuration rests with the local council.

In deciding on the final layout of the bands, a council would need to consider the sensitivity of the flood risk profiles achieved across the floodplain for various combinations of risk bands. A "Risk Analysis Matrix" provides an effective basis for undertaking this evaluation. The Risk Analysis Matrix in Figure 43 shows a risk analysis for structural damage to traditional housing (i.e. a single storey slab on ground brick veneer dwelling house), which is one of the most vulnerable forms of construction.

Two and three risk band comparisons for the Lower Hawkesbury Nepean floodplain (e.g. Windsor or Penrith areas) are presented to assist councils develop effective risk bands as part of local floodplain risk management studies and plans. It is not intended that the guidance given in this document should provide a final configuration for risk bands for adoption by council but rather a method for testing the sensitivity of different risk band configurations.

In comparing the risk rating for Windsor and Penrith (or any other floodplain location) it is necessary to consider the relationship between depth of flooding and the associated structural damage. The cost of structural damage versus the depth of above floor flooding for a traditional single storey brick veneer slab on ground house is shown in Figure 55. Figure 41 in Chapter 9

Figure 55 *Relationship between depth of above floor flooding and structural damage costs to a single storey brick veneer slab on ground house*



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gives an indication of the flood depth ranges for Windsor and Penrith. From this figure it can be seen that the depth of flooding for the flood of record (post dam) at both Windsor and Penrith is almost identical at around 1.5 metres. As a result, the amount structural damage (i.e. around $36,000) and hence the relative risk values and the risk ratings, are very similar. Whilst the depth of flooding above the 1:100 AEP level in an improbable event (such as the PMF event) at Windsor is significantly greater than at Penrith, the rarity of these events would result in a similar low risk rating.

For this comparison, the sensitivity of combining Risk Bands D and E (presented in Chapter 9 as separate bands) is assessed (see Figure 56). Flood Risk Bands A, B and C remain unchanged for this comparison.

Whilst the very low risk associated with Risk Band E would allow traditional single storey houses, Risk Band D would only allow flood aware single storey housing as a minimum standard. If traditional single storey housing was to be permissible for the entire single band (combined bands D and E i.e. flood of record up to PMF level), a "High Flood Risk" rating would need to be assigned to the lower areas of this band (i.e. near flood of record level) because damage could exceed $34,000. However, this could be reduced to the "Medium Flood Risk" by adoption of flood aware single storey design for these areas as structural damage would be about $9,000 less.

In conclusion, the Risk Matrix helps demonstrate the value of using three bands on two bands above the 1:100 AEP flood level from a risk management perspective. Other factors such as any increased housing costs and practical implementation aspects need to be considered when finally deciding on the number of risk bands above the base flood planning level.

Figure 56 *The effect of combining two upper Risk Bands for a residential area (Windsor or Penrith)*

Risk analysis for structural damage to residential development in floodplains
Based on traditional single storey brick veneer - slab on ground house

Floor level range in terms of AEP	Likelihood of above floor flooding	Chance of experiencing in a life time	Structural damage consequences					
			Insignificant < $1,000	Minor $1,000 - $5,000	Moderate $5,000 - $25,000	Major $25,000 - $50,000	Catastrophic loss of house $150,000 plus	
1:10,000 AEP to PMF	Improbable	0.7% - 0.07%	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	
1:1,000 to 1:10,000 AEP	Rare	7% - 0.7%	Low Risk	Low Risk	Low Risk	Low Risk	Medium Risk	Risk Band E
Flood of record to 1:1,000 AEP	Unlikely	30% - 7%	Low Risk	Low Risk	Low Risk	Medium Risk D Only	High Risk	Risk Band D & E
1:100 AEP to flood of record	Possible	50% - 30%	Low Risk	Low Risk	Medium Risk	High Risk	Extreme Risk	Risk Band C
1:50 to 1:100 AEP	Likely	75% - 50%	Low Risk	Medium Risk	High Risk	Extreme Risk	Extreme Risk	
Below 1:50 AEP	Almost Certain	100% - 75%	Medium Risk	High Risk	Extreme Risk	Extreme Risk	Extreme Risk	

Note: Figure 56 reflects that the most serious impact on the individual / household would be significant structural damage or the total loss of the house. Although the loss of any contents can have some financial implications, contents can be progressively replaced over time. There is more choice in replacing contents than in repairing the building structure. Furthermore, some contents losses may be foregone if the borrowing capacity is limited. On the other hand structural damage must be rectified to a satisfactory minimum standard before a dwelling can be considered safe enough to reoccupy.

Based on the above analysis the following "Steps" relate to three risk bands above the 1:100 AEP flood level. However, as noted previously the number of risk bands is largely dependent on the flood range. Fewer bands would be more appropriate where the flood range is smaller.

Step 2 Categorising Flood Risk Bands

It should be noted that in areas subject to high flows the hazard due to water velocity may dominate. At these locations there might only be one or two risk bands because velocity rather than depth of water will be the predominant contributing factor in causing damage to houses and other buildings. An example of this categorisation is likely to be found in the downstream reaches of the Hawkesbury River where the presence of the steep gorges result in floodway conditions along the narrow floodplains near the river. In this region, the bands would range from Floodway to Extreme or High Flood Risk with no areas falling within the Medium or Low Flood Risk bands.

Table 15 *Flood Risk Band Characteristics*

FLOOD RISK BAND	CHARACTERISTICS
Floodway	These are areas of the floodplain where a significant discharge of water occurs during some stage of flooding. While often aligned with naturally defined channels, floodway conditions may arise in larger flood events where high velocity flow paths may develop. The Flood Hazard Definition Tool may be able to help identify these locations. Potential risk to life and destruction of property make these areas unsafe for residential occupation.
Extreme Flood Risk	These areas are below the 1 in 100 AEP level where exposure to residential flood damage is excessive and the hazard can occur too often when site occupation is continuous and on a long term basis.
High Flood Risk	This can be defined as the area of land above the 1 in 100 AEP flood level that still has a high hydraulic hazard and where there is a need for evacuation. The High Flood Risk Band is where high flood damages are possible but risk can be substantially reduced with reasonable and cost-effective flood aware building and planning controls.
Medium Flood Risk	This can be defined as land between the flood of record and the 1 in 1000 AEP flood. It is not subject to high hydraulic hazard due to high velocity. The significant risk of major flood damage can be reduced by the application of appropriate building and development controls.
Low Flood Risk	This can be defined as land within the floodplain which is above the 1 in 1000 AEP flood level. There will be a low cost benefit to compulsorily applied flood related controls as the likelihood of damages is low for most land uses. Most land uses would be permissible in this risk band. The diagrammatic definition of the possible bands (for the lower Hawkesbury Nepean valley flood range) and their implications for planning controls are illustrated in Table 16.

Table 16 *Graduated Planning Controls*

Low Flood Risk	Medium Flood Risk	High Flood Risk	Extreme Flood Risk	Floodway
Damage risk low. Modifications to building structures not worthwhile.	Risk can cost effectively be reduced by minor building requirements to achieve a Low level of risk.	Damages beyond the financial capabilities of homeowners. Structural modifications to buildings can cost effectively lower risk to achieve a Medium level of risk	Major damage occurring too frequently for residential development.	Hydraulic hazard and destructive forces too high for safe occupation. Significant erosion risk.
PMF				
	1000-year flood			
		Flood of record		
			1 in 100 AEP	
No controls for most uses	Main areas where flood related development controls could be applied to modify risk by controlling likelihood and /or consequences of flooding			Most development restricted

Step 3 Prioritising Land Uses in the Floodplain

The next component in the preparation of the planning matrix is to prioritise land uses within the floodplain. This is achieved by identifying discrete categories of land uses with similar levels of vulnerability to the flood hazard. In this example the following categories have been selected:

- Critical uses and facilities
- Sensitive or vulnerable uses and facilities
- Residential subdivision
- Residential
- Commercial and industrial
- Tourist related development
- Recreation and non-urban
- Concessional or minor development.

Land uses are specified in environmental planning instruments and listed in each band in the planning matrix in accordance with an acceptable flood risk band. This can identify which land uses are appropriate for certain areas of the floodplain and where varying degrees of flood related development or building controls are warranted to reduce the risk.

Step 4 Controls to modify building form and response to flooding

The next component is to define different planning controls to seek to modify building form and the ability of the community to respond effectively in the event of a flood. This is influenced by location in the floodplain and the type of land use. The types of controls can be categorised under seven main headings:

- Floor levels
- Building components and methods
- Structural soundness
- Flood effect on others
- Car parking and driveway access
- Evacuation
- Flood management and design.

The development controls can be varied in response to local community attitudes to risk, the vulnerability of the land use category to the flood hazard and the location within the floodplain.

Implementation of the Planning Matrix.

The most appropriate mechanism for the implementation of the flood risk bands and the planning matrix is through an environmental planning instrument, supported by a development control plan.

Commercial Uses With a Residential Component

General

Some commercial land uses include a residential component either as their primary purpose or ancillary to the main use. Commercial buildings may be more structurally robust than standard dwelling houses and better able to withstand flood damage because they tend to be substantial structures and have to be designed to withstand other hazards such as fire. Nonetheless the occupants are still at risk from flooding. A flood plan which includes on-going flood awareness amongst staff and occupants is important. Staff should be trained in formal flood evacuation plans and emergency protocols, as they are now for other emergencies such as fire or bomb threat. Ensuring that emergency protocols are maintained in perpetuity would need to form part of any SES and council public awareness program.

Clear permanent signage on the evacuation routes needs to be incorporated into new commercial development on the floodplain where overnight accommodation is provided.

Hotels, motels and resorts

Hotels and the like should have a FPL for habitable floors comparable to residential properties to protect the residents as well as the property. Although evacuation of such premises will add to the vehicle load on evacuation routes, visitors and temporary residents are unlikely to have any significant reason to delay their departure.

Tourist caravan parks

Caravans, being of lightweight construction, are particularly vulnerable to damage in flood events, yet are regularly located near to rivers and creeks, often well below the 1 in 100 AEP flood level. Unanchored caravans start to float where over-ground flood depths exceed 2.0 metres. If swept away, they can cause damage downstream by adding to the flood debris load. Organised removal of caravans to higher ground following a flood warning may not be practicable in all cases because of the short warning time, lack of adjacent high ground suitable for caravan storage, permanent vans which are effectively not mobile and absent owners. Securing caravans to avoid movement has been done on existing caravan sites; however, the success of this method of damage reduction is reduced in locations where there is little advance flood warning.

It is preferable that new caravan parks with permanently sited vans not be sited below the level of the 1 in 100 AEP flood. Facilities such as ablution blocks may be at a lower level but should be constructed to a standard to minimise damage from inundation.

Mobile home parks

Mobile home parks, which have permanent residents, should be classed as residential and the floor level FPL should not be lower than the 1 in 100 AEP flood.

Mobile homes provide a source of affordable housing; thus mobile home park occupants may include a significant proportion of older people or families who are least able to afford permanent homes. As some of the more vulnerable members of society, they are least able to cope with the impacts of flooding, such as loss of their home, financial losses, loss of social support or health related consequences.

It should be recognised that the lightweight structure of mobile homes is vulnerable to flood damage if inundated and cannot offer protection to contents. Anchoring the home securely will assist in preventing the home being dislodged and becoming flood debris, which can cause damage downstream. The only effective means of reducing flood damages is to reduce the chance of flooding. This can be achieved by having a floor level FPL no lower than the 1 in 100 AEP flood.

Evacuation of mobile home park residents is no less critical than for permanent housing areas and access to higher ground beyond the PMF needs to be provided for new mobile home parks in the floodplain. Designing internal roads for new mobile home parks, with a continuously rising grade to higher land beyond the extent of flooding, to avoid overtopping by local flooding will assist in evacuation.

Non-Residential Land Uses on Flood Prone Land

Planning guidance is provided for a range of common land uses, primarily non-residential development, on flood prone land. Whilst commercial buildings may be less vulnerable to damage from deep flood water because of their construction, scale and materials, the guidance given in Chapter 10 on building flood aware design houses can be applied to domestic-scale non-residential premises. Other important issues relate to safety, evacuation and protection of contents in a flood event and restoration of essential services after a flood.

Community Infrastructure and Facilities

Community infrastructure and facilities should, wherever practicable, be located and designed to function effectively during and immediately after a flood, commensurate with a specified level of risk. Community infrastructure includes:

- Hospitals;
- Health care institutions such as nursing homes and aged care facilities;
- Police and emergency service facilities and operations centres;
- Ambulance stations;
- Electricity substations;
- Water pumping stations and essential sewerage treatment plant infrastructure;
- Communications network facilities such as telephone exchanges;
- Stores for archives, public records, valuable records or items of cultural or historic significance;
- Evacuation centres.

Such facilities:

- are essential to the management of emergency events; or
- provide critical services and have equipment that may be damaged by flooding; or
- have occupants who are particularly vulnerable.

Depending on the scale of the development, the State Environmental Planning Policy (Major Projects) may apply to these projects. Through the floodplain risk management process, the council (or the Minister) would need to determine a tolerable level of risk for these highly vulnerable land uses. There may be no choice but to locate them on flood prone land because there is no alternative site. Preferably, they should not be located below the PMF but it is recognised that new community infrastructure may need to be located on flood prone land to service existing flood prone towns and villages. In such cases the main considerations would be the safe evacuation of occupants and protection of critical components to facilitate post-flood recovery.

Vulnerable occupants

Vulnerable occupants are defined as those who are unable to self evacuate. Organising and implementing assisted evacuation for elderly, sick or disabled occupants is both time and resource intensive in terms of providing sufficient ambulances, buses and trained staff. The flood behaviour in the Hawkesbury-Nepean valley is such that a long warning time is unlikely to be available. Hospital patients and nursing home residents cannot be taken to standard evacuation centres, but have to be moved to similar institutions beyond the flood-affected areas where appropriate levels of specialised medical and nursing care can be provided. This places the residents of such facilities in a very hazardous situation and poses a burden on the emergency, community and health services at a time when demands upon them will be stretched to the limit. (Danielson 2000), (Figure 57).

Figure 57 *Memorial Home being evacuated*

Evacuating hospitals and nursing homes for the elderly or disabled is resource and time intensive, and distressing for the vulnerable occupants. Suitable specialised alternative accommodation beyond the flood affected area has to be available.

It should be recognised that there are already a number of residential aged care facilities and a general hospital located well below the level of the Hawkesbury-Nepean PMF. The Department of Health and emergency services are planning for the evacuation needs of these existing facilities. If there is no alternative but to locate and build new facilities below the PMF to serve the needs of the existing population, then an all-weather emergency evacuation access road with continuously rising grade which provides access to suitable alternative facilities beyond the PMF should be provided. In addition, managers of these facilities should ensure that they have flood evacuation protocols in place, which can be implemented with the assistance of the emergency services.

Similar issues arise in the evacuation of other special needs or institutionalised populations. Such populations are unique victims of the threat because of their total dependence on institutional staff. Schools, correctional centres or remand centres fall into this category with the added complication of evacuating prisoners due to the necessity for protection of the general public (Danielson 2000). There are two correctional centres located either wholly or partially within the Hawkesbury-Nepean floodplain. As such centres are already located on flood prone land, any expansion plans should factor in the demands posed by the need to evacuate at short notice in a severe Hawkesbury-Nepean flood. The key to success is pre-planning on the part of the authorities. A major constraint in institutional evacuation is bus and bus driver availability given the likely high demand and short warning times available in a severe Hawkesbury-Nepean flood.

Ensuring the continuity of essential services

Public infrastructure and facilities are essential to the normal day-to-day functioning of any town and most are also essential to serve the surrounding rural areas. The prime determinant of their location is to be able to conveniently serve the community as part of wider servicing plans determined by each agency, which is usually, but not always, a government agency. Ideally, new facilities should be located out of the floodplain i.e. above the PMF. This would then ensure their continued operation during and after all flood events.

There is the potential for severe Hawkesbury-Nepean flooding to have a catastrophic effect on the functionality of essential infrastructure and severely undermine the ability of agencies to maintain normal service provision. Agencies or others charged with responsibility for providing essential public services are therefore advised to develop flood risk management plans which consider a range of floods up to the PMF for their vulnerable assets located on flood prone land.

In all cases, the flood liability of the road access to essential facilities should be determined. Upon receipt of a flood warning, sites may need to be accessed by experienced personnel to isolate, remove, relocate or otherwise protect plant and machinery from the impending flood.

It should be recognised that when new residential communities are built on flood prone land, they also require essential services and infrastructure. In such cases the risk posed by flooding and any additional costs in providing such facilities should be considered in any development agreement or contributions plan. This would preferably be addressed at the rezoning or development control plan stage of the planning process.

Whilst the evacuation of hospital and nursing homes and other institutions is paramount, flood damage to hospitals and nursing homes is also potentially high due in part to the day-to-day functional requirements for at-grade disabled access to the buildings. Design solutions including the use of ramps and lifts and avoidance of single storey construction, could improve flood protection without compromising at-grade access.

As with dwellings built to minimise flood damage, flood aware design can reduce damages. Measures include:

- strengthened or water proof building or infrastructure components e.g. concrete panels to prevent damage from deep or fast flowing flood water,
- alternative designs with raised floor levels to reduce the frequency of key components being inundated; and
- raised platforms or upper floors for critical or expensive plant and equipment to reduce the probability of irreparable water damage.

Although there may be additional costs incurred in adopting building measures to address the flood risk, the cost should be balanced against the consequences (including costs) of the facility being unusable during the inevitably long recovery period. After a flood, the demand for the essential services will continue and alternative, temporary arrangements may be necessary. The cost of service recovery places a burden on the provider, the government and the community. A burden which, with careful planning, could be reduced given that the Hawkesbury-Nepean flood risk is foreseeable.

Emergency operations headquarters

Under the lead agency of the State Emergency Service, other emergency services including the Rural Fire Service and Police have coordinated roles in a major flood event. Local headquarters tend to be sited within the LGA they serve and may have to be located below the PMF. However, divisional or regional headquarters should be located on land above the PMF, but with good road access to the floodplain areas in order for emergency flood plans to be implemented without disruption in an operational event.

Flood evacuation centres

The Department of Community Services, as part of its welfare provision for disaster victims, has an on-going role to identify suitable premises beyond the level of the PMF which can be used on a temporary basis as flood evacuation centres. The centres are used not for accommodation but for processing evacuees and administering immediate relief. The type of premises which lend themselves to evacuation centres need to have ample car parking, large function rooms, and ample facilities such as toilets and catering facilities. Large social clubs are preferred but universities and some high schools may also be used. As severe Hawkesbury-Nepean flooding may occur concurrently with flooding in other catchments, care needs to be exercised to ensure that evacuation centres remain accessible and are above the local PMF. Evacuation centres need to have uninterrupted access to essential services e.g. water, electricity and communications.

In the planning of greenfield development where land is both above and below the level of the Hawkesbury-Nepean PMF, there are opportunities to ensure that accessible sites above the PMF level are reserved for evacuation centre purposes early in the planning process.

Museums and storage of archives

Repositories of archives, essential documents and cultural artefacts are best located on land not subject to any known natural hazard. Hawkesbury-Nepean flooding is characterised by short warning times giving little opportunity to mount emergency operations to relocate bulky, precious or fragile items to alternative premises out of the floodplain. Packing and removal of museum and art collections including archived materials and documents is a specialised and complex task that cannot necessarily be undertaken at short notice.

Restoration of water-damaged historic documents and artefacts is a highly specialised, extremely expensive and lengthy process. Informed land use decisions can avoid incurring such losses and associated costs. Flood-free locations can ensure the continued conservation of material which has cultural heritage significance.

Schools

Schools built at or above the 1 in100 AEP flood level with at least two storeys are better able to provide some protection for expensive and/or essential portable equipment and stock than single storey schools. Losses can be both tangible and intangible. Tangible losses include damage to school buildings, contents and equipment. Intangible losses include:

- community and individual distress when students' work is destroyed or damaged; and
- the disruption to the continuity of students' education if the school is forced to remain closed for a lengthy recovery period.

Therefore in new developments, there are merits in locating new school premises at higher levels.

If a school is sited adjacent to local evacuation routes it could also provide an easily identifiable community meeting point during an evacuation, offering opportunities for public transport coordination. Siting playing fields and recreation areas on land below the level of the 1 in 100 AEP flood event maximises the use of available land.

Public utility infrastructure

The siting of public utility infrastructure such as substations, pumping stations and communication network facilities, varies depending on scale of development and network imperatives, (Figure 58).

Sites for major infrastructure should be located to ensure that access for emergency vehicles

Figure 58 *Sewage Treatment Plant on the floodplain*

For operational reasons, Sewage Treatment Plants are usually located on low-lying ground. Operational disruption, potential for pollution or damage to critical components due to frequent flooding may be limited in some circumstances by containment within a levee (providing there is no effect on others in the floodplain by building the levee).

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remains open in a flood event for as long as practicable to enable staff to switch off or move plant to minimise damage before the flood approaches. Infrastructure should be designed to reduce the risk to plant and equipment caused by inundation or velocities, (e.g. pole-mounted equipment, raised platforms for expensive essential plant, tilt-up concrete panel walls etc). The higher the site on which these facilities can be located, the easier and quicker would be the recovery period. In determining an appropriate level, consideration should be given to the scale of the facility, the consequences of any disruption to the service and the cost and ease of replacement or repair. For example there may not be sufficient merit in locating a small pumping station or substation at higher levels. However, unless it is operationally essential that they be located in close proximity to residential or commercial customers, it is suggested that essential infrastructure be located no lower than the 1 in 500 AEP and preferably above the PMF.

Industrial and Commercial Premises, Shops, Offices

Industry and commercial premises have differing vulnerabilities to flood damage. Flood hazard information should be available for business managers to make informed decisions on the implications of flood prone locations. A few key approaches to consider include:

- Appropriate building design can reduce flood damages to the building, plant, stock or materials;
- Accessible, high-level storage areas within a building can provide some protection against water damage; and
- Back up or storage of essential records off-site beyond the level of the PMF is prudent.

Business managers would also be aware of the need to provide a safe working environment under the requirements of the Occupational Health and Safety legislation. Formal flood evacuation procedures should be in place at all premises. These matters should comprise part of normal risk management business planning.

The SES has introduced a Business FloodSafe Plan to provide information and raise awareness in the business sector. Any program should recognise that the business sector is highly diverse and will require a targeted approach to ensure success.

Hazardous Industry

Hazardous industries or storage of hazardous or toxic materials e.g. liquid fuel depots should not be located on flood prone land as hazardous materials stored or used on site may leak into the floodwaters, adding significantly to the contamination load. Some industries may require a long lead in time to shut down their processes to secure materials or plant against damage from immersion. Warning times of severe floods in the Hawkesbury-Nepean are very short and may not give sufficient time to close down industrial processes.

Car Parks

Underground or basement car parks (i.e. below ground level) or covered bunded car park facilities are subject to inundation as flood waters rise. The collective value of parked vehicles and stored items is considerable. Basement parking should ideally be fully flood protected without the reliance on mechanical devices. To avoid early inundation, they should be designed with entry ramps, ventilation entry points and pedestrian exits positioned in such a way as to ensure that water would not enter until the last possible moment in a flood event. However, it should be recognised that such design measures to prevent early entry of water can cause problems with rapid flooding of the car park if waters continue to rise above the level of the ramp, which acts then like a breeched levee. This can be very dangerous for anyone trapped in the car park and clearly marked, separate pedestrian exits are essential. Where it is possible to do so, it is preferable to have the crest level of all accesses to the basement at or above the PMF.

Multi-storey buildings can provide occupants with high-level refuges during short duration floods. In

Figure 59 *Good signposting is essential for flood evacuation*

Clear signage is necessary to alert users of underground car parks which are liable to flood of the evacuation arrangements.

flash floods, this may be preferable to evacuation if vehicles are parked in underground car parks. In such circumstances, an accessible refuge not only needs to be provided but clear signage to the refuge needs to be posted within the public areas of the building including the car park.

The hazardous nature of underground car parks emphasises the need for full public awareness to ensure prompt and early evacuation to ensure that the cars could be removed from the car park before the evacuation routes become impassable and before the car park becomes flooded. Any cars remaining under water in a car park could be assumed to be written off. Consideration should also be given to the initial slow flooding of the underground carpark to help act as a warning mechanism to those in the carpark area.

Underground car parks for commercial buildings such as shopping centres often house plant and equipment e.g. air conditioning units. Locating these higher within the building would reduce the chances of damage to this equipment.

Open car-parking areas and carports with open sides are appropriate at or below the FPL for residential and commercial development. If located within flood storage areas, losses to parked cars and damage to car park structures (e.g. pay kiosk, public conveniences etc.) may be expected in flood events. To assist in evacuation of vehicles, car park exits should direct drivers to a continuously rising evacuation route. Signage advising of flood levels and clearly marked exits to evacuation routes would assist in maintaining public awareness (Figure 59).

Management of Riparian Corridors

Built forms of development on floodplains increases impervious areas with consequential detrimental effects on riparian areas. The management of riparian corridors which incorporates both floodplain management objectives and environmental objectives can result in healthier ecosystems and safer floodplain development. Having stable and healthy riparian areas can be effective in reducing the risk of adverse flood impacts associated with bank instability or channel widening. The events critical to the health of riparian areas are the low flow, more frequent events.

By adopting a range of management measures including:

- water sensitive urban design (WSUD); and
- appropriately protected and planted buffers and vegetated corridors,

bank integrity, water quantity and water quality changes arising from more frequent event runoff regimes associated with floodplain development can be mitigated and biodiversity conservation achieved, (Table 17).

Water sensitive urban design

Not incorporating the base flows and more frequent floods into management of the floodplain can lead to degradation of the riparian zone and potentially increase flood risk to development on the floodplain. Maintaining the flow regime for the full range of events is likely to:

- lead to more stable stream systems;
- prevent stream degradation processes such as incision and widening;
- reduce loss of land;
- maintain buffers between developed land and channels;
- protect and maintain riparian values; and
- reduce expenditure on channel stabilisation and stream rehabilitation for degraded streams.

***Table 17** Comparison of the importance of high and low frequency flood events to riparian values*

Riparian Value		Base flows and small events (<1.5 year ARI)	Large events (>1.5 year ARI)
Ecological	Biodiversity	Critical to maintaining natural wetting and drying regimes suited to riparian species. Critical to retention of existing riparian native vegetation.	Infrequency means minimal impact on habitat.
	Water Quality	Critical as majority of pollutant loads are carried from developed parts pf the catchment in smaller events.	Infrequency means minimal impact on water quality.
	Geomorphology	Flood extent varies in upper, middle and lower reaches of the river. Critical to shaping and alignment of streams and maintaining stream stability.	Important, though infrequent, modification to channel cross section and alignment.

(Adapted from Bain and Liebman 2005)

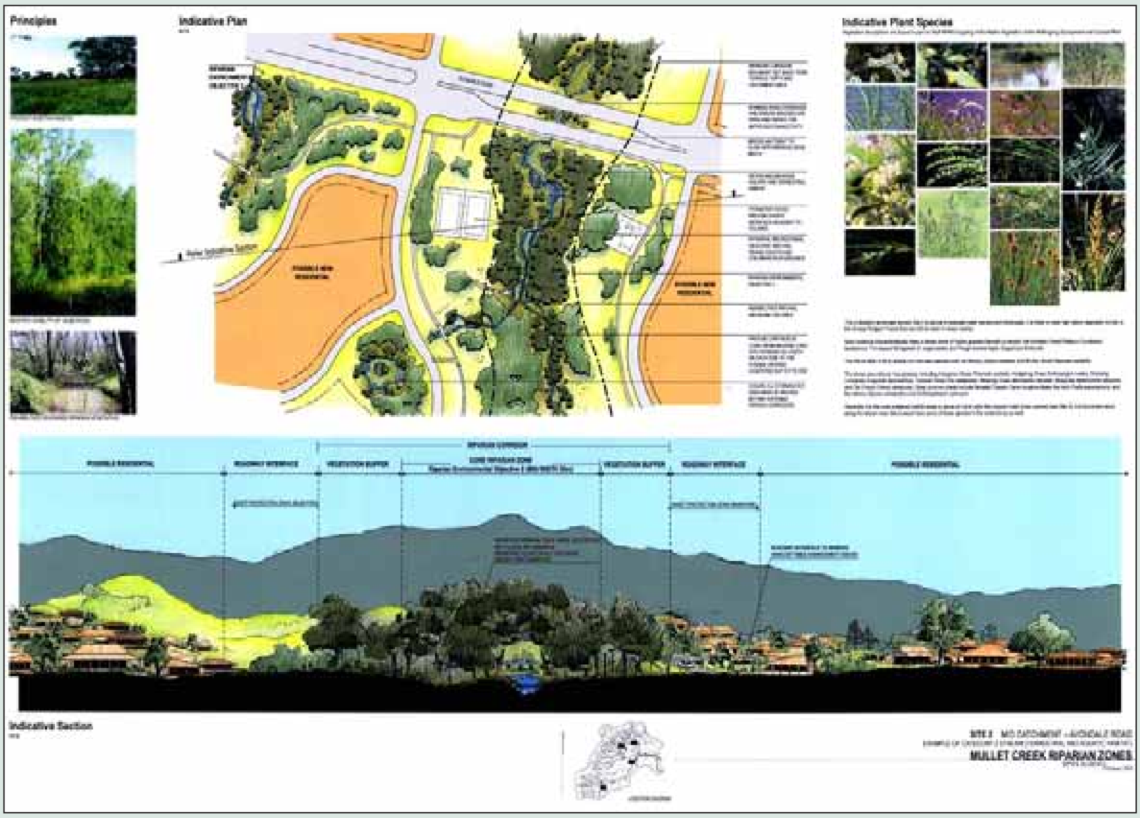
New subdivisions can adopt water sensitive urban design approaches to achieve significant environmental benefits and flood risk reduction for the more frequent flood events. It can incorporate water quantity improvement measures (to slow down the flow) and water quality improvement measures (to remove nutrients and suspended solids) such as artificial wetlands, buffer strips, swales, and domestic rainwater tanks.

Environmental improvements on riparian land

Maintaining or establishing vegetated riparian corridors can meet three environmental objectives:

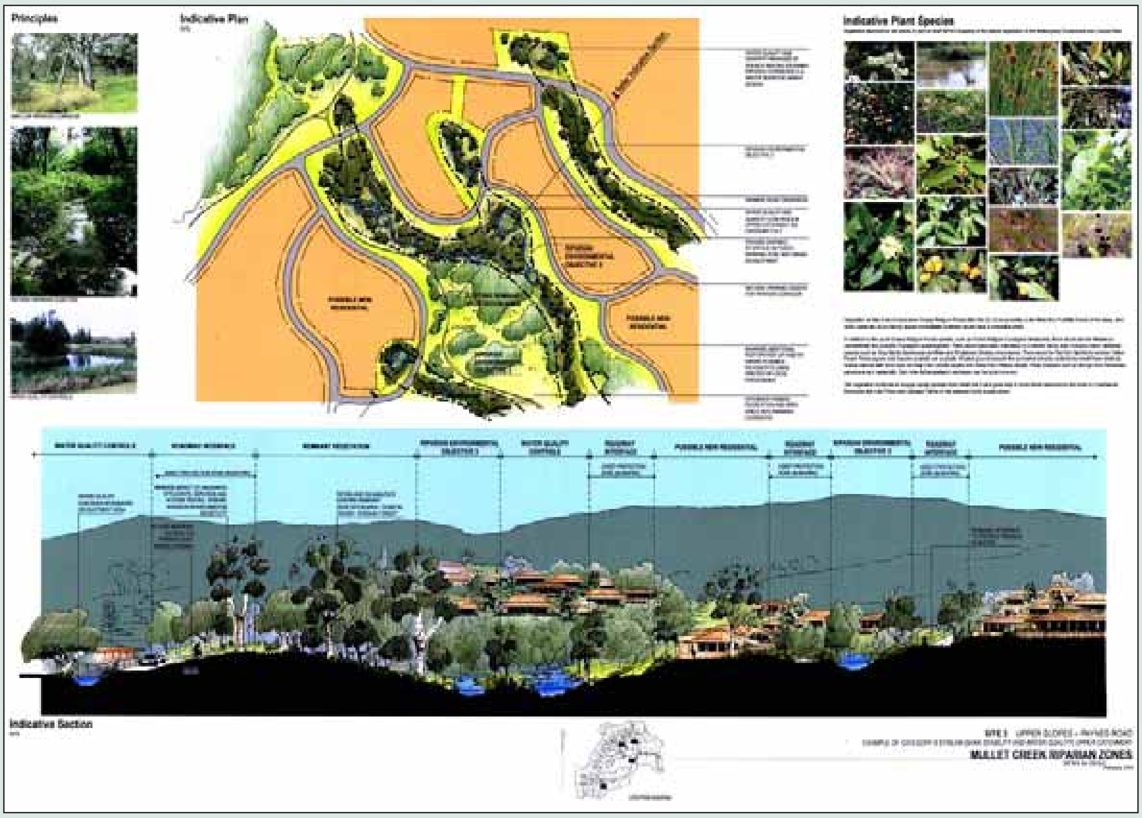
- Maintenance of the connectivity between significant or remnant stands of high conservation value vegetation, can provide habitat for flora and fauna. Different species have differing ranges, and an appropriate corridor width from the top of the bank needs to be negotiated to ensure good environmental outcomes. Part of this corridor should be a buffer strip to provide protection along the edges from adjacent development impacts (e.g. introduction of weed species). (DIPNR 2004).
- Replication of a naturally functioning stream environment with connectivity provides suitable habitat for aquatic and terrestrial fauna. The riparian corridor and vegetated buffer strip can protect the watercourse. (DIPNR 2004).
- By preventing soil erosion through a vegetated strip, bank stability can be achieved and water quality improved. However, it is recognised that in already highly degraded urban and peri-urban landscapes water quality objectives may not be achieved even with bank stabilisation.

Figure 60 *Mullet Creek Riparian Zones – mid catchment*



Although this example is not sourced from the Hawkesbury-Nepean valley, it demonstrates how stream mapping together with setting objectives for the riparian area and detailed site planning can achieve successful protection of the environmental attributes of the waterway, accommodate frequent flooding within open space zones and provide an attractive living environment.

Figure 61 *Mullet Creek Riparian Zones–upper slopes*



In the upper zone where the stream gradient is steeper and the velocities potentially higher, bank stability and water quality are important considerations.

Local riparian corridor management strategies need to be developed so that existing flood risk and liabilities are not exacerbated. Responsibility for the management of riparian corridors is an issue which should be addressed early in the planning process. Without on-going management, dense vegetation, be it native or exotic, can grow along watercourses. Dense vegetation acts as a blockage to floodwaters and leads to a wider area being subjected to flooding and higher flood levels upstream. In new greenfield development it is necessary to understand that post-development flood levels may differ from those modelled pre-development. The impact of established vegetated riparian corridors should be factored in to the flood models when determining the flood planning level for development.

If modification of a natural stream is essential, the work should be designed following best management guidelines for the rehabilitation and restoration of streams.

It should be remembered that within any river system, there are variations in the upper, middle and lower reaches of the catchment. In the upper reaches where the floodplain tends to be more confined, the land required to provide an adequate riparian corridor will represent a greater proportion of the floodplain than in the lower reaches where the floodplain tends to be more extensive.

An example of how riparian corridors have been incorporated into development plans for the upper slopes and the mid-catchment of Mullet Creek in the Illawarra is given in Figures 60 and 61. This example demonstrates how residential development, roads and drainage can be designed to achieve good environmental and floodplain management outcomes and provide opportunities for open space and recreation.

Recreation Facilities

There is a demand for recreational facilities associated with rivers and other water bodies which can only be met by developing land with a high frequency of flooding. These may be quite appropriate uses on low-lying land with a FPL well below the 1% flood level, even though the flood risk is extreme and frequent inundation may occur.

Boatsheds, public toilets, kiosks, cafes and other low-key uses which are used only intermittently and with no overnight stays, may be appropriate uses at these lower levels. Evacuation of visitors and workers would inevitably occur in frequent, not just rare flood events. Continuously rising grade evacuation routes leading out of the extreme and high-risk areas should be provided and clearly signposted.

There are however, environmental and biodiversity considerations in riparian corridors along watercourses, which limit built forms of water-front development or access to the river. The management of riparian corridors is discussed in more detail above.

Consent should be required for all land uses on flood prone land to enable a merit-based assessment to be carried out for each proposal.

Active Open Space, Parks and Playing Fields

Active open space facilities such as ovals, can be located in the lower-lying areas below the flood planning level adopted for dwellings and can effectively separate the riparian corridors from the built forms of development.

Open space areas can assist in drainage for frequent events and are often sited and designed to have a dual purpose as detention basins. Downstream development needs to be protected from the consequences of sudden overtopping from upstream detention basins, (Figure 62). Care needs to be exercised to avoid damage or losses in floods larger than the event for which the basin was designed. This can be particularly hazardous for downstream residential development where residents may get virtually no warning of the basin suddenly overtopping or embankment failure. This creates a flash flooding situation which not only causes increased property damage due to

Figure 62 *Detention basin upstream of dwelling houses*

Detention basins can overflow quickly creating a hazardous situation for residents in dwellings down-slope of the basin.

Figure 63 *Livestock make use of available high ground*

During flood events, higher ground with access to shelter, water and fodder is needed for valuable livestock. In severe events, the movement of stock adds to the traffic load on evacuation routes.

velocity but also because there is no warning time, emergency services are unable to respond and residents are unable to reduce damage by raising contents and may also be unable to evacuate to save themselves. More information on the siting and design of detention basins can be found in the Subdivision Guidelines.

While it is generally preferable for open spaces rather than buildings to flood, even open space areas may be damaged and polluted by floodwater and the debris it deposits. They may remain affected after the water has subsided. It should not therefore be assumed that flooding of open spaces is acceptable in every case. In order to determine what level of flood risk is considered acceptable by the community and the council, the activities proposed for the land will need to be known. Playing fields and synthetic surfaces are particularly susceptible to damage. The potential damage, periodical closure to the public, loss of amenity and clean up implications should be considered in rezoning, development proposals or works for open spaces.

Rural Land Uses

Some rural land uses are well suited to floodplains as they are able to make use of the fertile alluvial soil. The Richmond Lowlands in the Hawkesbury-Nepean valley represent some of the best agricultural land in NSW. In some cases the viability of low lying agricultural land may be increased by the construction of small levees which reduce the frequency of flooding and thus reduces crop damage and can limit weed invasion. However, the benefit should be balanced against the loss in resupply of nutrients from the river and the potential for increased riverine erosion.

Councils already limit development in rural and environmental protection zones. Good management practices to overcome the nuisance caused by frequent floods can reduce the damages to plant and machinery, such as pumps etc. Ensuring that equipment can be easily accessed and removed to higher land will do much to reduce losses. Non-habitable agricultural buildings can be constructed of materials such as sheet metal, block work or tilt-up concrete panels, which facilitate easy post-flood cleaning and do not tend to deteriorate or lose structural strength if inundated.

Floodplains are regularly used for livestock grazing including agistment of horses. In the Hawkesbury-Nepean valley, because of the large flood range, there may not be any higher land which is accessible and available to use as a refuge for animals, (Figure (63). The SES and the NSW Department of Primary Industries (Agriculture) is able to advise on what measures should be taken to protect stock, including horses, in flood events (NSW DPI 2005). Movement of stock by road may be necessary and owners of livestock should be aware of alternative flood-free locations. This requires them to be:

- aware of the flood risk;
- in receipt of timely flood warnings;
- able to reach the stock early in a flood event; and
- be ready to move livestock to identified refuges which are above the level of the predicted flood. This may include having all-weather access with a rising grade leading to evacuation routes.

In major or severe flooding, when evacuation of urban areas is also taking place, there is the potential for traffic conflict on the nominated evacuation routes arising from both heavy vehicles carrying livestock and private cars.

Rural Residential Development

Rural residential development and dwellings associated with farms on low-lying agricultural land are particularly vulnerable to frequent floods. Replacement of older rural dwellings with new dwellings is occurring in rural areas notwithstanding the flood risk from frequent floods and the potential for early isolation and eventual inundation in major floods, (Figure 64). There is a continuing demand for rural residential development and subdivision on the rural – urban fringe, both on flood prone land and where the only access is across flood-prone land.

The flood risk can be reduced for rural residential lots by locating building envelopes for dwellings and driveways on land which is as high as possible and which is linked to higher land with continuously rising accessways.

The FPL for habitable rural residential rooms should be no lower than for urban residential properties i.e. no lower than the 1% AEP flood plus 0.5 metre freeboard. It is common for houses to be raised on a filled earth platform to achieve this level. However, an elevated floor level above natural ground level can encourage residents to delay evacuation resulting in them being trapped and isolated even in a flood of the same magnitude as that selected for the FPL, (Figure 65). In the Hawkesbury-Nepean valley, isolated elevated properties at the 1 in 100 AEP level can eventually be overtopped in rarer floods with dire consequences if the occupants have failed to leave in time. There is also a need to ensure that the building can withstand predicted velocities in floods larger than the flood selected for the FPL.

Figure 64 *Isolated rural properties*

Frequent flooding can leave rural and rural residential properties isolated making evacuation by road impossible. If floodwaters rise further then resource-intensive rescue is the only option.

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Figure 65 *Elevated house on flood prone land*

When elevating dwelling houses to reduce flood damages, in the Hawkesbury-Nepean it is essential that early and timely evacuation occurs before residents become isolated and rescue is required.

As rural residential development is typically very low density, the provision of evacuation routes can be challenging and expensive. It may not always be necessary if the land adjoins land higher than the PMF and there is vehicular access to this land that is open to the public. Individual driveways need to be all-weather surfaces and be drained such that they remain open when evacuation is needed. They should rise continuously to a nominated evacuation route or to a road that gives continuously rising access to higher land above the level of the PMF. It is preferable that the destination location remains serviced with power and other essential services in the flood event.

A dispersed settlement pattern could result in slower delivery of warning messages by the emergency services compared to denser urban areas, especially if there is a reliance on door-knocking as the primary warning method. Together with preparations for moving animals, there is the potential for delayed evacuation from rural residential properties.

Detailed information on subdivision layout and access roads for flood prone land can be found in “Designing Safer Subdivisions – Guidance on Subdivision Design in flood prone areas”.

Filling

Filling of flood prone land may include:

- Raising flood prone land to enable an otherwise low-lying site to be developed by reducing the probability of the land flooding;
- Disposal of waste material;
- Filling for the purposes of building levees or embankments for infrastructure etc.

These are discussed below.

Land raising

To maximise the developable area, filling is often used to raise the level of the land so that it is at or above the flood planning level. However, the degree to which filling impacts on flood behaviour, the environment, biodiversity and the ability of the proposed development itself to manage that flooding, needs to be carefully considered.

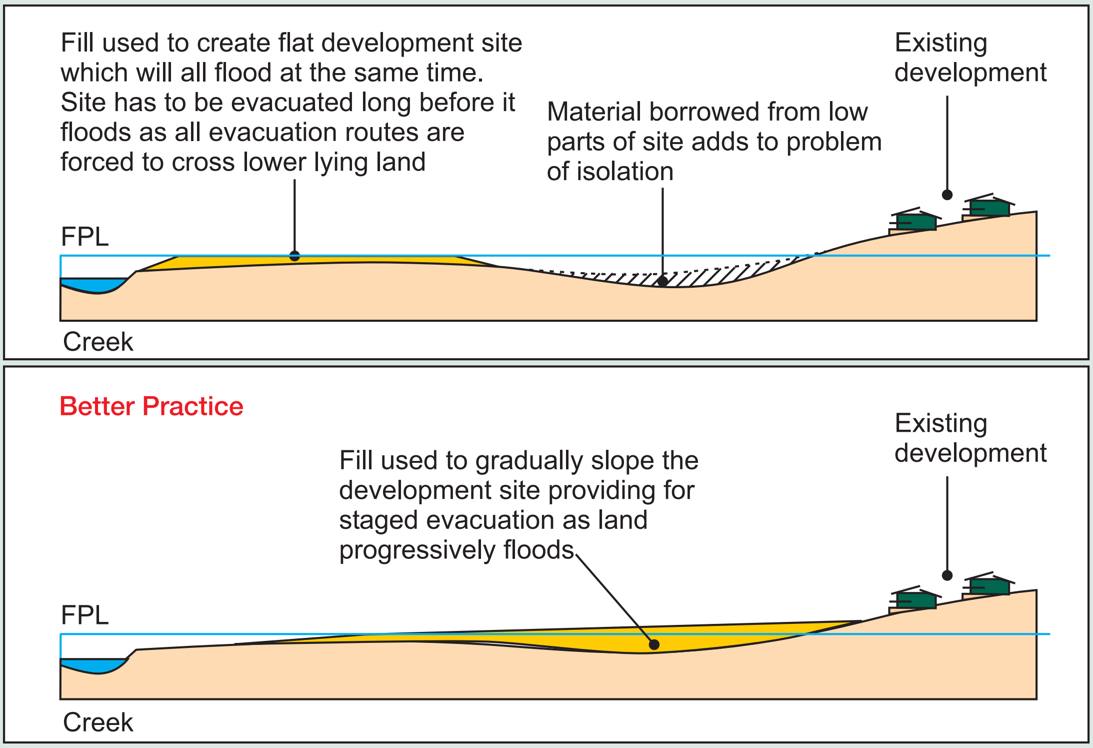
Filling may alter flood hazard by reducing depths in all events and/or excluding floodwaters up to a certain design event. However, fill can also affect flood behaviour by removing flood storage and blocking or partially blocking floodways. This may increase flood hazard outside the site by increasing levels, velocities and flows, which may limit the use of other land. The impacts of filling can vary in different flood events so the impacts need to be considered across the full range of floods.

Proposals for filling should not create 'islands' where new development would be isolated in the floodplain, thus creating a potentially hazardous situation for residents who would require evacuation in flood events. A preferred approach is for a filled area to adjoin an adjacent higher area, which is already developed or planned for development as shown in Figure 66. Furthermore, the filling should be adequately graded upwards towards the high land to aid orderly staged evacuation. This matter is discussed in detail in the "Designing Safer Subdivisions – Guidance on Subdivision Design in flood prone areas".

Whilst filling may offer protection from damage for a selected flood, it can give a false sense of security in respect to larger events which will overwhelm protection measures. Danger to personal safety, particularly in larger events needs to be considered carefully and may result in the need for other risk management measures being considered. These may include improved access for evacuation or if possible, more warning time. If alternative protection cannot be achieved and risks are determined to be too great, it may result in the development being scaled back.

There are environmental issues to consider when filling or raising the ground level with local or imported fill. Council may already impose restrictions on filling in its area through environmental planning instruments. The Department of Environment and Conservation also regulates the filling of land in some circumstances.

Figure 66 *Filling to raise land for development*



Filling of land should not create "islands" which have the potential for isolation and residents becoming trapped in flood hazard areas.

Filling should be set back from the banks of watercourses in order to protect the ecological attributes of that area and to avoid loss of flood storage and impeding floodways.

In summary, the issues relating to filling which should be considered include:

- avoidance of creating isolated 'flood islands';
- provision for staged evacuation by road;
- the fill material: source, means of transport, type of material(s), potential for contamination, acid sulphate soils, salinity, importation of weeds;
- adverse impacts on local water quality due to leaching, erosion and sedimentation and the need for managed control measures;
- impacts on flood-dependent ecosystems and biodiversity;
- impacts on local drainage and/or local flood behaviour; and
- geotechnical considerations such as stability of finished ground.

Waste disposal

The filling of land for waste disposal is controlled by government regulations and guidelines and will in almost all circumstances require development consent. It may also need an environmental impact assessment in which the full range of risks can be considered. The following issues, which also apply to any land filling, need to be addressed:

- the fill material: source, means of transport, type of material(s), potential for contamination, acid sulphate soils, salinity, importation of weeds;
- adverse impacts on local water quality due to leaching, erosion and sedimentation and the need for managed control measures;
- impacts on flood-dependent ecosystems and biodiversity;
- impacts on local drainage and/or local flood behaviour; and
- geotechnical considerations such as stability of finished ground.

However, where there is the potential for a waste disposal site to be inundated there is the potential for serious environmental consequences well beyond the boundaries of the site. This applies to flooding both by mainstream Hawkesbury-Nepean flooding and local creek flooding. The impact of a range of floods up to the PMF on the proposed facility should be addressed in any environmental assessment. To avoid the risk of widespread off-site contamination, sites below the level of the PMF should be avoided and alternative sites considered out of the floodplain.

Levees and embankments

Although not a practical alternative to mitigate Hawkesbury-Nepean floods because of the scale of the flood problem, levees have been frequently used elsewhere to protect existing development in flood prone areas. There are situations where they are appropriate to reducing flood risk but should always be accompanied by a suite of flood-related development controls, public awareness strategies and emergency management measures.

The height or crest of a levee is determined by a number of factors:

- what it is that requires protection;
- the cost;
- the physical limitations of the site;
- the level to which floods can rise relative to ground levels; and
- visual impacts.

A flood level needs to be selected as the standard for the levee design but unless a levee is designed to mitigate the PMF, it will be overtopped at some stage. When a levee overtops, the consequences can be disastrous to the community that it is designed to protect because of the sudden inundation behind the levee. High velocities and rapidly rising water behind the failed or overtopped levee can increase property damages and result in unacceptable personal danger levels, compared to a floodplain which is allowed to flood gradually and progressively.

To overcome increasing the risk:

- The levee needs appropriate design and provision of spillways to avoid uncontrolled high velocity flows, or even levee failure when it overtops;
- On-going maintenance of the levee crest;
- Flood-related development controls for development protected by the levee;
- Provision for drainage of local overland flow from behind the levee to the creek or river;
- Emergency planning for levee overtopping and/or floodwaters continue to rise;
- Management plans for infrastructure protected by the levee to reduce damage and facilitate recovery;
- On-going public education to ensure a flood-aware community, which understands the levee can overtop or even fail in certain circumstances and is prepared for the consequences.

Constructing a levee may have environmental consequences or impacts on local agriculture because of changes to local watercourses and drainage. It can also have beneficial effects in reducing the spread of weeds but can deprive the floodplain of a source of nutrient enrichment. These matters should be addressed.

As with any development involving large amounts of fill, there is the potential for levees to increase flood levels elsewhere on the floodplain. A levee proposal should address this issue.

Established Towns on Flood Prone Land

Many towns, including the historic Macquarie towns of Richmond and Windsor, are located on land which is all, or almost all below the level of the PMF. Notwithstanding the flood risk, there is an obvious need and desire to maintain continuity in both services and essential infrastructure to serve these long-established and thriving communities. This results in the need for upgrading and replacement of buildings, structures and plant as necessary. It is simply not practical to consider the relocation of essential infrastructure to flood-free sites above the PMF level when flood-free sites are not available in the locality.

Figure 67 *Large debris has the potential to cause damage*

Large debris objects floating amongst houses in the floods of 1978, Windsor.

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Figure 68 *Debris can collect on fences*

Light debris carried by flowing floodwaters collected on a fence following 1998 floods in Wollongong.

However, to reduce future damages, agencies are encouraged to recognise the full range of flood risks to existing infrastructure and plant which is both above and below the current flood planning level. If extensions, additional plant or upgrading works are proposed for infrastructure in established flood prone urban areas, there may be property-specific measures which can be considered to reduce the risk.

Infill and redevelopment proposals in established flood prone areas should incorporate the risk reduction measures put forward not only in these guidelines but in the companion guidance reports: "Reducing Vulnerability to Flood Damage – Guidance on building in flood prone areas" and "Designing Safer Subdivisions– Guidance on Subdivision Design in flood prone areas".

Minor ancillary development

Minor development, which may be ancillary to other development, includes fences, sheds, temporary buildings and other structures that are often light-weight. These structures have the potential to influence flood behaviour and increase flood hazard especially when located in floodways, (Figure 67).

By obstructing flow, fences and the like can divert water, act as traps for debris thus increasing the afflux, or if dislodged by moving floodwater, can become debris themselves, (Figure 68).

Where a flood study identifies land as a floodway, a council is advised to require consent for ancillary structures. Fences which are open, or are capable of collapsing rather than forming a solid barrier allow water to pass through more readily and are less likely to be become unsafe during floods or become moving debris themselves.

SECTION IV

TOWARDS ACHIEVING SAFER, SUSTAINABLE FLOODPLAIN COMMUNITIES

12 ROLES AND RESPONSIBILITIES

Flooding has wide social, economic and financial ramifications. Managing the risks to reduce the consequences of flooding and achieving safer occupation of the floodplain can only be sustainable if all stakeholders involved in decision-making on flood prone land take an appropriate level of responsibility for managing the risk. This shared management of the risk requires a recognition and understanding of the flood problem and knowledge of what solutions are both available and feasible.

Duty of Care

This section is not intended to be a substitute for obtaining independent legal advice on floodplain risk management decisions. It is simply intended to alert public authorities and others to their duty of care when carrying out floodplain risk management functions.

The Local Government Act 1993 (s. 733) offers indemnity to a public authority for flood liable land decisions which it makes, or advice which it gives in good faith, provided that the decisions are substantially in accordance with the principles contained in the NSW Floodplain Development Manual 2005. The Civil Liabilities Act 2002 may also assist in determining liability.

All parties involved in development decisions have a general duty of care to take reasonable care to avoid foreseeable risks of injury or harm to the residents and workers who will ultimately live or work on that land. The onus rests with the authority making the decision to ensure that due process in relation to floodplain risk management is complete and accurate and that reasonable recommendations are complied with. If it is known that flooding is inevitable and that steps can be taken to reduce damage and loss of life then a failure to act appropriately may be considered to be negligent. Authorities can take risk mitigation measures to assist in discharging their duty of care. These guidelines and the accompanying Subdivision and Building Guidelines put forward a range of measures which can be adopted to mitigate but not entirely eliminate the flood risk.

Of importance, is how obvious is the flood risk. Research has found that public awareness of flooding is low especially in floodplains such as in the Hawkesbury-Nepean where the flood risk is not obvious. The flood risk within the floodplain varies and in the higher parts of the valley that are above the level of the probable maximum flood there is no risk of riverine flooding, but this varying risk is not apparent. It is reasonable to conclude that most people would not regard Hawkesbury-Nepean flooding as posing an obvious risk. Those individuals who have been exposed to Hawkesbury-Nepean flooding in the past have only experienced relatively minor floods, even though they may have been extensive in area. These minor floods have affected predominantly rural land and have had benign behaviour compared to the severe Hawkesbury-Nepean floods which will occur at some stage in the future.

The Civil Liabilities Act 2002 states that a person (in this case, a floodplain management authority and consent authority) is not negligent in failing to take precautions against a risk of harm unless:

- ***The risk was foreseeable***
  If the flood risk is known, it is foreseeable.
- ***The risk was not insignificant***
  In many parts of the Hawkesbury-Nepean floodplain, major flood risk is very significant with serious consequences.
- ***A reasonable person in the same circumstances would have taken those precautions (against a risk of harm)***
  These guidelines promote better flood risk mitigation approaches to residential subdivision.

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An important issue is the 'proximity' of those authorities who are making the decision on risk mitigation measures, and those taking the risk (residents, workers, tenants). Clearly the authority which makes a decision is not the same as individuals thus affected by that decision. That authorities know:

- major or severe Hawkesbury-Nepean flooding poses significant risks to residents; and
- those residents are made more vulnerable because they are not able to be protected by flood insurance,

puts a higher onus on the authorities to act reasonably to prevent losses and/or danger. The low probability (i.e. less than 1%) of major or severe Hawkesbury-Nepean floods occurring does not diminish that responsibility.

Local Councils

The NSW Government's Flood Prone Land Policy identifies local councils as the floodplain risk management authorities for their local government area. As such, councils have the most effective role in managing the risk. Stakeholder roles and responsibilities can be most effectively integrated into councils' floodplain risk management process through its floodplain risk management plan, which includes cooperation between representatives of state and local government and the community. Under the Policy, councils establish floodplain risk management committees, which include community groups and specialist government agencies, to produce floodplain risk management studies and implement floodplain risk management plans (FRMP). Through this process, councils can formulate a local flood risk management policy and incorporate flood-responsive land use planning and appropriate development controls and standards into their local environmental plans and development control plans. These Guidelines can assist councils in the preparation or amendment of local environmental plans and development control plans in order to provide a clear and consistent basis upon which development applications can be determined.

Councils, with the assistance of the local emergency management officer (LEMO) also have a key role in assisting the emergency services in a flood event. Councils may supply equipment, plant and machinery, buildings and other facilities and resources, to assist the emergency services and the community both during a flood event and in the recovery and clean-up period. Councils should be aware that calls upon their assets and facilities are likely to be made for various emergency situations. This consideration should influence the siting and design of depots and other facilities to ensure continued functionality, wherever possible, for the full range of potential emergencies including flooding.

State Government Departments and Agencies

Department of Environment and Climate Change

The Department of Environment and Climate Change (DECC), formally The Department of Natural Resources, has a role in floodplain risk management. It provides policy guidance and consistent specialist technical assistance to councils on all flooding matters. Its primary objective is to ensure that the NSW Government's Flood Prone Land Policy is implemented. It provides specialist input to councils' floodplain risk management committees and assists councils in their floodplain risk management studies and implementation of floodplain risk management plans. DECC also administers grant programs to assist councils in carrying out their floodplain risk management role.

Department of Planning

The Department of Planning shapes the future of the State by planning and monitoring both the built and natural environment. Through state plans, strategies and policies, it is able to direct development in the State to foster community and regional growth. The Metropolitan Strategy is a broad framework to promote and manage growth within the Sydney basin. It outlines a vision and directions for the next 25 years. More detailed planning will be included in regional and sub-regional strategies.

The need to accommodate Sydney's growth has resulted in increased development densities in existing suburbs and the release of greenfield sites in the Hawkesbury-Nepean valley. As extensive tracts of land earmarked for development are below the level of the Hawkesbury-Nepean PMF, there is a need for the best practice floodplain risk management approaches put forward in the three Guidelines to be factored into the planning process. Timely consideration of these important flood risk management issues, will avoid an otherwise inevitable increase in flood damages arising from new development on land subject to severe, albeit rare, Hawkesbury-Nepean flooding.

State Emergency Service

The State Emergency Service (SES) is responsible for coordinating the response to floods and storms. The SES:

- has in place a series of up dated emergency flood plans and the resources to carry out the emergency response;
- improves and provides flood warning systems and delivers the flood warnings;
- carries out evacuations for communities that are threatened or when houses are made uninhabitable due to floods or storms;
- rescues those who are endangered, trapped or injured by floods or storms;
- resupplies communities and individuals isolated due to flooding;
- carries out emergency works on properties damaged by floods or storms;
- coordinates immediate welfare requirements for affected communities, in conjunction with the Department of Community Services; and
- is committed to raising public awareness and preparedness for flood events.

Increasingly, the SES contributes to the environmental planning process carried out both by councils and the State Government for urban release areas, new residential development and tourist development which is proposed on flood prone land. The main focus of the SES input into planning decisions relates to flood evacuation of new residents and the implications for the evacuation of existing at-risk occupants of flood prone land.

There is close liaison between the SES and the Bureau of Meteorology to ensure enhanced flood prediction and timely issue of flood warnings to enable a prompt response by the emergency services. In a flood event, other emergency services including the NSW Police and the Rural Fire Service (RFS) assist in the operational tasks.

The agency performs its operational functions ably assisted by volunteer members, drawn from the local community. The role played by the volunteers, who personally commit time and effort to emergency operations, is critical to the Service being able to manage flood emergencies. The volunteers' commitment goes a long way towards safer occupation of the floodplain.

Department of Community Services

The consequences of a flood can be extremely disruptive and traumatic for the affected community members. The Department of Community Services (DoCS) assists in community recovery after an event through the administration of financial assistance and other measures aimed at disaster relief to relieve hardship and distress. It has the responsibility of administering a flood recovery plan, which includes the organisation of evacuation centres located beyond the extent of the PMF. It identifies evacuation centres out of the floodplain. DoCS has found that centres are best located in large building complexes such as clubs which are designed to cope with large numbers of people at one time; such facilities tend to be easily accessible and well provided with car parking spaces, catering and toilet facilities.

As part of the flood recovery plan, a range of non-governmental organisations including the Red Cross, St Vincent de Paul, Anglicare and the Salvation Army, provide basic and essential services to those affected or displaced by the flood. The ability of these organisations to implement this essential role relies heavily on volunteers and community input and support.

Utility providers

Providers of essential utility services, both public and private, have a two-fold responsibility to manage their assets on floodplains and to flood risk management. Firstly, they have a responsibility to provide services to communities occupying flood prone land. However, to ensure continuity of supply, care needs to be exercised in locating fixed assets. New or upgraded infrastructure should be located in accordance with the guidance provided in these guidelines in order to minimise disruption, reduce outages and facilitate recovery and repair.

Secondly, during and after a flood event, providers have a responsibility in securing supply, service and equipment to:

- ensure continuity of service;
- provide alternative means of supply during disruption, if possible; and
- repair or replace equipment and restore services in a timely manner after an event.

Public health and safety is a key issue in regard to drinking water supplies and the provision of sewerage, gas, electricity and communication services.

Government agencies with land management and development responsibilities

Many government agencies have responsibility for land and property management on flood prone land. Each agency's risk management plan should include an understanding of the implications of the flood risk in relation to the:

- safety of occupants for a range of flood events up to the PMF;
- potential for flood damage to the agency's property; and
- continued functionality of the agency's buildings/property after inundation.

Of particular importance is the need to have current plans in place for the flood evacuation of particularly vulnerable occupants such as patients of hospitals, school students and inmates of correctional centres.

Peak Bodies

Floodplain Management Authorities of NSW

The NSW Floodplain Management Authorities (FMA) was established nearly 50 years ago to promote sound and responsible floodplain management. Its sixty-five members include local councils in NSW with significant flooding problems.

The FMA is accepted by State and Federal Government as representing the interests of floodplain communities in NSW and those with a role in managing the floodplains to reduce future flood losses. It is a peak body, which is in a pivotal position to convey information to decision-makers in a consistent, effective and impartial manner. As part of its services to members, it organises an annual conference which promotes dissemination of leading edge research and examples of good floodplain risk management from NSW, interstate and overseas, to councillors, local and State Government floodplain engineers, planners, emergency managers and consultants.

Educators and Professional Organisations

Teachers

In NSW high schools, the earth and environmental studies syllabus includes how the hydrological cycle and associated river systems function. Flood information can be made available at environmental study centres and integrated into both primary and secondary curricula. Through this avenue, knowledge of flooding as a natural process of river evolution can be increased. Information about rivers and creeks and their relationship to human settlement can be explained in a local context. Through the geography syllabus, the social implications of living and working on floodplains can be explored. Raising levels of knowledge in younger generations is likely to have long-term benefits. In the shorter term, flood awareness and information will reach parents through their children.

The SES has provided a geography kit for use by secondary school teachers, as part of the FloodSafe Hawkesbury-Nepean public awareness strategy. It provides information in a graphical format on flooding, flood damages and on the work of the Hawkesbury-Nepean Floodplain Management Strategy.

Tertiary educators

Study units relating to natural hazard risk management including floodplain risk management need to be included in the core curricula of undergraduate and postgraduate courses for land management, land economics, engineering, surveying, architecture and urban and regional planning in order to effect changes in graduates' approach to the development of flood prone land. The result should be a better understanding of the inherent flood risk and means to effectively manage that risk.

Professional bodies

Professional bodies can inform professionals involved in the development process about the impacts of natural hazards and how to plan and build for safer, sustainable communities through continuing education programs.

The Planning Institute of Australia (PIA)

The PIA represents professional urban and regional planners. It establishes and administers standards of professional competency, develops and disseminates planning knowledge to the profession, increases member knowledge through education, training and research and provides a forum for an exchange of views. The PIA has worked with Emergency Management Australia (EMA) to promote the publication Planning Safer Communities, (Emergency Management Australia 2002) and to hold intensive workshops for planners. Planning Safer Communities demonstrates how integrated land use planning can reduce the impact of natural hazards and avoid risk to life, property and environmental systems from natural hazards. The focus is on risk reduction at the interface between communities and the natural environment by integrating risk reduction into the planning process. The PIA can promote sustainable floodplain developments to its members through targeted seminars or workshops as part of the continuing professional development programs

Engineers Australia

Engineers Australia facilitate career development through continuing professional development and set the standards for engineering education and practice responsive to the needs of social justice and sustainability. Traditionally floodplain management has been in the hands of engineers who have, understandably, sought engineering solutions to mitigate flooding and manage the risk. Increasingly, it is becoming apparent that sustainable solutions to floodplain risk management also lie in better management of flood prone land by promoting new development and land uses, which are commensurate with the flood risk. Engineers Australia can play a pivotal role in changing attitudes leading to an industry acceptance of non-engineered solutions to floodplain risk management.

Stormwater Institute of Australia

The Stormwater Institute of Australia (SIA) is for those involved stormwater management. It aims to provide a safe and sustainable urban environment through flood and pollution management, using innovative and affordable stormwater management systems. Its mission is to provide an effective, efficient and integrated stormwater industry. It embraces sound research and technical excellence with a strong focus on information dissemination to its members and other professionals in the industry through a range of publications and events. It is in an ideal position to promote flood awareness amongst its members and influence practitioners to promote, plan and design sustainable urban drainage solutions, to reduce the flood risk.

Community

Developers

Developers have a responsibility to recognise and address the full range of flood risks which can impact on their development. They should ensure that new development on flood prone land does not adversely affect flood behaviour upstream and downstream beyond the site. Developers should aim to reduce the exposure of new residents and others to flood risk – with all its attendant consequences of property damage, financial losses and social and health impacts.

The manner is which the flood risk is managed may affect the final form of the development.

Applicants are responsible for providing sufficient information to the consent authority, usually council, to enable it to determine development applications in accordance with the Environmental Planning and Assessment Act 1979 (s. 79 C). Section 79 C requires that the following matters be taken into consideration in determining a development application:

- the provisions of any environmental planning instrument;
- any development control plan;
- the likely impacts of the proposed development – including social, environmental and economic impacts;
- the suitability of the site for development; and
- the public interest.

Individuals

Those individuals who own property, run businesses, develop and build on flood prone land or live or work on floodplains, have a personal responsibility to make themselves aware of the flood risk. It has been demonstrated that an aware and prepared community is more resilient and less vulnerable. It is able to respond better to a natural disaster than an unprepared community.

To assist the community, the SES promotes a community education program under the 'FloodSafe' logo. Further information on this program can be found in Chapter 13 of these guidelines.

Individuals who are planning new development on flood prone land can now make informed choices about the location, type and style of development, given the availability of information on the flood risk and the information in the guidelines. Councils should make sure that such information is readily available to those making enquiries. In this way, in the longer term, property damages can be reduced, recovery periods shortened, and the adverse consequences of flooding kept to a minimum.

Once the flood risk management measures have been identified for an individual dwelling or building it is the owners' responsibility to ensure that the effectiveness of any particular risk management measure is not diminished through subsequent actions or works on their site.

It is however, recognised that no assumptions ought to be made about the level of awareness within the community about flooding. A flood event may occur at any time and many individuals may be unaware of the flood risk. There remains a need for effective emergency management strategies to be in place at all times to protect all occupants of flood prone land.

Business owners and operators

In the Hawkesbury-Nepean valley, many commercial and industrial areas will be affected by flooding up to the PMF. Businesses will be flooded more frequently than dwellings because of the tendency to have a lower FPL for non-residential uses. Should a significant flood occur, the impacts on businesses would be severe.

Employers have a duty of care to ensure the health, safety and welfare at work of all employees and others at the workplace. Implementing the duty of care principle means planning for the prevention of workplace accidents, injuries and illnesses. It is the employer's responsibility to ensure that all reasonably practicable measures have been taken to control the risks to prevent all possible injuries in the workplace. Whilst most occupational health and safety focus is on the workplace itself, external factors such as natural hazards, including the risks from severe flooding, should not be ignored if it has the potential to adversely impact on the safety of the workplace.

The SES has developed a Business FloodSafe Plan to assist businesses to be prepared for a flood by planning appropriately. Details of this plan can be obtained from the SES.

Business disruption following a major flood

If major flooding is predicted and an evacuation is called, all staff will have to evacuate. Even if the premises are only isolated and not eventually inundated, trading may be disrupted for some time.

Buildings, equipment, stock, plant, records, data and other assets can all be damaged or destroyed by floodwaters. In some locations where water is not only deep but is subject to velocities, there is the potential for structural and contents damage.

If an area is inundated and homes, infrastructure and essential services are damaged, destroyed, or unable to be used, it may be many weeks or months before the area is able to be reoccupied and returns to normal. Business disruption is inevitable. This can have significant local economic consequences and prolong recovery.

To include flooding as a criteria when identifying hazards in the workplace and when developing and implementing risk control strategies, employers need to be aware of the flood hazard and have a knowledge of how floods can impact on their business. An understanding of the:

- frequency of floods;
- range of floods;
- expected velocities; and
- warning times available,

is necessary in order to make informed decisions. Councils and the SES may be able to assist in the provision of this type of information.

In order to respond appropriately to flood warnings, employers, workers and others in the workplace need to understand the threat and warning systems; they need to be aware of evacuation procedures and any procedures for securing or removing stock or plant.

Some businesses may choose to protect their records and data through back-up facilities off-site, beyond the PMF limits.

Incorporating flood-aware building design into the premises can reduce water damage. By considering flood risk, buildings can be designed or modified to enable stock, plant or materials to be stored or moved easily to higher levels, thus reducing the probability of direct water damage.

13

COMMUNICATING FLOOD RISKS

Introduction

Hawkesbury-Nepean River flooding can be so severe that it damages homes and other property, threatens lifestyles and the viability of local businesses. Flooding can be a risk to life in high hazard areas, including areas that become isolated by rising floodwaters. The Hawkesbury-Nepean Floodplain Management Strategy found that there are no practical and cost effective flood mitigation options available to influence the behaviour of the severe floods in the valley, but there are measures that can reduce the consequences of the floods.

Communicating flood risk gives the public the opportunity to make informed decisions about living and working on the floodplain and share in the responsibility for that decision. Without such information, the community is likely to be outraged when a major flood results in their expectations not being met.

Thus, flood-affected communities should be made aware of the flood risk that may affect them and their property and the role they, as householders or business managers, can play in reducing their own risk. Within the Hawkesbury-Nepean community, there are individuals who can assist others within the community to better understand and respond to the flood risk. Those with influence should act responsibly to ensure that communities are able evolve into flood-aware communities over time. A flood-aware community will be able to make appropriate choices about the location, design and materials used in its new homes and be able to respond and recover better from a flood event than one that is in ignorance of the threat.

> It is not a question of if a flood happens but rather when it happens.

What Are the Issues?

- The community does not appreciate the significance of the risk posed by Hawkesbury-Nepean floods.
- People expect a safe environment in which to live and work. They expect decision-makers to inform them of known foreseeable natural hazards and the risks those hazrds pose.
- A long-term communication program is needed to overcome people's natural indifference to, or denial of, rare flood events, which they believe do not immediately affect them.
- Not only do the public need to be well informed, those in positions of authority also need to be well informed.
- Conveying accurate and credible information to the community prior to, during and after a flood is essential.
- A public awareness program should recognise that there are different audiences that need to hear messages about flooding and it should strategically target all communities, using a range of tools.
- A flood awareness program should do more than just provide appropriate information: it must promote changes in attitudes and behaviour towards the flood risk.
- Not all sectors of the community can be expected or indeed are able to respond to public awareness information. Only a small proportion will change their behaviour and make efforts to manage their own risk. The majority will be more dependent on those in authority to make appropriate decisions for them, whilst others will continue to deny that the risk is 'real' and fail to change their position. In addition, there will always be individuals who, for a wide range of reasons are not receptive to public awareness messages. Authorities need to be aware of their responsibility for these highly vulnerable groups in flood events.
- People threatened by flooding may experience strong feelings of fear, anxiety and helplessness, including a desire to protect their possessions which can lead to behaviours that are neither helpful nor appropriate in the circumstances.

A communications program needs to recognise this and prepare people both mentally and psychologically.

- Any public awareness campaign will need to be adapted over time to ensure it remains current and relevant to changing trends.

If levels of awareness, knowledge and involvement in decisions remain low then it is most likely that after a severe flood event, residents will be outraged. Their vulnerability will generate condemnation. Residents will want to know why they were not adequately told of the risk beforehand. There may be liability implications for authorities if people have not been provided with adequate opportunities to increase their awareness.

Who Has Responsibility for Flood Awareness?

Promoting and maintaining a permanent and adequate level of awareness requires a positive approach by government agencies and councils. Community leaders, residents, workers and business managers on the floodplain have an individual and collective responsibility to be open-minded and receptive to information on the flood risk. Achieving success is not straightforward and requires an on-going commitment and investment in terms of time, effort, money and other resources to achieve positive results.

State Emergency Service (SES)

The SES has specific roles related to communicating the flood risks:

- Preparing flood plans for communities at risk;
- Assisting the Bureau of Meteorology in developing and disseminating official flood and storm warnings;
- Translating official flood warnings into likely effects and disseminating that information; and
- Educating the public to ensure that those at risk know how to protect themselves and their property.

The SES and other partner agencies responsible for the implementation of the Hawkesbury-Nepean Floodplain Management Strategy devised a Public Communications Program under the banner of "FloodSafe – Hawkesbury-Nepean", (Figure 69).

***Figure 69** Hawkesbury-Nepean FloodSafe logo*

This FloodSafe program has been in operation since 2000.

The FloodSafe public education strategy aims to:

- Increase public awareness generally about the risk of flooding and how to be prepared.
- Encourage individuals to protect their families, homes, and possessions in times of flood.
- Develop public education resources at the local level. This includes information specifically for householders, teachers, school students and businesses.
- Increase knowledge of evacuation routes through appropriate signage along the routes.
- Promote community recovery after floods.
- Disseminate information from local councils about the flood hazard and local resources.
- Provide the media with background information on Hawkesbury-Nepean flooding prior to flood events and undertake media management during a flood event.

The Program is implemented by the SES and supported by SES volunteers trained in community liaison and media management. A dedicated web site has been created at www.floodsafe.nsw.gov.au. It includes information about the FloodSafe Program, frequently asked questions, Hawkesbury-Nepean Floodplain

Management Strategy reports and the role of the SES.

Local councils

Local councils can generally provide both property-specific and floodplain-wide flood hazard information. Councils work closely with the local SES to provide educational material, which focuses on ensuring that the population at risk knows what to do and how to react effectively at the onset of a flood.

Councils, in conjunction with the community and government agencies, prepare and implement floodplain risk management studies and plans as the basis for their local flood risk management policies. Under the policy, Councils are able to ensure that people are made aware of the flood risks and are able to make informed choices.

When property changes hands, Councils have a statutory requirement under the Environmental Planning and Assessment Act 1979, as amended, to provide information through planning certificates. These section 149 certificates note the risks and hazards and any local flood risk management policy that apply to the property. Section 149 certificates have limitations as a public awareness tool and this is discussed further below.

The NSW Government's Floodplain Development Manual 2005 provides advice to councils regarding the provision of accurate, comprehensive and consistent flood data for internal use within council, and externally to government agencies, the general public, consultants and developers.

Hawkesbury-Nepean councils are assisted by the Flood Hazard Definition Tool, which has been provided to councils through the Hawkesbury-Nepean Floodplain Management Strategy. This GIS based computer software tool can ensure the provision of consistent flood data. Unlike traditional flood data sets, which require technical training to interpret the information, the visual display makes the hazard easier to understand. However, users do require some training in use of the tool in order to understand its limitations when applying it to individual properties. Council should ensure only staff trained in the use of the tool responds to public inquiries on flood hazards.

> A council should not wait for people to ask for information on flooding.
>
> If you don't know that the area floods how can you be expected to ask the right questions?
>
> People are better able to make informed decisions about the flood risk if they have access to sufficient information that is provided in a clear, helpful and non-technical manner.

Council's Flood Information Policy

There are clear benefits in streamlining and safeguarding the internal and external dissemination of flood information as part of a council's corporate risk management responsibilities to ensure it can maintain a good faith defence to any liability claims. Council has to have a proper system in place to deal with requests for information in order to rely on the defence of 'good faith", as the concept extends to both acts and omissions (Marsden 2005).

A policy for the collection and dissemination of flood-related information can assist this process having regard to existing procedures. The policy could include:

- Objectives;
- Process for the maintenance of information;
- Responding to information requests;
- Updating information;
- Access and use of information;
- Means of information release; and
- Monitoring and review of the policy.

The following objectives are suggested:

- To ensure that those handling or receiving flood information understand the distinction between risks associated with flooding and controls imposed by the council to mitigate against the consequences of selected flood events.

- To increase flood risk awareness amongst the general community and council personnel involved in land and asset management, strategic planning and the development assessment process through a flood related information service.
- To ensure that the general community and council personnel recognise that flood mitigation strategies have limitations and are unlikely to provide protection for the full range of floods.
- To ensure the consistent release of flood related information.
- To advise of restrictions that may be imposed on development due to the land being flood-affected and opportunities available to individuals to further reduce their personal risks.
- To minimise the consequences of flooding by increasing community preparedness and to increase its capacity to recover post-flood.
- To ensure that the council meets its statutory obligations in regard to the dissemination of flood related information.
- To promote council's floodplain management initiatives to the community.

Responsibility for the compilation, management and release of flood data needs to be carried out by appropriate staff: usually council's flood engineers. A range of methods can be used to disseminate information e.g. a flood brochure, Frequently Asked Questions (FAQs) and flood certificates. Standard information can be provided both in print form and on council's web site. Examples are discussed below.

Section 149 Certificates

Planning certificates are issued by a council under section 149 of the Environmental Planning and Assessment Act 1979 for any land in its area and must be attached to a contract of sale of property. Councils charge a fee is charged for issuing a section 149 certificate. A certificate must include the matters prescribed in the Environmental Planning and Assessment Regulation 2000 (section 149(2) certificate) and it may include advice on other relevant matters (section 149(5) certificate).

Schedule 4 of the 2000 Regulation requires the notification to include:

"Council and other public authority policies on hazard risk restrictions. Whether or not the land is affected by a policy:

a) adopted by the council, or

b) adopted by any other public authority and notified to the council for the express purpose of its adoption by that authority being referred to in planning certificates issued by the council, that restricts the development of the land because of the likelihood of land slip, bushfire, flooding, tidal inundation, subsidence, acid sulphate soils or any other risk"

As the local floodplain management authority, each council determines its own policy for section 149 certificate notification. Inconsistencies arise between councils in regard to the extent of flooding information they provide. Councils are only required to provide a "yes" or "no" answer as to whether it has a flood prone land policy. Further, there is potential ambiguity as to what notification should be given when a council is aware of a flood risk but where a policy does not exist.

A certificate issued under section 149(5) of the Act requires that a council "include advice on such other relevant matter affecting the land of which it may be aware". This longer certificate requires disclosure of all flood information council holds. However, as there is an additional fee it is not always requested, being not required for contracts of sale.

The primary purpose of section 149 Certificates is to advise of any policies relating to flood risks. However, the recipients often erroneously interpret the absence of flood risk policies as equating to the absence of flood risk.

A consistent approach to section 149 Certificate content between councils would help ensure that the disparities in communicating the same risks within the same floodplain are removed.

No flood policy is not necessarily the same as no flood risk.

In order to fully inform recipients of the a section 149 Certificate all known potential sources of flooding and/or inundation would be included. This includes:

- mainstream riverine flooding;
- local flooding from tributary rivers or creek systems;
- combined mainstream and local flooding;
- inundation from stormwater and local overland flow; and
- coastal flooding.

It is recognised that section 149 certificates, whilst fulfilling a statutory requirement, are not a particularly effective means of communicating risk. They are generally only obtained when a property is on the market. Thus, long-term owners and tenants do not learn of any revised flood prone land policies or new flood information through this means of communication. Vendors obtain a certificate but they and the purchasers may not understand the contents due to the legal format and language. Indeed, the conveyancer also may not fully understand the implications of the flood hazard information on the certificate.

Section 149 certificates cannot be relied upon as the sole means of disseminating flood information to the public.

As an adjunct to the report titled “Achieving a Hawkesbury Nepean Floodplain Management Strategy” completed in November, 1997, Egan National Valuers (NSW Pty Ltd) undertook a Valuation Study in 2000 to address concerns raised by the community as to possible affects upon property values of existing and proposed planning controls and notifications.

The Study indicated that perceptions of the importance of such notifications may vary depending on the state of the property market given its cyclical nature. Furthermore, it was noted that the level of accurate knowledge in the community as to the background of a PMF notification was subject to a high level of misinformation. To overcome this, significant education of the community and participants in the property market, such as real estate agents, solicitors, valuers and lending institutions is required to counter misrepresented views which may lead to increase levels of anxiety in the community.

Notwithstanding this, the Egan Study concludes that available sales data shows there is little or no discernible fall in property values as a result of the PMF classification (on Section 149 certificates). Variations in sales level were noted when a higher level of flood risk was evident such as that within some areas of South Windsor which are affected by more frequent flooding such as a 20 year ARI flood.

Flood Certificates

A non-statutory approach would be for a Council to issue a ‘flood certificate’ relating to each property on the floodplain. A flood certificate may be issued separately or appended to the section 149 certificate.

Although Flood Certificates would allow flood risks to be clearly and consistently provided at any time to both owners and occupiers, they do have limitations. Interpretation of flood levels will be necessary for properties which lie between the flood levels identified in the flood study. The information which a Council relies upon in providing a flood certificate may have certain limiting factors which need to be disclosed in the certificates; for example it would need to specify that the information is based on a nominated flood study and is applicable to the date of that study. Clearly if the flood study is not up to date and further development or works have taken place in the floodplain which could have influenced flood levels then a Council may choose to not issue certificates until such time as it has accurate and up to date information.

Electronically available information

A council's web site can provide:

- 24-hour, 7-days-a-week access to flood hazard information, including historic floods;
- access to information for those unable to visit council offices during business hours;
- fast and efficient retrieval of electronically stored information;
- readily available up to date information;
- flood liability for individual properties, if sufficient information is available.

A good example of how a web site can be used as a communication tool is Lismore Council's web site at www.lismore.nsw.gov.au. It includes information on why Lismore floods, a photo gallery of historic floods, what do in a flood, the history of floods, flood information and details of Flood Safe week which is held every year in February, (Figure 70). In conjunction with the SES, the web site includes a two-page information sheet of important flood information for householders. Also included on the council web site is the SES' emergency plan (Displan) for Lismore, flood evacuation routes and plans of the CBD.

Figure 70 *Lismore City Council's Flood Safe week logo*

Unlike many council web sites, Lismore provides tables of flood and floor levels for all properties affected by the 1 in 10 year and the 1 in 100 year flood levels, updated on an annual basis. The tables include street address, property description for commercial property, levels in metres AHD for floors, gate and road centre and levels for the 1 in 10 AEP and the 1 in 100 AEP floods. Useful links are provided to other related sites such as the SES and the Bureau of Meteorology. As the flood and floor levels are sourced from multiple sources without independent verification, Lismore council expressly disclaims liability and responsibility for the information provided in this way and urges users to seek all other information such as local knowledge and professional advice as appropriate.

The Internet should always be used in addition to, rather than as a replacement for more traditional means of information dissemination. There are sectors of the community who either do not choose to or are unable to access information electronically. These include those most vulnerable to flood hazard in particular the very elderly and the socially disadvantaged.

Information displayed in public places

Providing flood information in the form of signage, information panels, commemorative plaques etc in public places can be a useful tool in raising awareness of flooding to the general public. These are often referred to as "Flood Icons". Local 'ownership' of the flood problem can be achieved through community involvement in creating and/or maintaining the information. Such information signs tend to be limited in their scope but because they provide link real flood events with familiar locations or buildings, they are a useful reminder.

In 1998, as a community art project, Fairfield City Council and Fairfield High School created a design comprising numerous hand crafted tiles on the sloping banks of Prospect Creek at Fairfield Park as a Flood Icon to commemorate the 10th Anniversary of the 1988 floods, (Figure 71).
This unusual and imaginative icon is a constant reminder of the impacts of local floods and was undoubtedly important in aiding recovery of those people who were flood affected. However, without any accompanying explanatory material displayed on-site, the low-profile design in a quiet part of Fairfield Park is unlikely to have any long-term significant impact on awareness levels in the wider community.

Figure 71 *Fairfield City Council flood icon, Prospect Creek, Prospect Park, Fairfield*

In 1999, Macleay Council erected a Flood Icon in Clyde Street Mall, Kempsey, in the form of a carved timber pole marked with coloured rings at the various historic and predicted flood levels, together with an explanatory plaque, (Figures 71 and 72). The top of the pole (approximately 6 metres above the pavement) is intended to demonstrate the level of the PMF at Kempsey. Its erection was part of the 50th anniversary commemoration of the major flooding in 1949 in which six people lost their lives.

The Kempsey Flood Icon generated considerable interest and some opposition from local business interests until further explanation of flood terminology and probabilities was provided. This illustrates how no single means of communication is ever sufficient to convey the full message about flood hazard and risk. A real understanding what “risk” or “probability” mean is generally lacking in the wider population. Every effort should be made to use straightforward vocabulary and avoid abbreviations or jargon.

Kempsey also placed markers around the town for the 1949 peak flood level, which was at the time estimated to be a 1 in 100 AEP event. Similarly, in Windsor historic floods are marked on a wall in Thompson Square where there is a marker for the peak of the 1867 flood of record and even earlier flood levels are carved into the corner of the Doctor’s House there. Although flood markers tend to be deliberately discrete, they are informative and provide a subtle reminder of the ever-present flood risk.

Figure 72 *The flood icon pole in the main shopping area of Kempsey*

***Figure 73** Kempsey Flood Icon Pole – plaque transcript*

BOND OF CO-OPERATION
KEMPSEY SHIRE COUNCIL

Kempsey Flood Icon

This Flood Icon was unveiled by the Mayor of Kempsey Shire, Cr Peter Mainey on 27th August, 1999 to mark the 50th anniversary of the peak of the 1949 flood in the Macleay River and as an indication of the flood levels on the gauge at the Kempsey bridge.

The icon is marked to indicate:

1 in 5 year predicted flood (white line)
1 in 10 year predicted flood (yellow line)
1 in 20 year flood and May 1963 level (orange line)
June, 1950 flood level (green line)
August, 1949 flood level (red line)
1 in 100 year predicted flood level (blue line)

The top of the pole represents the level of the predicted Probable Maximum Flood, (PMF) which could occur in the Macleay.

Print media

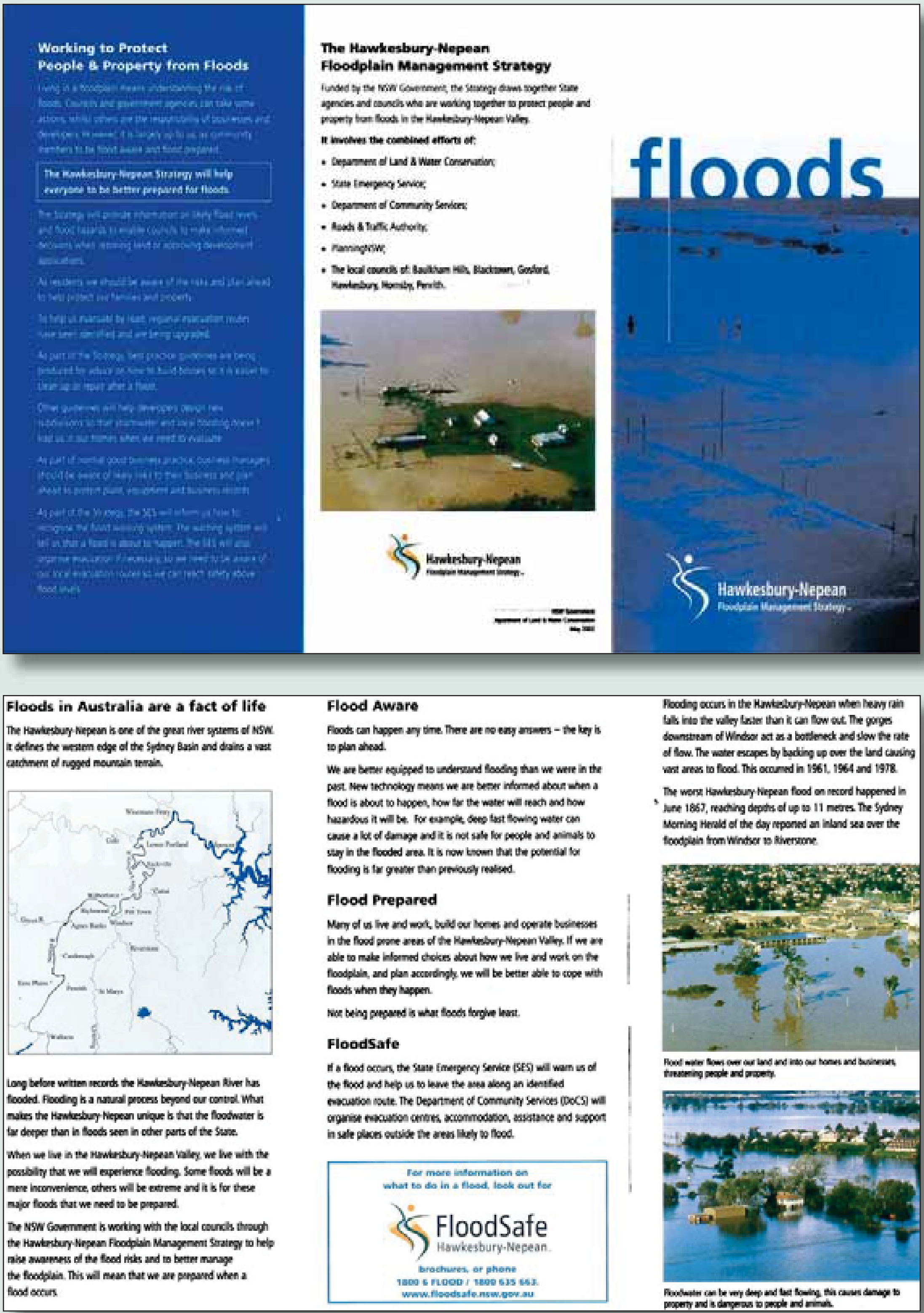
Using plain English or community languages, leaflets and brochures are a common way for a council to summarise local issues relating to the flood risk. They can provide summaries of flood prone land policies, describe historic floods or provide information about the floodplain risk management process. A leaflet entitled "Floods" has been distributed to councils as part of the Hawkesbury-Nepean Floodplain Management Strategy, (Figure 74). It provides a regional overview of Hawkesbury-Nepean flooding and a summary of what the State Government and councils are doing to help the community to be better prepared for floods.

However, a generic leaflet with non-targeted distribution is unable to indicate how river flood heights can relate to individual properties but may indicate the sequence of evacuation road closures, or the design flood heights in relation to familiar landmarks or buildings. It can alert people generally to the flooding problem without focussing on preparedness aspects. All flood leaflets should provide emergency contact phone numbers.

Since 2001, Lismore Council has nominated the first week in February as Flood Safe Week. During this period, printed flood information is hand-delivered to every household affected by the 1 in 100 AEP flood. The information provides a property-specific diagram of a house with:

- levels in metres AHD for the floor, front gate, and centre of the road;
- the approximate 1 in 100 AEP flood level and 1989 flood level at that building;
- a sketch map of the town showing evacuation routes;
- the last roads out (to be flooded) and a chart of historic flood heights and dates;

Figure 74 *HNFMS Flood brochure*



Working to Protect People & Property from Floods

The Hawkesbury-Nepean Strategy will help everyone to be better prepared for floods.

The Hawkesbury-Nepean Floodplain Management Strategy

Funded by the NSW Government, the Strategy draws together State agencies and councils who are working together to protect people and property from floods in the Hawkesbury-Nepean Valley.

It involves the combined efforts of:

- Department of Land & Water Conservation;
- State Emergency Service;
- Department of Community Services;
- Roads & Traffic Authority;
- PlanningNSW;
- The local councils of: Baulkham Hills, Blacktown, Gosford, Hawkesbury, Hornsby, Penrith.

Hawkesbury-Nepean

floods

Hawkesbury-Nepean
Floodplain Management Strategy

Floods in Australia are a fact of life

The Hawkesbury-Nepean is one of the great river systems of NSW. It defines the western edge of the Sydney Basin and drains a vast catchment of rugged mountain terrain.

Long before written records the Hawkesbury-Nepean River has flooded. Flooding is a natural process beyond our control. What makes the Hawkesbury-Nepean unique is that the floodwater is far deeper than in floods seen in other parts of the State.

When we live in the Hawkesbury-Nepean Valley, we live with the possibility that we will experience flooding. Some floods will be a mere inconvenience, others will be extreme and it is for these major floods that we need to be prepared.

The NSW Government is working with the local councils through the Hawkesbury-Nepean Floodplain Management Strategy to help raise awareness of the flood risks and to better manage the floodplain. This will mean that we are prepared when a flood occurs.

Flood Aware

Floods can happen any time. There are no easy answers – the key is to plan ahead.

We are better equipped to understand flooding than we were in the past. New technology means we are better informed about when a flood is about to happen, how far the water will reach and how hazardous it will be. For example, deep fast flowing water can cause a lot of damage and it is not safe for people and animals to stay in the flooded area. It is now known that the potential for flooding is far greater than previously realised.

Flood Prepared

Many of us live and work, build our homes and operate businesses in the flood prone areas of the Hawkesbury-Nepean Valley. If we are able to make informed choices about how we live and work on the floodplain, and plan accordingly, we will be better able to cope with floods when they happen.

Not being prepared is what floods forgive least.

FloodSafe

If a flood occurs, the State Emergency Service (SES) will warn us of the flood and help us to leave the area along an identified evacuation route. The Department of Community Services (DoCS) will organise evacuation centres, accommodation, assistance and support in safe places outside the areas likely to flood.

For more information on what to do in a flood, look out for

FloodSafe
Hawkesbury-Nepean

brochures, or phone
1800 6 FLOOD / 1800 635 663.
www.floodsafe.nsw.gov.au

Flooding occurs in the Hawkesbury-Nepean when heavy rain falls into the valley faster than it can flow out. The gorges downstream of Windsor act as a bottleneck and slow the rate of flow. The water escapes by backing up over the land causing vast areas to flood. This occurred in 1961, 1964 and 1978.

The worst Hawkesbury-Nepean flood on record happened in June 1867, reaching depths of up to 11 metres. The Sydney Morning Herald of the day reported an inland sea over the floodplain from Windsor to Riverstone.

Flood water flows over our land and into our homes and businesses, threatening people and property.

Floodwater can be very deep and fast flowing, this causes damage to property and is dangerous to people and animals.

The Hawkesbury-Nepean Floodplain Management Strategy (HNFMS) produced this Flood brochure in 2002 for distribution to all councils in the Strategy area and appropriate government agencies, to raise public awareness about the flood problem in the Hawkesbury-Nepean valley.

- how the CBD of Lismore was affected by floods;
- practical information on what to do in a flood;
- how to respond to flood warnings;
- emergency phone numbers; and
- updates on flood mitigation works.

Distribution of leaflets with council rates notices is a low-cost means to convey flood messages to landowners, but unlike letter box drops, they may not reach tenants. How effective information disseminated in this way is, is questionable as there is a risk it may simply be discarded unread because the recipient has not requested the information.

Whilst brochures are an effective way of conveying awareness and preparedness messages, the information is not necessarily received or retained. Letterbox drops can ensure delivery of the message to the target audience but do not guarantee that the information is read, understood or acted upon. Follow-up studies in Woronora found that under a third of recipients had any recall of having read delivered leaflets and only about a quarter kept them for future reference. (Molino and Huybrechs 2004). Southern Cross University carried out a survey for Lismore Council and found a good response to the public education messages about flooding with the majority (71%) considering themselves prepared for a flood. Nonetheless, the Lismore survey results reported that there would be resistance to leave home if there was a call for evacuation. (www.lismore.nsw.gov.au).

> The biggest hurdle to overcome in any public awareness campaign is a reluctance to translate increased knowledge of the risk into behavioural change.

Property flood level information labels

Sutherland Shire introduced a voluntary system of fixing labels with coloured bands indicating flood level information in the meter boxes of flood-affected houses in Woronora. (Figure 75). The label makes it clear what the implications of flooding are for the individual house and where to get additional information. This is a simple method of informing both the owners and tenants of the flood risk in a very specific way. The information is fixed in an accessible and permanent location at the house and is not removed or lost when occupants change. A follow-up study found that five years later all the labels were still in place and 60% of residents either knew the flood colour coding or knew to go to the label to find out.

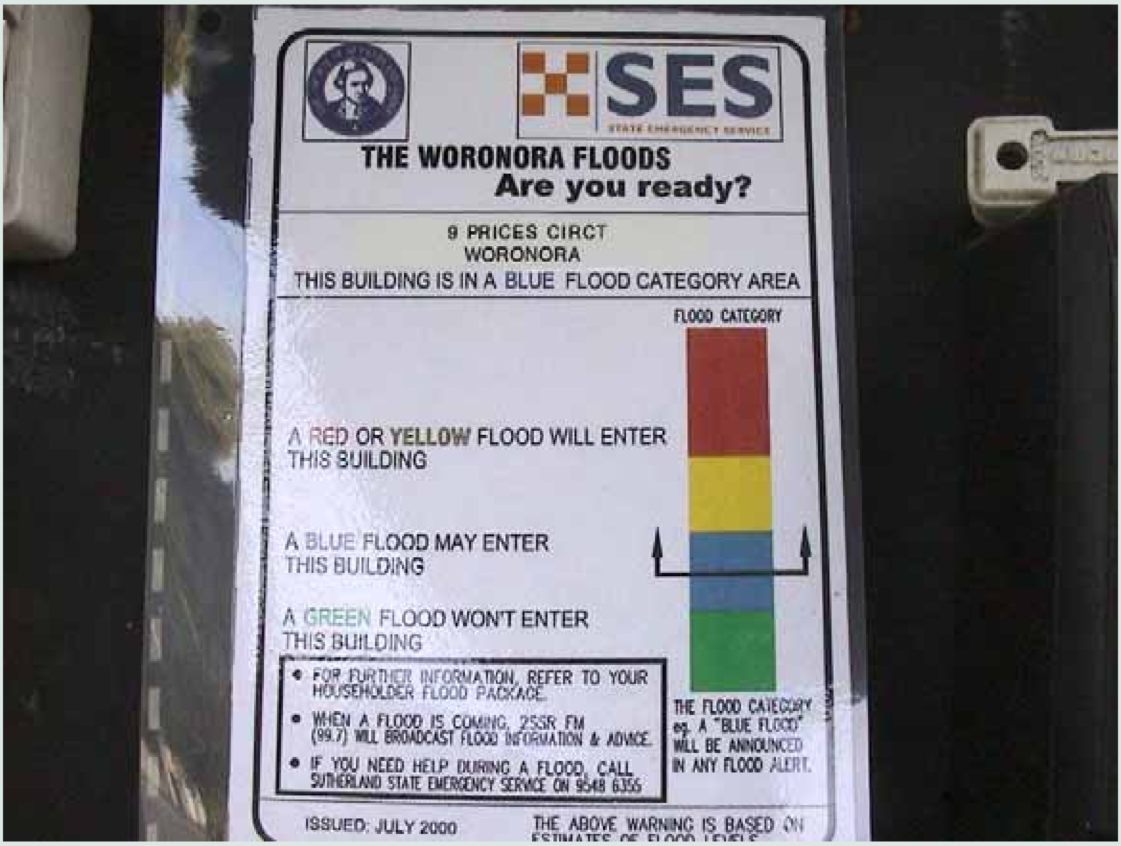
However, as it is a voluntary scheme, many homes in Woronora do not have the labels, as there was not a good take-up rate by residents with many refusing to acknowledge the local flood risk. (Molino and Huybrechs, 2004). Clearly the introduction of property-specific flood information labels has to be accompanied by a suite of other public awareness measures to increase understanding of the flood risk. Only then can residents appreciate that the labels are designed to help them when a flood occurs, rather than seeing flood information as a threat or a stigma.

What Are the Barriers to Success?

There can be wide variation in how flood awareness messages are accepted between communities and between households, and indeed no campaign is ever going to achieve a 100% success rate. Notwithstanding these limitations, easily understood flood information should be made available to various groups and individuals within the community. Some of the key considerations of any flood communication program in the Hawkesbury-Nepean include:

- Recognition that because urban flooding occurs infrequently, people are less likely to take an active interest in flood awareness messages.
- The community is likely to perceive the risk of flooding as low and therefore of no concern.

Figure 75 *Flood markers in meter boxes*



Sutherland Shire Council employed a voluntary scheme whereby labels such as this were fixed to meter boxes in Woronora as permanent flood markers specific to each building.

- People lead busy lives and are pre-occupied with the concerns of day-to-day life. It is not easy to make the time to find out about natural hazards, which may appear irrelevant.
- In growth areas, population turnover demands messages to be periodically repeated to ensure newcomers are not uninformed.

How Can Public Awareness Be Funded?

Committing funds for sustained public awareness programs for a flood that occurs only rarely, such as severe Hawkesbury-Nepean flooding, can present a challenge.

The Local Government Act 1993 enables councils to raise special rates for purposes that would give a special benefit. However, whilst this would allocate funds to the nominated special purpose, e.g. public awareness, it would mean that less rate revenue would be available for other council purposes. An alternative means of raising revenue is a special annual charge to apply in local government areas where properties are affected by the Hawkesbury-Nepean PMF. Although this approach has been adopted in the Blue Mountains for bushfire emergency service purposes, to apply it to a different natural hazard i.e. flooding, in other council areas, may require legislative changes to the Local Government Regulation.

Voluntary planning agreements can enable a developer to fund works and services, which are normally funded directly by government. Where a flood prone site is to be rezoned or developed, a voluntary planning agreement could be explored as an avenue for contributions to the SES's or council's local public awareness campaigns for the area. Such agreements are able to provide a monetary contribution, land dedication or material public benefit towards a public purpose which can include recurrent expenditure. (DIPNR 2005).

The NSW government funds the SES public awareness programs, with additional funding allocated through the Hawkesbury-Nepean Floodplain Management Strategy to address public communication in the Hawkesbury-Nepean floodplain.

Conclusion

The responsibility for raising public awareness about Hawkesbury-Nepean flooding lies with councils and the SES. However, the success of their programs can be enhanced by decision-makers, community leaders and community members themselves having a better general understanding of the basics of floodplain processes and the concept of risk. If possible, any public awareness program should make use of community members who have had direct flood experience within the Hawkesbury-Nepean valley and a good understanding of the full range of possible flooding.

It should be recognised that there will inevitably be a limited low level of interest in the absence of any real flood. However, having an effective public communications strategy in place will assist council in its duty of care. To do this effectively, authorities need to adopt a suite of approaches, using a range of consistent and easily comprehensible communication tools, to inform the public of the risk of flooding and the means to manage and reduce risk to themselves and their property.

Everyone can contribute to averting future problems by a having raised level of flood awareness, as flood aware communities are more likely to support moves for flood aware planning and development controls including building controls for new dwellings. Thus new development can reduce the increase in flood damages which will inevitably occur as development in floodplains continues.

SECTION V

APPENDICES, GLOSSARY AND BIBLIOGRAPHY

APPENDIX A

SAMPLE FLOOD CERTIFICATE

Council Name

Flood Certificate

Property:	*16 Albany Way, Lachlan Downs*
	Lot 2, DP 456890
Owners:	*John and Jenny Smith*

Known Flood and Ground levels of the property:

The lowest floor of the main building on this property is	20.9 m AHD
Source of information	Survey dated 1998
The lowest ground level on this property is	20.4 m AHD
Source of information	Survey dated 1998

Estimated flood levels

Size of flood	Flood level m AHD	Depth over floor level (without freeboard)	Depth over lowest ground level
PMF	27.6	8.3 m	8.8 m
1 in 1000 year flood	23.3	4.0 m	4.5 m
Flood of record	19.7	0.4 m	0.9 m
1 in 100 year flood	17.3	Not flooded	Not flooded
1 in 20 year flood	14.9	Not flooded	Not flooded

The **PMF** is the probable maximum flood that could conceivably occur. It is extremely rare.

The **1 in 1000 year** flood has a 0.1% chance of occurring in any one year.

The **flood of record** in the (insert name of river) floodplain is estimated to be a 1 in 300 year event *(figure reflects the return interval of the relevant flood of record for each certificate).*

The **1 in 100 year** flood has a 1% chance of occurring in any one year.

The **1 in 20 year** flood has a 5% chance of occurring in any one year.

Classification of Flood Risk:

Council records indicate that the property is located within

Flood Risk Band D

and has a

LOW Risk Rating

Flood risk bands are rated as Extreme, High, Medium or Low. The bands reflect the level of financial risk from flood damages which would occur if there were no additional flood-aware building controls applied to new dwellings on this land. The flood risk management bands are described in the Flood Policy, copies of which are available from the Council offices.

APPENDIX B

DETERMINING FREEBOARD

What is Freeboard?

Freeboard is defined in the NSW Government's 2005 Floodplain Development Manual:

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

Freeboard is incorporated into the flood planning level (FPL). It is added on to the level of the flood selected for planning purposes to give the FPL.

The Manual recommends that a freeboard of 0.5 metre would be acceptable for residential floor levels and in most floodplains, this will provide an adequate factor of safety. A floodplain risk management study may identify cost-effective benefits from having a higher figure.

The purpose of a freeboard is to allow for uncertainties. It provides a reasonable level of confidence that a property built at the FPL is protected against the design flood. It does not give protection against rarer (higher level) floods. If protection against more severe floods is demanded, then a different design flood should be chosen, rather than a deeper freeboard.

Freeboard in the Hawkesbury-Nepean Context

Given that the Hawkesbury-Nepean valley is subject to flood risk that is considerably higher than many other NSW floodplains, advice is provided on determining if a variation to a 0.5 m freeboard is warranted in this context when setting FPLs for:

- the floor levels of dwelling houses and other occupied buildings;
- public infrastructure e.g. roads and railways; and
- drainage works;

in order to provide a factor of safety which is reasonable and appropriate for this floodplain.

The magnitude and extent of Hawkesbury-Nepean flooding, means that levees are not a practical option for reducing the flood hazard in urban areas. This is because the scale of the levees, which would be necessary to mitigate the flooding, would have significant and unacceptable social, economic and environmental impacts. Levees may be an option to address local circumstances in non-urban situations. This can be determined through the floodplain risk management process.

Consideration of Uncertainties in Determining Freeboard

A freeboard reflects an error margin or all-encompassing factor of safety to compensate for uncertainties that exist in:

- the flood model estimation, or

confidence in the estimation of the various components which affect flood protection:

- wave action,
- afflux, and
- climate change.

The approach reflects the impossibility of quantifying either the increase in flood levels associated with the each component or the likely coincidence of two or more components occurring. As such, a rigorous review of the allowance for each of the components would be unlikely to be credible. This approach can be used if a variation from the commonly adopted standard freeboard of 0.5 metre is justified to accommodate exceptional flooding characteristics. These uncertainties are discussed below.

Flood model estimates

A flood study is a comprehensive investigation of flooding behaviour for the full range of floods up to the probable maximum flood (PMF). It is part of the floodplain risk management study and plan process. A flood study incorporates:

- flood models, including:
  - hydrologic models - converting rainfall to run-off), and
  - hydraulic models - converting flows to water levels;
- flood levels;
- extent of flooding;
- velocity; and
- the distribution of velocity.

Where sufficient historical flood data is available, flood frequency analysis is used to increase the reliability and credibility of flood estimates. This can provide flood levels derived from flood modelling which is based on data from real flood events which have occurred in the past. There are uncertainties inherent in any flood modelling.

If existing flood model(s) are to be used to determine freeboard, then the relevance of that particular flood model for that purpose should be ascertained. Can it provide the necessary confidence, is it robust, is it recent enough, are the assumptions on which the modelling was based still relevant, are new more reliable models available, is more modelling necessary?

Flood planning levels rely on the application of flood models based upon limited data within the catchment. It is necessary to understand the broader uncertainties of applying the model to the floodplain and more site-specific uncertainties. The modelled levels can be either higher or lower than would actually occur. This can be addressed by including the sensitivity of flood flows and levels to the assumptions, design inputs, and the accuracy of any flood frequency studies.

Uncertainties in relation to flood estimation include the following:

- amount and accuracy of the information on which the model is based;
- general uncertainty associated with a limited understanding of the rainfall and run off physical processes on a catchment basis;
- the level of experience of the practitioners engaged to do the modelling;
- the types of models, and the approaches adopted in the model to represent physical processes; and
- the level of on-going research and likely improvements in understanding physical processes.

Peak water levels for the rarer design floods are less precise because there are more uncertainties in the estimates. If a rarer design flood is chosen, the freeboard should not be reduced.

It should be remembered that design floods are generally based on median and not maximum inputs (except for design rainfall data) in order to account for joint probability of flooding mechanisms.

It can be more difficult to estimate design flood levels at some locations, such as where there is a sharp bend in the river or change in gradient. In such cases a deeper freeboard would be more appropriate because there is less reliability in the derivation of design flood levels due to modelling limitations.

A detailed list of the uncertainties which relate to flood modelling in regard to flood frequency analysis, hydrological modelling and hydraulic modelling is given in Appendix C. It can be used as a check list against which to assess the potential uncertainties relating to the flood models for a particular location.

It is not good practice to use the outputs from a local flood study and floodplain risk management plan prepared for one specific local catchment and apply them without further assessment to another local catchment, even in the same council area. Each floodplain has unique characteristics that need to be addressed independently.

The Hawkesbury-Nepean floodplain has recently been subject to very extensive and robust internationally endorsed modelling process, especially in the more settled parts. This is in contrast to other floodplains, where there may be less rigorous modelling available. Thus, in the Hawkesbury-Nepean valley, there is no reason to suggest that a greater than normal freeboard allowance should be made for uncertainties in flood model estimation.

Wave Action

Floodplain models do not include any wave action, whether wind, hydraulic or turbulence related. The models estimate an average water level. Waves add uncertainty to the determination of peak water levels because of difficulties in estimating wave impacts and the waves coinciding with peak water level.

Waves have the potential to cause damage to levees and exposed property which is sited at the design flood level due to increased peak water level and the additional forces acting on structures. As the wave crest will be higher than the design flood water level, a freeboard provides property protection by ensuring that the floor level is above design flood level.

Extensive areas of floodwaters, or ‘fetch’, can be subject to wind-generated waves. In western rural floodplains and coastal areas adjacent to large lakes and estuaries, the fetch can be quite large. The open expanse of many areas subject to Hawkesbury-Nepean backwater flooding makes wind generated waves a real threat. Wave size depends on the extent of the fetch and wind behaviour. The wake of emergency boats, vehicles and the down draught from emergency operations’ helicopters can also generate waves.

The impact of waves is very site-dependent and varies with weather conditions. The slope of the land and the location within the floodplain influences how high wave action will reach[1] and should be factored in to freeboard selection.

Put simply, steeper slopes at the edge of the inundated area tend to result in higher level wave run-up than gentler slopes. The independence of these variables favours a conservative approach to freeboard.

Afflux

Afflux is the term used for the change in water level when water is held back by an obstruction to the water flow in the conveyance areas. Immediately downstream of the obstacle, levels may be reduced as a result of an obstruction, whilst upstream the levels may rise.

Afflux is inevitable and variable across a developed floodplain. Afflux can occur:

- locally around individual structures such as houses;
- upstream of narrow areas of the floodplain where adjacent hills encroach;
- upstream of an area of particularly dense vegetation;
- upstream of culverts, bridges and openings in linear infrastructure such as railway or road embankments;
- due to blockage of drainage infrastructure;
- as a result of broad scale development or filling of the floodplain.

As part of the local floodplain risk management study and plan process, the influence of potential obstructions on the flow of floodwaters should be addressed. Obstructions can act as barriers depending on their size, shape and alignment to flow. Flow is slowed by, and diverted around obstructions; flow concentrates or spreads to other areas of the floodplain depending on local topography and location in the floodplain. Obstructions influence:

- velocities as ponded water accelerates through available waterway areas;
- depths both upstream and downstream; and
- the extent of water across the floodplain.

[1] *This is called run-up. More information about wave action can be found in the Shore Protection Manual 1984, Coastal Engineering Research Center, Dept. of the Army, Waterways Experiment Station, Corps of Engineers.*

A flood study would identify floodways, flood storage, flood fringe areas and the outer floodplain for the design flood event. Development in flood storage areas is inappropriate if it results in a loss of storage or creates an afflux downstream.

Regional or greenfield afflux should already be factored into the determination of the design flood level through the flood modelling process. Freeboard is not the appropriate floodplain risk management tool for addressing any uncertainty associated with regional afflux.

An afflux is significant if it leads to a

- 10% increase in discharge, or
- 0.1 metre increase in level upstream or downstream.

Its significance depends upon the potential impacts of any change. Cumulative impacts both upstream and downstream should be identified through this process.

Afflux varies locally and especially once a site is developed. Freeboard can be used to account for this local afflux. Local afflux is greater when velocities are higher and although Hawkesbury-Nepean flooding is mainly characterised by low velocities, post-development increases in local velocity will occur and will be site-specific. Modelling of some scenarios has shown that greenfield velocities could increase by a factor of 3 once a site is developed. For example, a site with a greenfield velocity of 0.7 metres / second would have a local developed velocity of 2.2 metres / second resulting in a local afflux of about 0.25 metre.

Ideally finished landforms and a likely development scenario need to be known to understand how to include afflux in the freeboard calculation.

Notwithstanding the inclusion of afflux in the design flood level, there is an inevitable cumulative impact on the floodplain arising from a multitude of small decisions and the ultimate development scenario may not be known.

The normal allowance for afflux in freeboard would be generally satisfactory for the Hawkesbury-Nepean floodplain.

Climate change

Recent research in Australia by CSIRO has demonstrated that there has been a marked warming of the climate of Australia in the last 25 years. There is considerable uncertainty and lack of consensus amongst experts on greenhouse induced climate change and the influence this will have on weather patterns and hence on flood behaviour. The changes in climate are ascribed to a combination of natural and human factors. For the Hawkesbury-Nepean, Dr Debbie Abbs of CSIRO and D. Ingle Smith (2001) predict climate change will have implications for flood behaviour and probability estimation in the Hawkesbury-Nepean catchment. Studies suggest that, although total rainfall will drop, intense rainfall events will increase in frequency and that all forms of flooding will also increase.

Smith has suggested that a 1 in 100 AEP Hawkesbury-Nepean flood today will progressively change and may be regarded as a 1 in 50 AEP event by 2070.

CSIRO[2] climate change studies have been carried out for southeast Queensland and northeast NSW. These studies indicate increases in precipitation in catchments in mountainous regions but little change to rainfall intensities for large catchments (ie those greater than 6,000 km^2). This suggests little change in flood behaviour for the large Hawkesbury-Nepean catchment (22,000 km^2). However, downscaled climate change modelling carried out for northern NSW may not be applicable to the Sydney region and further research may be necessary to give locally appropriate results (pers. comm. Abbs November 2003). The Bureau of Meteorology and CSIRO web sites may be able to provide current information in this regard[3].

Researchers recognise however, that there is existing long-term variability in Australian rainfall

[2] *Abbs D. A high-resolution modelling study of the effect of climate change on the intensity of extreme rainfall events, CSIRO Aspendale Vic. 2004*

[3] *www.bom.gov.au and www.dar.csiro.au*

and run-off arising from observed changes in ocean surface temperatures and regional circulation patterns, (S. Franks 2002). This existing variability makes accurate prediction of climate changes to flooding very difficult to discern with any degree of confidence. Of significance however, is the implication that design flood estimation based on historical flood data may not be readily applicable to the future floods due to different climatic conditions.

In low-lying coastal floodplains, tides exert an influence on flooding and this also needs to be assessed. Increased storm surge and accelerated sea level rise are a predicted consequence of greenhouse induced climate change. Both can have implications for coastal areas because of increased flood levels and extents. Sea levels are predicted to rise by 10-40 cms by 2050 leaving the communities along the east coast of Australia between Bundaberg and Wollongong more vulnerable (Abbs 2002 and 2004).

A floodplain risk management plan should be robust enough to cope with worse than anticipated climate change effects in a 30 year time frame. However, it must be recognised that any plan needs to be subject to periodical review in order to respond to emerging, credible information.

Sensitivity analyses can be undertaken for increased rainfall intensities and higher downstream water levels, as appropriate, to determine the significance of climate change.

Determining a precise component figure for climate change is not feasible, given the scientific uncertainty with the current predictions and limited locally applicable studies for the Hawkesbury-Nepean catchment. As the main purpose of a freeboard is to avoid property damage from the design flood event, an upper limit would seem appropriate in line with the precautionary principle. Nevertheless, this figure should have regard to the best available climate change data from the CSIRO.

Determining Variations to a 0.5 metre Freeboard

When determining a freeboard, it is necessary to understand how freeboard components should be combined, how they act independently and whether it is necessary to vary freeboard allowances and how differing freeboards can be adopted to suit particular land uses and development types. Various components that make up freeboard should be assessed to see whether flooding is so exceptional as to warrant a variation in the standard 0.5 metre.

Joint probabilities reduce the chance of occurrence. There is an extremely remote chance that in a flood event, each uncertainty factor will be at its maximum value and a similarly remote chance of each uncertainty factor being at its minimum value. Thus, advocating a freeboard where each uncertainty is maximised and then added cumulatively would be overly conservative. However, given known flood risks, ignoring the uncertainties would not represent best management practice according to State and Commonwealth guidelines and therefore may mean that duty of care obligations have not been properly exercised.

APPENDIX C

CHECK LIST OF POTENTIAL UNCERTAINTIES IN FLOOD MODEL ESTIMATES

Flood Frequency Analysis
Length of records. The longer the period the greater the accuracy of the method.
Quality of source of records: well recorded and/or contemporary observations during the flood can be more reliable than subsequent recollections long after an event or flood levels reported in newspaper articles etc.
Location and thus reliability of hydraulic control at gauging site over a full range of floods for the duration of records.
Frequency and range of flow gaugings undertaken. Often gaugings are only available for the smaller more frequent floods, therefore uncertain extrapolation is commonly needed to estimate the larger flood flows.
Changes in hydraulic characteristics e.g. vegetation changes, geomorphic changes.
Changes in the catchment hydrology e.g. clearing and/or development.
Appropriateness of method used to fit available data to give a particular flood frequency distribution.

Hydrological modelling
Quantity and quality of historical rainfall and related stream flow data needed for model calibration and validation: • many observations of the same event; • data on many events and many different size events; • spread of data across areas of interest; • spread of data across areas with localised variations.
Catchment state under design conditions such as: • Design loss rates; • Fullness of upstream dams at the start of flooding; • Land use and extent and type of vegetation.
Appropriateness of design rainfall intensities, spatial and temporal distribution and areal reduction factors.
Appropriateness of model parameters (e.g. catchment lag coefficients).

Hydraulic modelling
Quality and quantity of historical flood data: • many observations of the same event; • data on many events and many different size events; • spread of data across areas of interest; • spread of data across areas with localised variations.
Floodplain form, including vegetation - this affects assumed roughness and head loss values: • simple floodplain with regular features; • irregular floodplain with distinct changes in gradients, cross sections, direction of flow, hydraulic controls.
Propensity for change over time in floodplain and channel or waterway area e.g.: • erosion, • blockages, • vegetation density, • clearing.
Channel stability: • historical changes such as meanders, billabongs; • artificial changes e.g. channel 'improvements' such as straightening; • natural or induced changes to channel and floodplain geomorphology.
Existing flow conditions: • uniform or • flow characteristics change suddenly
Location within the catchment: • fast flows dominated by stream slope; • where backwater effect limited to short distance upstream; • in downstream floodplains, hydraulic obstructions have a potential to result in extensive affluxes (i.e. increase in upstream flood levels); • several tributaries make flooding more complex; there is high variability in flood levels. Consideration of joint probability of flooding in all or several tributaries necessary.

GLOSSARY, ABBREVIATIONS, TERMS AND ACRONYMS

(the) Act	the Environmental Planning and Assessment Act 1979.
Afflux	the term used for the change in water level when water is held back by an obstruction to the water flow in the conveyance areas. Immediately downstream of the obstacle, levels may be reduced as a result of an obstruction, whilst upstream the levels may rise.
Anabranch	a branch of a river which leaves the main stream and enters it again further on thus creating an island.
Annual Exceedance Probability (AEP)	the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (see average recurrence interval).
Australian Height Datum (AHD)	a common national surface level datum approximately corresponding to mean sea level. It is used to measure height in metres.
Average Annual Damage (AAD)	depending on its size, or severity, each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	an area of land, which is drained to a specified point, such as the sea, by a main stream including tributary streams.
Design flood	a statistical estimate of a flood based on probability analysis of flood and/or rainfall data. An average recurrence interval (ARI) or annual exceedance probability (AEP) is given to the estimate. The design flood is the selected annual flood for setting flood planning levels (FPLs) for planning purposes, construction of levees, drainage works and the like. Unless the PMF is chosen as the design flood, real floods larger than the design flood can be expected.
Development	**infill development**: usually refers to the development of one or more vacant urban lots which are generally surrounded by existing development. **greenfield development**: refers to development of rural land for urban purposes. It is usually preceded by changes to the environmental planning instrument and may involve detailed design criteria through a Development Control Plan before development can occur. It may require major extensions of urban infrastructure. **redevelopment**: refers to rebuilding of an existing urban area. It is also known as “brownfield development”. For example, as urban areas age, or pressures for development change, it may become appropriate to clear either individual lots or large scale sites. Redevelopment may require changes to the environmental planning instrument and may involve detailed design criteria through a Development Control Plan before development can occur. It may also require major extensions of urban infrastructure.
Development Control Plan (DCP)	A detailed guideline that illustrates the controls that apply to a particular type of development or in a particular area. A DCP makes more detailed provision with respect to development to achieve the purpose of an environmental planning instrument and is made according to the Environmental Planning and Assessment Act 1979, as amended.
Digital Terrain Model (DTM)	A digital terrain model is a digital representation of the ground surface by an array of elevation (heights) values referenced to a common datum. A DTM represents the terrain relief of a given area. Also known as a Digital Elevation Model (DEM).
Discharge	the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

Effective warning time	the time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture or equipment, evacuate people and transport their possessions.
Emergency management	a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Flash flooding	flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the peak of rainfall which causes the flood.
Flood	relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood education, flood awareness and flood readiness	**flood education** seeks to provide information to raise awareness of the flood problem so as to enable individuals to make informed decisions about living in a floodplain and to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness. **flood awareness** is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. **flood readiness** is an ability to react within the effective warning time.
Flood fringe areas	the remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	is synonymous with flood prone land and with floodplain, i.e. land susceptible to the PMF event.
Flood of record	the highest flood recorded. Note that flood records are only available for floods which have occurred since European settlement; however, there may be evidence of higher floods having occurred in previous times. Within the Hawkesbury-Nepean valley, the height of the flood of record may be greater in some parts of the floodplain than in another.
Flood mitigation standard	the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
Floodplain	area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Floodplain risk management options	the measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	a management plan developed in accordance with the principles and guidelines in the NSW Floodplain Development Manual 2005. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
Flood planning area	the area of land below the flood planning level and thus subject to flood related development controls.
Flood Planning Level (FPL)	is the combination of flood level (derived from a significant historical event or flood of specific AEP) and freeboard selected for floodplain risk management purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. An FPL sets the minimum floor level in a given area or for different land uses.
Flood proofing	a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
Flood prone land	is land susceptible to flooding by the probable maximum flood (PMF) event. Flood prone land is synonymous with flood liable land.
Flood Prone Land Policy	the NSW Flood Prone Land Policy can be found in the Floodplain Development Manual (2005).

Flood risk	potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk**: the risk to which a community is exposed as a result of its location on the floodplain. **future flood risk**: the risk to which a community may be exposed as a result of further development on the floodplain. **continuing flood risk**: the risk to which a community is exposed after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is its flood exposure.
Flood risk band	an area of flood prone land lying within a specified range of flood probabilities (e.g. between the 1% and 0.5% AEP flood) to which a particular set of development and building controls apply.
Flood storage areas	those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodway areas	those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change. Freeboard is included in the flood planning level.
Habitable room	in a **residential dwelling**: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. in **industrial or commercial premises**: an area used for offices or to store valuable possessions susceptible to damage in the event of a flood.
Hazard	a source of potential harm or a situation with a potential to cause loss. In the context of these guidelines hazard is flooding which has the potential to cause damage to the community.
Hydraulics	term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
Hydrograph	a graph, which shows how, at any particular location, the discharge or stage/flood level varies with time during a flood.
Hydrology	term given to the study of the rainfall and run off process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Intangible damages	damages which are not quantifiable. In the context of floodplain risk management, intangible losses may include social rather than economic factors such as trauma, depression, loss of social cohesion, ill health, loss of opportunities.
Local Environmental Plan (LEP)	an environmental planning instrument prepared by a council and, after public exhibition, made by the Minister for Planning, under the provisions of the Environmental Planning and Assessment Act 1979. An LEP generally includes objectives and development standards for land uses and development within a number of different zones.
Local Environmental Study (LES)	a study to inform the preparation of a local environmental plan (LEP).
Local flood risk management policy	a succinct written summary of a council’s floodplain risk management plan. Details of what a policy should include can be found in Appendix I of the Floodplain Development Manual (2005).
Local overland flooding	inundation by local run-off rather than overbank discharge from a stream, river, estuary, lake or dam.
Mainstream flooding	inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Merit approach	the merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, including environmental planning instruments. At a site-specific level, it involves consideration of the best way of conditioning development permissible under the floodplain risk management plan, local floodplain risk management policy and environmental planning instruments.
Minor, moderate and major flooding	both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding**: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which land holders and townspeople begin to be flooded. **moderate flooding**: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding**: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
Modification measures	measures that modify either the flood, the property or the response to flooding.
Peak discharge	the maximum discharge occurring during a flood event.
Probable maximum flood (PMF)	the largest flood that could conceivably occur at a particular location usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this extremely rare event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a floodplain risk management study. In the Hawkesbury-Nepean valley, downstream of Warragamba Dam, the PMF is assessed as having a 1 in 100,000 AEP.
Probability	a statistical measure of the expected chance of flooding (see annual exceedance probability).
Regional Environmental Plan (REP)	an environmental planning instrument prepared by the Director-General of the Department of Planning and, after public exhibition, made by the Minister for Planning, under the provisions of the Environmental Planning and Assessment Act 1979. A REP is similar in form to an LEP and may include objectives and development standards for land uses and development within a number of different zones. An REP addresses matters of regional significance.
Regional Environmental Study (RES)	a study to inform the preparation of a regional environmental plan (REP).
Risk	chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of flood risk it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Run-off	the amount of rainfall which actually ends up as stream flow, also known as rainfall excess.
Section 149 certificate	a certificate issued under section 149 of the Environmental Planning and Assessment Act 1979, by a local council for any land within the area of the council advising of environmental planning instruments, zoning and other relevant matters including whether policies on hazard risk restrictions (including flooding) affect the land.
Stage	equivalent to water level, measured with reference to a specified datum.
Stage hydrograph	a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
State environmental planning policy (SEPP)	policy proposed by the Minister for Planning under the Environmental Planning and Assessment Act 1979, and approved by the Governor. A SEPP addresses matters of state significance.
Tangible damages	damages that can be quantified. In a floodplain management context, they may include physical damages to buildings or infrastructure.
Water surface profile	a graph showing the flood stage at any given location along a watercourse at a particular time.
Zoning	the system of defining objectives and land uses which are permissible or prohibited in environmental planning instruments.

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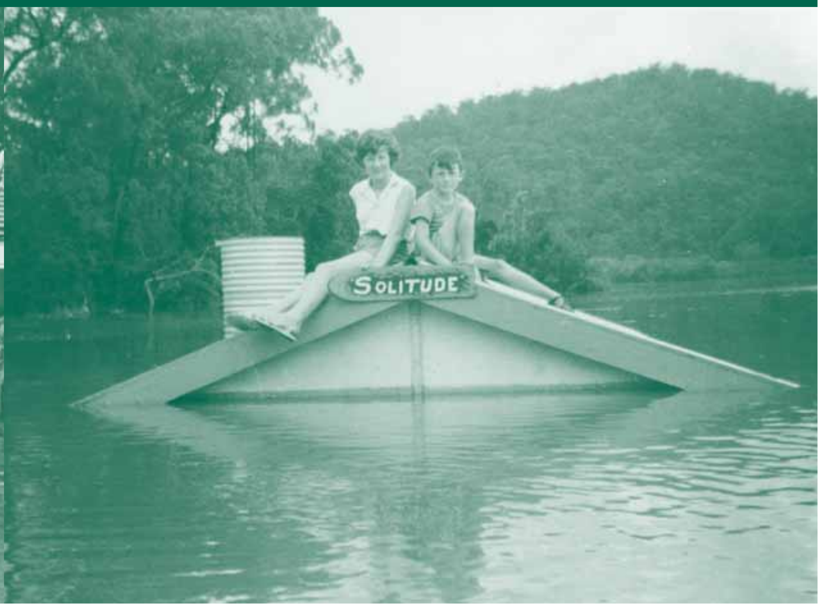
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