CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY & PLAN

Overlooking Cabramatta Creek and Warwick Farm Racecourse during the 1986 flood (photo courtesy Liverpool City Council)

UPDATED REPORT

October 2004

Bewsher Consulting Pty Ltd
Floodplain Management Consultants

LIVERPOOL CITY COUNCIL
FAIRFIELD CITY COUNCIL

CABRAMATTA CREEK
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UPDATED REPORT

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SUMMARY

Introduction

Bewsher Consulting Pty Ltd was originally commissioned by Liverpool City Council, in conjunction with Fairfield City Council and the Department of Land and Water Conservation (now the Department of Infrastructure, Planning and Natural Resources), to undertake a floodplain management study for Cabramatta Creek.

A number of working papers were prepared during the course of the study and a draft main report issued in May 1999 [Bewsher Consulting, 1999].

The draft report was not finalised at the time, largely due to uncertainties associated with a major highway proposal (referred to as the WSO project in this report) that bisects the Cabramatta Creek catchment. The proposed highway and associated compensatory flood mitigation works has a significant impact on Liverpool Council's detention basin strategy – in particular, whether or not an earlier proposal to construct a large multi-purpose basin in the middle of the catchment, known as Basin 22, would be feasible.

By late 2002 many of the uncertainties regarding the proposed WSO and Basin 22 had been resolved. Subsequently, Liverpool and Fairfield Councils requested that the draft Cabramatta Floodplain Management Study be updated.

This floodplain management study and plan is based on the previous draft report submitted in May 1999, updated where appropriate to account for changes that have occurred since this time.

Bewsher Consulting has been assisted by Don Fox Planning (town planning advice), the University of NSW Water Research Laboratory (hydraulic modelling), Nelson Consulting (environmental matters) and Southern Aerial Surveys (aerial mapping).

The study was overseen by both Liverpool Council's floodplain management committee and Fairfield Council's floodplain management committee. These committees consisted of Councillors and staff from both Councils, community representatives, and officers from other organisations, such as the Department of Land and Water Conservation (now DIPNR), State Emergency Services and the Department of Urban Affairs and Planning.

Principal Outcomes

The outcomes of this study include:

- a comprehensive set of aerial photography and detailed contour mapping of the catchment;
- revised flood information in the form of maps showing flood contours and flood extents for a range of flood events, in digital format for incorporation into both Councils' GIS computer systems and as hard copy plans;
- a comprehensive assessment of floodplain management measures, including a review of planning controls, flood mitigation works and other measures to reduce potential flood problems within the catchment;

- a range of working papers on specific issues investigated throughout the study, which have been progressively presented to the floodplain management committees;
- the Main Report (this document) which summarises the working papers that have been undertaken, and presents an overall outline of the floodplain management study and the recommended floodplain management plan; and
- an Executive Summary which provides a concise summary of the study and recommended floodplain management plan.

Flood Behaviour

Flood behaviour has been analysed using the RAFTS hydrologic model to simulate flows throughout the creek systems, and the RMA-2V two dimensional hydraulic model to simulate the extent and depth of flooding within the catchment. Both models were calibrated to floods that were recorded in August 1986 and April 1988. These models provide the necessary tools to assess the impact of catchment development, compensatory flood mitigation works, and other potential flood mitigation works to alleviate existing flooding problems.

The floodplain has been divided into three flood risk precincts (high, medium and low) as part of the updated study. Different development controls are also proposed for the catchment depending on the type of development and the flood risk precinct that the development is located. These controls are included in a planning matrix to be attached to Flood Risk Management Development Control Plans that have been proposed for both Liverpool and Fairfield Councils.

A flood damages database of potentially flood affected properties has been prepared as part of the study. The database provides details of those properties likely to be inundated in different sized floods and allows the quantification of potential flood damages. Key results from the database indicate that:

- 2,838 residential homes and 218 commercial/industrial buildings would be flooded above floor level in the PMF;
- In the Liverpool LGA, 74 homes and 80 commercial/industrial buildings would be flooded above floor level in the 100 year flood;
- In the Fairfield LGA, 50 homes and 24 commercial/industrial buildings would be flooded above floor level in the 100 year flood;
- The predicted flood damage in the 100 year flood is $16M for Liverpool, and $4.8M for Fairfield.

Community Consultation

Community consultation has also been a major component of the study. This has included liaison with community groups and authorities, regular presentations to both Councils' floodplain management committees, two community newsletters and questionnaires, two public meetings, and the intended public exhibition of the draft Main Report and Executive Summary.

The Floodplain Management Plan

A recommended floodplain management plan showing preferred floodplain management measures for Cabramatta Creek is presented in **Table 11.1** and also shown on **Figure 11.1**. The preferred measures have been determined from a range of available measures, after an assessment of the impacts on flooding, as well as environmental, social, and economic considerations.

Recommended options that modify flood behaviour include:

- a revised detention basin strategy for Liverpool City Council;
- three other detention basins to provide compensatory flood storage for the proposed WSO highway;
- a further detention basin on Brickmakers Creek at Amalfi Park and/or channel improvement measures downstream of Amalfi Park;
- channel works, culvert amplification, and creek rehabilitation works in Brickmakers Creek, between Homepride Avenue and Elizabeth Drive;
- improved flood access along major arterial roads;
- a package of works in the Elizabeth Drive/Tresalam Street area; and
- the preparation of bushland management plans and the clearing of rubbish and debris from the creek waterways.

Recommended options that modify property include:

- voluntary house raising;
- flood proofing individual buildings; and
- controls on new development through a planning matrix approach, which provides guidance on appropriate land uses and other development controls.

Recommended options that modify people's response to flooding include:

- a flood awareness program;
- improved flood warning system and emergency response management; and
- the preparation of flood action plans.

Timing and Funding

Timing of the proposed works will depend on each Council's overall budgetary commitments, and the availability of funds from other sources. Funding will be available through a number of sources, as identified in **Table 11.1**. Components of the Plan will be able to be carried out directly by either Liverpool Council or Fairfield Council, whilst other components that affect both Council areas will need to be carried out jointly.

Oblique aerial photo of Lower Cabramatta Creek (November 1998), viewed from the middle of the catchment downstream to the Georges River. Most of the lower floodplain is located within open space reserves. A formed floodway that was constructed some 30 years ago is prominent in the foreground.

PHOTO 1
Lower Cabramatta Creek

1. INTRODUCTION

1.1 ABOUT THE UPDATED STUDY

Bewsher Consulting Pty Ltd was originally commissioned by Liverpool City Council, in conjunction with Fairfield City Council and the Department of Land and Water Conservation (now the Department of Infrastructure, Planning and Natural Resources), to undertake a floodplain management study for Cabramatta Creek.

A number of working papers were prepared during the course of the study and a draft main report issued in May 1999 [Bewsher Consulting, 1999].

The draft report was not finalised at the time for various reasons, including:

- uncertainties associated with the location of a proposed major highway, known as the Western Sydney Orbital (WSO), which was to traverse the study area;
- issues with flood compensatory measures to be incorporated within the proposed WSO highway;
- uncertainties with a major detention basin, known as Basin 22, which had been proposed in the draft report to satisfy joint flood mitigation and WSO objectives; and
- changes in Council staff following the issue of the draft report.

By late 2002 many of the uncertainties regarding the proposed WSO and Basin 22 had been resolved. Subsequently, Liverpool and Fairfield Councils requested that the draft Cabramatta Floodplain Management Study be updated.

This floodplain management study and plan is based on the previous draft report submitted in May 1999, updated where appropriate to account for changes that have occurred within the study area since this time.

1.2 OBJECTIVES OF THE STUDY

Cabramatta Creek has a history of flooding. Recently, the April 1988 and August 1986 floods caused considerable damage and disruption within the catchment. Numerous residential houses, commercial buildings and industrial buildings were inundated during these flood events. There was also damage to public infrastructure and utilities, such as roads, water supply and sewerage facilities.

The first objective of the Cabramatta Creek Floodplain Management Study was to examine flooding problems throughout the catchment for a range of development conditions. This is to identify the extent and depth of flooding that can be expected within the catchment.

The second objective of the study was to look at flood mitigation works and other measures to reduce flooding problems within the catchment. Environmental, social, economic and engineering issues have been considered in assessing these options. Extensive community consultation has also been an important component of this phase,

to ensure that all practical options were investigated, and that the views of the community are taken into consideration.

The final objective of this study was to present a recommended floodplain management plan for implementation by Liverpool City Council and Fairfield City Council. The plan outlines the best possible measures to reduce flood damages in the Cabramatta Creek catchment.

1.3 THE STUDY AREA

Cabramatta Creek is a major tributary of the Georges River, located in the south-west of the Sydney Metropolitan region. The catchment, which is shown on **Figure 1.1**, has an area of 74 km^2. It is bordered roughly by the South-Western Freeway and the Hume Highway in the east, Denham Court in the South, Sydney Water's "Water Race" at West Hoxton in the west, and the suburbs of Cabramatta, Mt. Pritchard, Heckenberg, Busby, Hinchinbrook, Green Valley and Cecil Hills to the north.

The study area comprises five major subcatchments. These are:

- Upper Cabramatta Creek;
- Hinchinbrook Creek;
- Maxwells Creek;
- Brickmakers Creek; and
- Lower Cabramatta Creek (Liverpool and Fairfield Council areas).

Most of the catchment area is located within the Liverpool City Council area. The north side of Lower Cabramatta Creek, downstream of Elizabeth Drive, is located within the Fairfield City Council area. A small proportion of the upper catchment is also located within the Campbelltown City Council area, and the Ingleburn Military Camp.

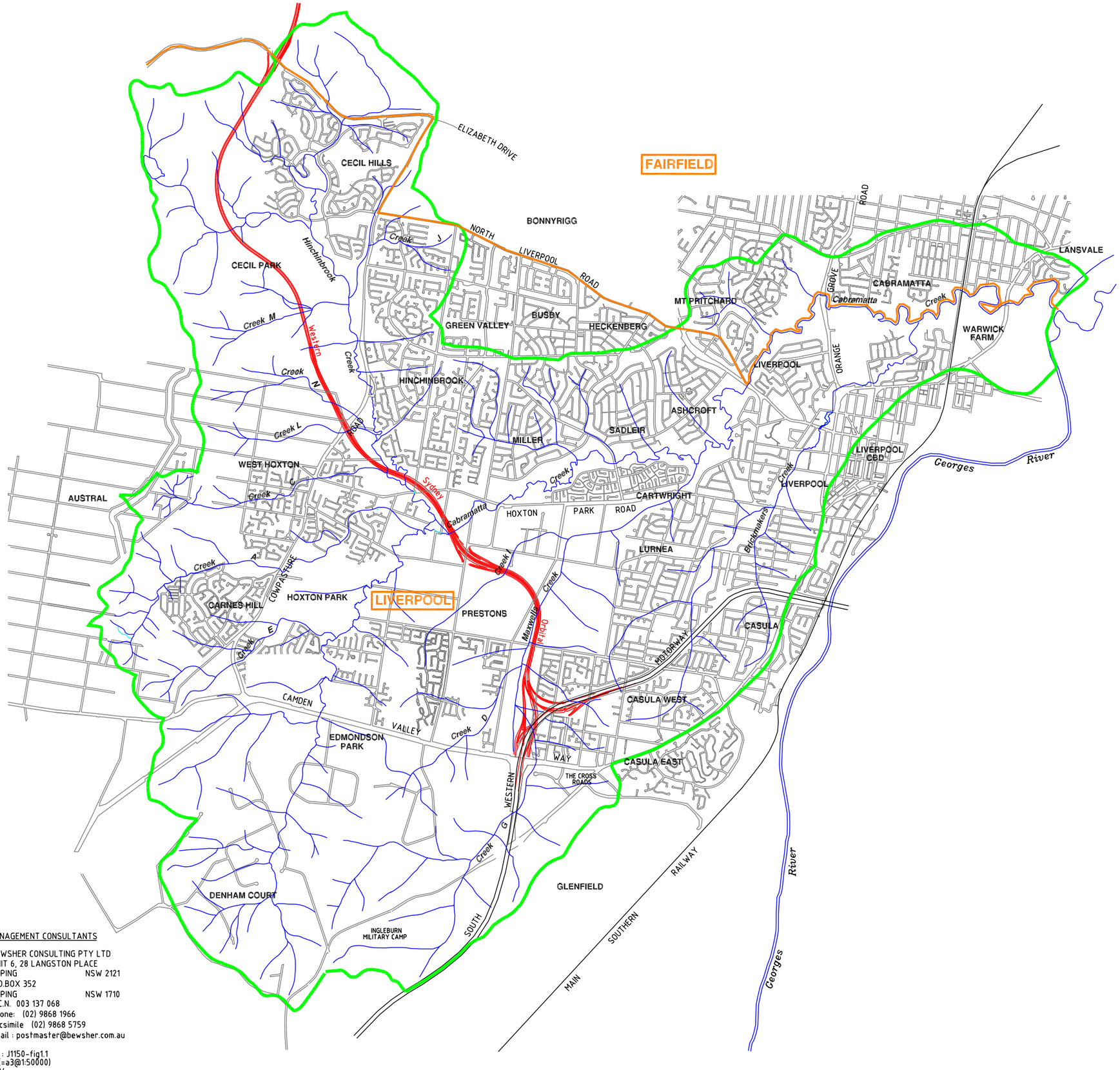
This study is focussed on assessing main stream flood problems within the floodplain of Cabramatta Creek and its main tributaries, and recommending measures to reduce these problems. The floodplain is defined as that land which is potentially subject to flooding by the highest flood that could conceivably occur, which is often referred to as the probable maximum flood (PMF).

1.4 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone lands in NSW rests with the local council. The NSW Government provides assistance on state-wide policy issues and technical support. They also provide financial assistance to undertake flood and floodplain management studies, such as this current investigation, and for the implementation of works identified in these studies.

A Flood Prone Land Policy and a Floodplain Management Manual [NSW Government, 2001] forms the basis of floodplain management in NSW.

FIGURE 1.1



LEGEND

- Catchment Boundary
- Local Government Boundary

0 1 2km

Scale

THE STUDY AREA

CABRAMATTA CREEK
FLOODPLAIN MANAGEMENT STUDY

FLOODPLAIN MANAGEMENT CONSULTANTS

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Plot file name : J1150-fig1.1
Plot scale 50 (=a3@1:50000)
Date : May 2004

The objectives of the Policy include:

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

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

The implementation of the Flood Prone Lands Policy generally culminates in the preparation and implementation of a Floodplain Management Plan.

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

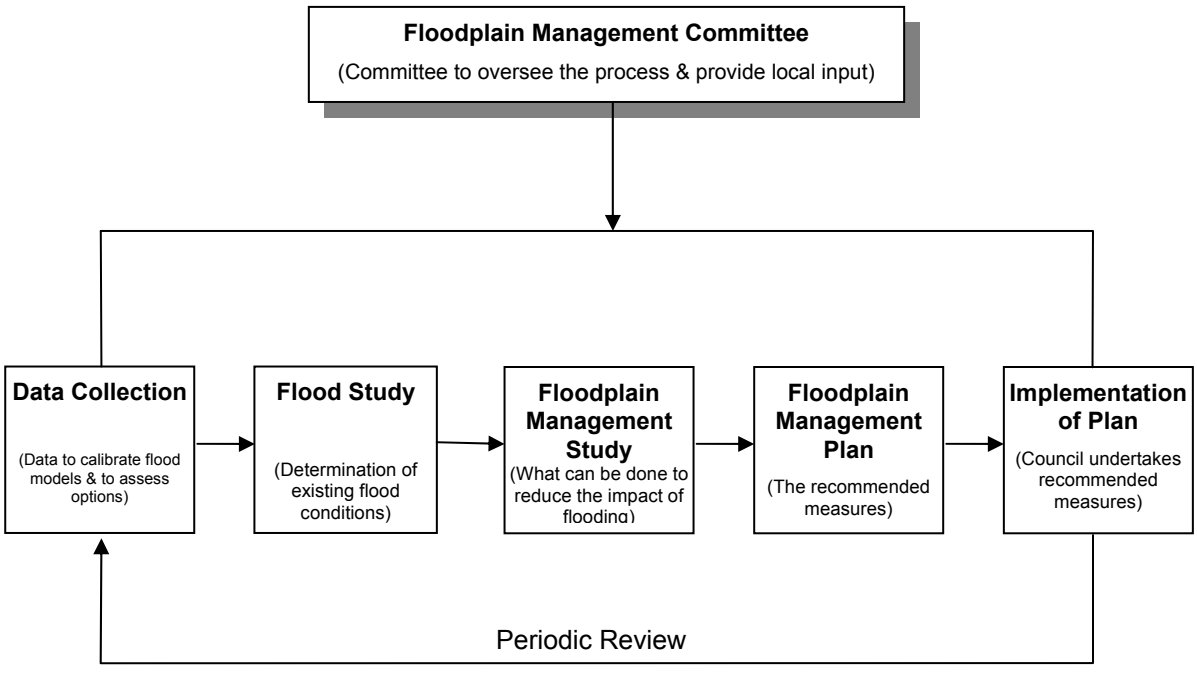


FIGURE 1.2
THE FLOODPLAIN MANAGEMENT PROCESS

1.5 THE STUDY TEAM

A multi-disciplinary team was assembled to undertake this study. The study team, and their key responsibilities, are listed in **Table 1.1**.

TABLE 1.1
The Study Team

Team Member	Key Responsibilities
Bewsher Consulting	Project management, hydrologic modelling, floodplain management, engineering
Don Fox Planning	Town planning
Water Research Laboratory	Hydraulic modelling
Nelson Consulting Pty Ltd	Environmental considerations
Southern Aerial Surveys Pty Ltd	Aerial photography and mapping

Throughout this study, Bewsher Consulting has been guided by both the Liverpool Floodplain Management Committee and the Fairfield Five Creeks Committee. Both committees have provided valuable direction, bringing together views from key Council staff, other departments and agencies, and community representatives.

1.6 OUTCOMES OF THE STUDY

A comprehensive set of aerial photography and detailed contour mapping was produced as part of the initial floodplain management study. The mapping forms the basis of topographic information under 1996 catchment conditions, and for determining the extent of flood inundation for a range of flood events. These maps represent a considerable investment by Council, but one that ensures that the subsequent floodplain management assessments are based on the best available base data. The mapping base is further described in **Section 2.3**.

Revised flood information was also prepared as part of the initial study. Maps of flood contours and flood extents were prepared for Cabramatta Creek and its tributaries, providing information on the flood problems within the catchment. The information has been provided in digital format for both Councils, for incorporation into their graphical information computer systems. The analysis of flood behaviour is presented in more detail in **Section 3**.

A comprehensive assessment of floodplain management measures was also investigated with a view to reducing flood problems within the catchment. The assessment is not only based on hydraulic performance and costs, but is also based on social, environmental and ecological issues, and community views.

A range of technical working papers were prepared as part of the initial floodplain management investigations. This allowed the Liverpool and Fairfield Floodplain Management Committees, as well as staff from both Councils and other Departments,

to monitor the progress of the study, receiving information as various tasks (or working papers) were completed. These working papers are outlined in **Table 1.2.**

Finally, a main report has been produced (this document) that summarises the findings of the various working papers and presents a draft floodplain management plan (**Section 11**) for the consideration of the community and both Councils.

A draft copy of the main report was issued to both Councils in May 1999. This report was updated in 2004 to reflect changes that have occurred within the study area since the previous draft report.

TABLE 1.2
Cabramatta Creek Floodplain Management Study Working Papers

Working Paper	Principle Author	Completed
Hydrologic (RAFTS) Modelling	Bewsher Consulting	June 98
Flood Study Report - Epoch 1 Conditions	Water Research Lab.	Dec 98
Flood Study Report - Epochs 2, 3,& 4	Water Research Lab.	In Prep.
Flood Warning and Emergency Response Management	Bewsher Consulting	#
Western Sydney Orbital - Management of Cross Drainage and Road Stormwater	Bewsher Consulting	Feb 99
Review of Planning Controls in New Release Areas	Don Fox Planning	Oct 98
Review of Section 94 Contributions Plans for Trunk Drainage in New Release Areas	Bewsher Consulting	May 98
Overview of Water Quality, Riverine Ecology and Vegetation Management of Creek Corridors	Nelson Consulting	Nov 98
Flood Damage Assessment	Bewsher Consulting	July 99
Floodplain Management Options	Bewsher Consulting	Nov 98
Strategy for Land Filling in Floodplains and Low Lying Areas	Bewsher Consulting	#
Denham Court Stormwater Management Strategy Report	Bewsher Consulting	#
Review of Local Flood Policies	Don Fox Planning	Oct 98
Total Catchment Management Strategy Report	Nelson Consulting	Dec 98
Community Consultation	Bewsher Consulting	Sep 98
Land Use and Social Profile Report	Don Fox Planning	Nov 98
Hydraulic Modelling of Floodplain Management Options	Water Research Lab.	#
RMA-2 Modelling of Cabramatta Creek at Elizabeth Drive	Water Research Lab.	Apr 98
Bibliography	Bewsher Consulting	June 97
Review of Basin Strategy	Bewsher Consulting	Mar 99

Working Paper omitted from study brief

2. BACKGROUND INFORMATION

2.1 PHYSICAL DESCRIPTION

Cabramatta Creek starts in the rural/residential suburb of Denham Court, which is located at the southern extent of the catchment boundary. From here the creek flows in a northerly direction under Camden Valley Way towards Hoxton Park, and its junction with Hinchinbrook Creek. The Cabramatta Creek and Carnes Hill Urban Release Areas are located within the Upper Cabramatta Creek subcatchment. Substantial residential development has already occurred in these areas, particularly to the west of Cowpasture Road. A number of detention basins have also been constructed in conjunction with the development. The Ingham's poultry farm also occupies a significant landholding in the area.

Hinchinbrook Creek commences at the northern extremity of the catchment, and flows in a southerly direction to join Cabramatta Creek towards the middle of the catchment. The newly developing suburb of Cecil Hills is located towards the top of the Hinchinbrook Creek subcatchment. Substantial development has recently occurred to the east of Cowpasture Road in the Green Valley and Hinchinbrook suburbs. Various flood mitigation works, incorporating a number of detention basins and water quality basins, have also been constructed in conjunction with this development. The Hoxton Park aerodrome is located on the western side of Hinchinbrook Creek, and further to the west a Regional Open Space corridor that has been substantially acquired by the former Department of Urban Affairs and Planning, although it remains partially used for agricultural purposes with existing dwellings being leased back to agricultural proprietors.

Hinchinbrook Creek joins Cabramatta Creek just below Hoxton Park Road. From here, Cabramatta Creek starts to flow in an easterly direction through the lower Cabramatta Creek catchment, towards the Georges River. A more prominent creek "corridor", up to 200m wide, becomes more evident throughout the lower catchment. This primarily consists of public open space, playing fields and golf courses. The Elouera Nature Reserve, which is an important pocket of native bushland, also forms part of this corridor. Cabramatta Creek flows through established residential suburbs in both Liverpool and Fairfield Council areas, including Miller, Cartwright, Sadlier, Ashcroft, Liverpool, Mount Pritchard and Warwick Farm. Major transport routes that cross the lower catchment includes Hoxton Park Road, Elizabeth Drive, Orange Grove Road (The Cumberland Highway), the Hume Highway and the Main Southern Railway.

Other major tributaries of Lower Cabramatta Creek include Maxwells Creek and Brickmakers Creek.

Maxwells Creek starts near the Ingleburn Military Camp and flows in a northerly direction through the existing Edmondson Park rural residential area, which has been identified as a future urban release area. The creek crosses the South Western Freeway and the M5 at The Crossroads, and continues north alongside the Liverpool Showground. This area is presently rural, although it has been zoned for future urban residential and industrial purposes. The creek becomes a grassed trapezoidal channel

downstream of Jedda Road, continuing through the Preston's industrial area and the older established residential suburb of Lurnea, before joining with Cabramatta Creek.

Brickmakers Creek starts upstream of Casula Mall shopping Centre and also flows in a northerly direction towards the lower end of Cabramatta Creek. The catchment comprises predominantly established urban residential areas, plus parts of the Liverpool Central Business District. The upper parts of the catchment are piped, with the creek first emerging at Amalfi Park. The Creek flows north through Pacuillo Park to Hoxton Park Road. The Creek continues beside the Liverpool Council chambers as a formed channel with concrete invert. Brickmakers Creek later reverts to a more natural form, flowing beside the western extent of the Liverpool CBD and peripheral residential area. This area largely contains commercial buildings and residential flat buildings. The Creek continues through Hargrave Park, and finally on to Cabramatta Creek near Durant Oval.

2.2 HISTORY OF FLOODING

Flooding is a natural phenomenon which has been occurring for thousands of years. In Cabramatta Creek it can occur when heavy rain falls over the catchment, from backwater when the Georges River is in flood, or from a combination of these conditions.

Over the last 50 years there has been at least 10 significant floods that have been experienced in Cabramatta Creek. These have resulted in floodwaters overtopping creek banks and flooding large areas of low-lying land adjacent to Cabramatta Creek and its other tributaries. Numerous residential, commercial and industrial properties have been flooded in the past, roads have been cut, public infrastructure has been damaged, and the social well-being of the community has been affected.

The most recent floods have occurred in:

- August 1986;
- April 1988;
- July 1988;
- April 1989;
- February 1990; and most recently in
- January 2001.

There is also some evidence of significantly larger floods occurring in the late 1800's. Floods with an average recurrence interval (ARI) of at least 100 years are believed to have occurred on the Georges River in 1873, 1889, and 1898. Whilst there is no data to confirm that flooding also occurred in Cabramatta Creek, it is nevertheless reasonable to assume that major flooding was also likely to have occurred throughout this catchment.

Oblique aerial photo of Upper Cabramatta Creek (November 1998), viewed from the central catchment looking upstream towards Cowpasture Road. Existing vegetation forms valuable wildlife corridors within the catchment.

PHOTO 2
Upper Cabramatta Creek

2.3 AERIAL MAPPING

A series of special low level aerial photography of the catchment was undertaken in 1996. Photogrammetric analysis of the ground terrain, in conjunction with additional ground level survey, allowed the production of various orthophotomaps of the catchment, consisting of ground contours superimposed on the aerial photography. The mapping base has been used to establish the flood models and to allow an accurate definition of the extent of flood inundation for various design floods.

Three sets of orthophotomaps were produced for this study, as detailed below:

- **A Catchment Map** — comprising four A1 sheets at a scale of 1:10,000 with 2m contours, covering the entire catchment. This was based on aerial photography flown at an altitude of 6,000m, with a resultant ground level accuracy estimated at ±0.6m.
- **A General Map Series** — comprising forty three A1 sheets at a scale of 1:2,000 with 1m ground contours, covering most of the catchment. These maps were subsequently supplemented with formlines at 0.25m intervals. The maps were based on aerial photography flown at an altitude of 1,200m, with a resultant ground level accuracy estimated at ±0.12m.
- **A Detailed Map Series** — comprising seven A1 sheets at a scale of 1:1,000 and with 0.5m contours, covering the Brickmakers Creek floodplain. These maps were based on aerial photography flown at an altitude of 650m, with a resultant ground level accuracy estimated at ±0.06m.

Hard copy prints of the above orthophotomaps have been produced, and a digital copy provided to both Liverpool and Fairfield Councils for integration into their graphical information computer systems. An index sheet for the 1:2,000 general map series is presented in **Figure 2.1**.

2.4 SOCIAL CONTEXT

An understanding of existing land use and population characteristics is an important consideration of this floodplain management study. The population, characteristics and development trends of the study area provide an understanding of the values of the community in regard to the utilisation of the floodplain, as opposed to sterilising its use to minimise the risks of flooding.

A demographic analysis has been undertaken for Cabramatta Creek and its main subcatchments. This analysis has been undertaken utilising 1986, 1991 and 1996 Census data.

During the years 1986 to 1996, the population growth in the Cabramatta Creek catchment increased by 12,953 additional persons, representing a 20% change. This was high compared to the total growth in the Sydney metropolitan region, which saw an 11% increase. The rate of growth within the study area was similar to that which occurred within the total Liverpool LGA (29% increase) and the Fairfield LGA (18% increase). This was mostly due to substantial urban release areas within the

study area. Overall, the Liverpool and Fairfield LGAs experienced the highest rate of new lots/dwelling production in the Sydney region.

Dwelling and population growth between 1986 and 1996 Censuses for each of the catchment areas are depicted in **Figure 2.2** (A and B). Salient observations include:

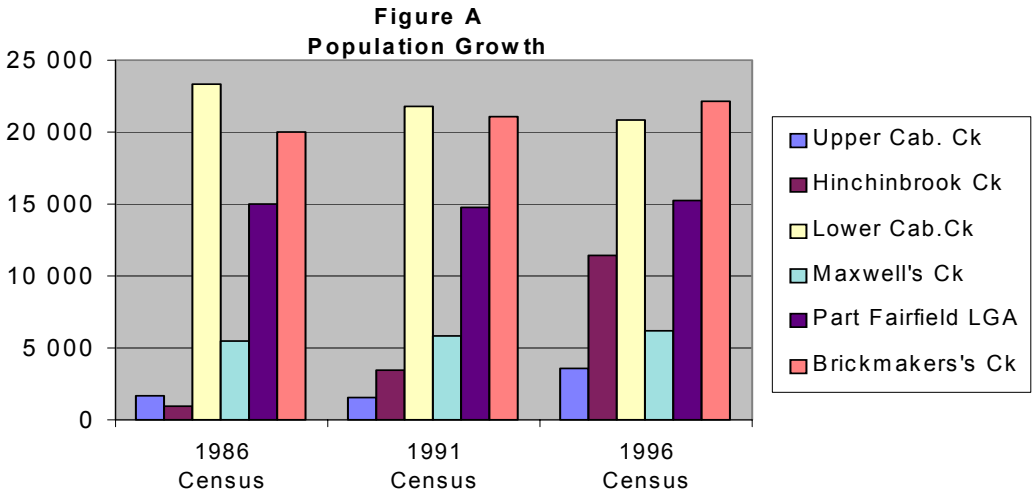
- the Lower Cabramatta Creek catchment is a relatively established area which has had effectively no increase in dwelling numbers and an overall decrease in total persons primarily due to a fall in dwelling occupancy ratios;
- the Upper Cabramatta Creek catchment is primarily a rural residential area and has had negligible growth in population, but has had substantial growth in the number of dwellings, between 1986 and 1996;
- the Hinchinbrook Creek catchment contains new urban release areas which have contributed to population growth between 1986 and 1996, during which 2,900 new dwellings were formed;
- the Maxwells Creek catchment area is partially comprised of future urban release areas and partially rural and rural residential areas and had a high increase in dwelling numbers (476) between 1986 and 1996, but with a modest rise in population primarily due to falling dwelling occupancy ratios;
- the Brickmakers Creek catchment is predominantly in an established area, but also includes an urban release area in Casula West, which has seen a substantial increase in population (1,042 persons) during 1986 to 1996, with a corresponding increase in dwelling numbers (1,045); and
- the Fairfield Council side of Lower Cabramatta Creek is a relatively established area and had modest population growth (199 persons) and dwelling growth (320 households) between 1986 and 1996.

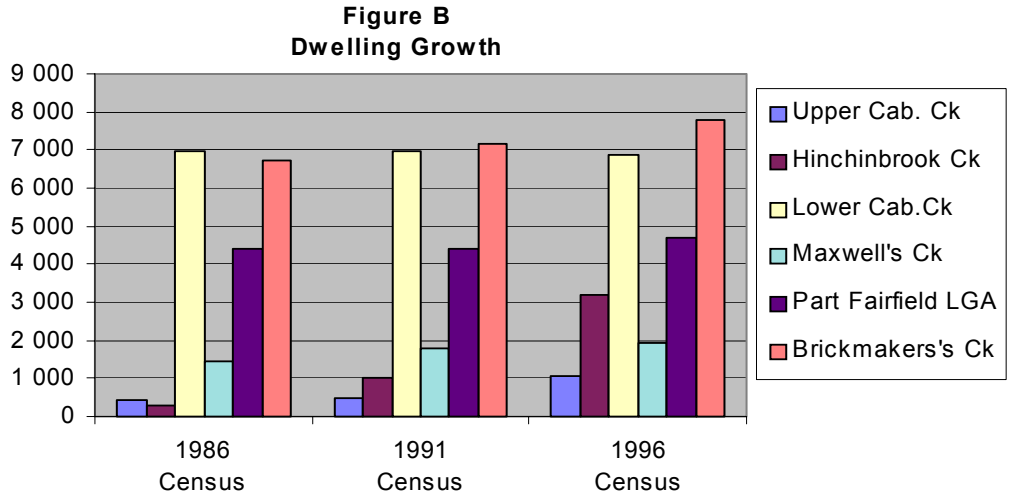
The proportion of people born overseas is depicted in **Figure 2.2** (C). A high proportion of the population in the study area is overseas born and/or speaks English poorly, particularly in comparison to the Sydney region. At the 1996 Census, 40% of the study area population were overseas born. Some areas like the Fairfield side of Lower Cabramatta Creek has a substantial (59%) proportion of overseas born people.

Individual and household incomes within the study area are low relative to the Sydney region. Correspondingly, unemployment is significantly higher in the study area in comparison to the Sydney region.

FIGURE 2.1

Index Sheet for 1:2000 Mapping Produced for this Study





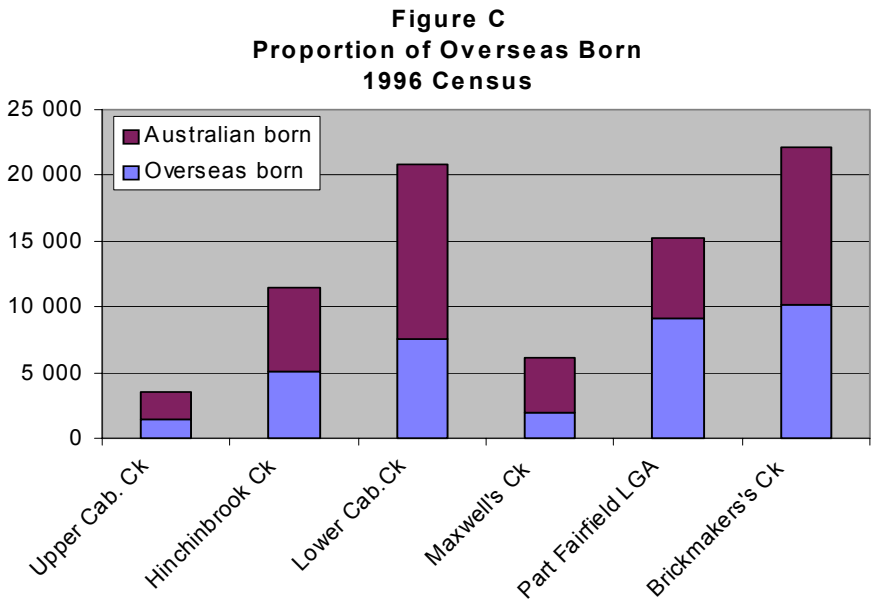


FIGURE 2.2
Demographic Trends in the Catchment Area

2.5 ENVIRONMENTAL ISSUES

Environmental issues associated with the Cabramatta Creek catchment are a key component of this floodplain management study. Whilst the objective of the study is primarily to address flooding issues, the impact on the environment of potential flood mitigation works needs to be carefully assessed. Wherever possible, flood mitigation works should be designed to enhance the environmental qualities of the catchment, rather than harming or exacerbating existing environmental problems.

Environmental issues affecting Cabramatta Creek and its tributaries include:

- poor water quality due to urban and rural runoff, septic tank seepage and sewage overflows, and possible leachate from contaminated sites. Water quality generally fails to meet ANZECC guidelines for recreation in terms of faecal coliform levels, and protection of aquatic ecosystems in terms of nutrient concentrations;
- the importance of the natural creek system and existing creek side vegetation in forming valuable wildlife corridors that span the catchment;
- modification of creek lines through channelisation, filling, formation of grassed verges, or exotic plantings, which limit the natural treatment processes of the creek system, fragment habitat for native species and can result in bank erosion through the formation of steep banks;
- clearing for urban development and the formation of informal tracks by trail bikes and four wheel drive vehicles, resulting in soil erosion, impacts on habitat values, degradation of Aboriginal sites and sedimentation of watercourses;
- the dumping of garden refuse, litter and large objects such as car bodies and shopping trolleys in and along creek lines; and
- weed invasion, including both terrestrial and aquatic noxious weeds, particularly creepers and vines which smother native species and nuisance aquatic plants which choke waterways.

2.6 PLANNING ISSUES

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

The Cabramatta Creek floodplain is part of a wider urban release area for the Sydney region, and there are expectations that development will occur in the area to satisfy both the housing needs of the expanding Sydney metropolitan region, and the development expectations of landowners. Development in the catchment will impact upon floodplain management in the following three ways:

- development in the catchment area which will contribute to the extent of impervious areas and ultimately an increase in runoff and flood levels, unless compensatory flood mitigation measures are instigated;
- development in the floodplain, but above the Flood Planning Level (FPL), which will be subject to the flood hazard but at a level of risk that is considered acceptable; and

- development in the floodplain and below the FPL which may be prohibited due to the severity of flooding (eg. in a high flood risk area) or permitted subject to appropriate controls being imposed relative to the type of land use and the nature of the flood hazard.

Flooding is only one issue which planners need to take into consideration when formulating land use strategies. However, flooding may become an important issue, particularly where there is a direct and significant risk to the community because of the potential for loss of life or high flood damage losses. These risks must be clearly understood by decision makers as they result directly from planning decisions, and are foreseeable. The minimum the community expects is that these decisions are made on an informed and reasonable basis.

2.7 PREVIOUS INVESTIGATIONS

A number of investigations have already been completed within the Cabramatta Creek catchment that deal with flooding issues. These include investigations undertaken as part of the current floodplain management study, and earlier investigations undertaken by other parties. These documents provide valuable insight into problem areas within the catchment, and possible solutions that may alleviate these problems.

A summary of previous investigations which are relevant to the assessment of floodplain management measures for Cabramatta Creek is provided below.

2.7.1 Lower Cabramatta Creek Floodplain Management Study

This study [Kinhill, 1991] was completed by Kinhill Consultants for Fairfield City Council. The study presents a floodplain management plan for the Lower Cabramatta Creek, between its confluence with the Georges River and Elizabeth Drive.

A series of flood mitigation measures were proposed comprising levees, channel works, formalised floodways and house raising. Specific works included;

- channel works near Elizabeth Drive Bridge;
- raising and lengthening the existing levee adjacent to Tresalam Street;
- extension of the floodway immediately downstream of Elizabeth Drive;
- channel clearing downstream of the floodway;
- removal of the fence around Cabramatta Golf Course;
- floodway construction upstream of Orange Grove Road;
- flood proofing of properties upstream of the Main Southern Railway;
- formation of a floodway both upstream and downstream of the Main Southern Railway; and
- flood proofing of two houses near the Georges River.

The above measures have been reviewed as part of the current study, in light of new flood level estimates and other works proposed in the rest of the catchment.

2.7.2 Hoxton Park Stage 2 Release Area Total Catchment Management Study

In 1989 Kinhill Consultants were commissioned by Liverpool City Council to undertake a study [Kinhill, 1992] of flooding issues associated with a major urban release area within the upper catchment, known as the Hoxton Park Stage 2 Release Area.

The study assessed the impact of proposed development both in terms of the quantity and quality of runoff from the new Release Area. The investigation assessed the likely increase in peak flows throughout the catchment as a result of the proposed development, and investigated means of limiting post-developed 100 year ARI flows to pre-developed conditions.

A trunk drainage strategy, know as Option A-3, was recommended that included the construction of 9 detention basins that would act as both flood mitigation and water quality control structures. The basins ranged in size from 50,000 m^3 to 183,000 m^3, with a combined total storage of 1,100,000 m^3.

Whist this study developed a basin strategy capable of alleviating the increased flows estimated to result due to the development of this release area, it did not address the issue of reducing existing flood problems, either by way of larger or additional basins, or by other flood mitigation measures.

2.7.3 Cabramatta Creek Total Catchment Management Study

This study [Kinhill, 1993], prepared for the Water Board, was an extension of the earlier Kinhill study, with the study area increased to incorporate the areas of existing development downstream of the new release areas.

In addition to the flood mitigation measures previously recommended for the Hoxton Park Stage 2 Release Area, and works identified in the Lower Cabramatta Creek Floodplain Management Study, several other flood mitigation works and measures were also presented within the existing Liverpool urban area. The main additional measures that were recommended include:

- implementation of an urban bush management program within the Elouera Nature Reserve, Hinchinbrook Creek and Lower Brickmakers Creek;
- channel maintenance programs for Brickmakers Creek and Maxwells Creek;
- the development of flood management plans for industrial properties in Maxwells Creek and Brickmakers Creek and Creek A;
- channel enlargement works in Brickmakers Creek, between Orange Grove Road and Moore Street;
- an additional culvert under Elizabeth Drive in Brickmakers Creek;
- road raising in the vicinity of Carboni Street and Collimore Avenue, in Brickmakers Creek;
- channel works along Maxwells Creek upstream of Jedda Road;

- elimination of a flood breakout in the Bernera Road area by the construction of a small levee;
- flood proofing the Liverpool Catholic Club;
- extension of a large floodway on Upper Cabramatta Creek, between Hoxton Park Road and Camden Valley Way, including bridgeworks;
- bridge works and road raising of Cowpasture Road on Hinchinbrook Creek;
- building and development controls;
- erection of flood warning signs; and
- a flood warning and evacuation study.

2.7.4 Cabramatta Creek Floodplain Management — Identification of Issues

This background paper was prepared by Lyall and Macoun Consulting Engineers for Liverpool City Council in 1995 [Lyall and Macoun, 1995]. It presents a critical review of reports previously undertaken for Cabramatta Creek and identifies current issues and concerns that should be considered in the preparation of a Floodplain Management Plan for the catchment.

Identified issues include:

- Access during Flooding — A number of arterial roads through the area are flooded during relatively minor floods, in particular Hoxton Park Road between First Avenue and Joadja Road, and Cowpasture Road at various locations. Determination of an appropriate level of service for these roads was seen as a key issue, along with improvements to signposting of road closures.
- Development Controls — Planning controls were seen as a key element for a future floodplain management study, with a review of current planning controls recommended.
- Flood Standard — There was concern over the blanket adoption of the 100 year ARI flood standard, and that there may be a perception that all land above this level would be free from flooding.
- Management of Public Lands — There is a perception that Council has inherited a legacy of drainage infrastructure and designated open space that has not been well planned or co-ordinated. It was recommended that any future floodplain management plan carefully examine options for preserving the conveyance capacity of the creek and floodplain whilst meeting community expectations for the provision of a bushland environment.
- Policies on Filling of Land — The preparation of guidelines for the filling of land, particularly flood prone land, was recommended.
- Environmental Issues — Whilst the focus of any future Floodplain Management Plan would be expected to be on flood related issues, it was recommended that a framework should be provided in which valuable ecological features can be preserved and water quality can be appropriately managed.

2.8 INVESTIGATIONS UNDERTAKEN SINCE 1999

A number of flood-related investigations have been undertaken within the study area since the draft floodplain management study report was prepared in May, 1999. Some of these investigations will impact on the recommended floodplain management plan, and have been considered in the preparation of this updated report. The main investigations that have been considered are discussed further in this Section.

2.8.1 Western Sydney Orbital Investigations

Bewsher Consulting, in conjunction with WBM Oceanics Australia, was commissioned by the Roads and Traffic Authority to assess the flooding impacts of the proposed WSO highway in July, 2001.

The main objective of these investigations was the development of a detailed hydraulic model to assist in:

- the sizing and location of waterway openings under the WSO highway;
- the sizing and location of detention basins; and
- definition of flooding impacts from various proposals for the highway.

The original RAFTS model developed for the Cabramatta Creek Floodplain Management Study was adopted for hydrologic modelling of catchment runoff. This model was refined to account for changes in the catchment since the previous analysis, to reflect 2001 catchment conditions. Other model parameter changes were also considered appropriate for these investigations, which are further discussed in **Section 3.2**.

A new two-dimensional hydraulic model, referred to as *TUFLOW*, was developed to model the flooding impacts of the proposed highway and flood mitigation measures. This model was dynamically linked to a one-dimensional model representing the main creek channel. The model is considered to be more detailed than the model used in the floodplain management study (RMA-2) in the vicinity of the proposed highway. However, the model does not cover the full extent of the study area provided in the floodplain management study.

Findings from the investigation [Bewsher Consulting, WBM, 2001] recommended various bridge and culvert sizes along the route of the proposed highway within the Cabramatta Creek catchment. It also recommended the construction of detention basins on Maxwells Creek, Cabramatta Creek and Hinchinbrook Creeks to mitigate any adverse flooding impacts from the proposed highway.

The proposed WSO highway has significant implications for the Cabramatta Creek Floodplain Management Plan. Some detention basins that were previously proposed within the catchment can no longer be built, due to the proposed route of the highway. Other proposed WSO basins can be enlarged to perform dual purposes.

The most significant implication of the subsequent investigations is the reduced size of the basin on Cabramatta Creek (Basin 22). This had originally been proposed as a

large dual-purpose RTA/Council basin to mitigate the flooding impacts of the proposed WSO, future development within the catchment, and to also reduce existing downstream flooding problems. Whilst a basin is still proposed at this location, its size is much reduced due to land acquisition costs and other technical difficulties (including a high saline water table at this location). Consequently, a significant reduction in downstream flood levels is unlikely as a result of this revised Basin.

A consortium has been chosen by the RTA to design and construct the proposed WSO highway. This consortium has been provided with the flood models developed by Bewsher Consulting and WBM Oceanics to further refine the size of bridge openings and WSO detention basins.

2.8.2 Brickmakers Creek Flood Investigations

This investigation was commissioned by Liverpool City Council in September 2003.

The objectives of the investigations were to:

(i) provide more detailed modelling of the reach of Brickmakers Creek, between Memorial Avenue and Homepride Avenue;

(ii) provide revised flood extents and flood contours for the 20 year, 100 year and PMF floods, if these need to be revised;

(iii) investigate flood mitigation works to reduce the impact of flooding on affected properties in this reach of Brickmakers Creek, particularly creek rehabilitation works previously proposed by other consultants

A detailed 2-dimensional *TUFLOW* model, dynamically lined to a one-dimensional model of Brickmakers Creek, was adopted for these investigations. The new model more accurately defined the break-out of floodwater from the creek into the Liverpool CBD area.

A report outlining the results of the investigations was provided in December 2003. This report is reproduced in Appendix C.

2.8.3 Edmondson Park Master Plan

Edmondson Park forms part of the Hoxton Park release area that was identified for urban expansion by the Minister of Environment and Planning in the mid 1980's. The Edmondson Park release area is located south of Camden Valley Way, within the upper Cabramatta Creek and Maxwells Creek catchment areas.

A master plan for this new release area is currently being developed. Details of proposed flood management measures within the release area are provided in a report titled "*Edmondson Park Master Planning - Water Cycle Management: Stormwater*" [GHD, 2003].

Two detention basins had initially been proposed within the Edmondson Park Release Area in the draft floodplain study. The master plan has further evaluated the floodplain management strategy for this site, based on more detailed consideration of planning

objectives and other site constraints. A revised strategy has been proposed that includes the construction of four wet/dry detention basins, and drainage corridors/easements/bioengineered channels within Upper Cabramatta Creek and Maxwells Creek. The overall objective of the strategy – to limit post development flows to pre development flows – appears to be met by this revised strategy.

2.8.4 Southern Hoxton Park Aerodrome Precinct

The Southern Hoxton Park Precinct also forms part of the Hoxton Park release area for future urban development. The site is located in the Hinchinbrook Creek subcatchment, west of Cowpasture Road and the proposed WSO highway.

A master plan for the new release area is currently being developed. Details of proposed flood management measures are provided in a report titled "*Southern Hoxton Park Aerodrome Precinct – Hydrological & Hydraulic Study*" [JWP, 2004].

One detention basin (Basin 6) had originally been proposed within this new release area on Creek M, as part of Liverpool Council's detention basin strategy [Kinhill, 1992]. The proposed route of the WSO highway later compromised the construction of a basin at this location. The draft floodplain management study recognised that Basin 6 could be omitted from Council's basin strategy providing a large central basin (Basin 22) could be constructed within the catchment. However, subsequent investigations have led to a much reduced Basin 22, with the result that detention storage within the new release area will now be imperative.

The master plan proposes a number of wetlands within the precinct. These wetlands also incorporate some detention storage. The combined detention storage volume provided is significantly less than the basin that was included in Council's original strategy, although model results appear to suggest that these are sufficient to restrict post developed flows leaving the site to pre developed flows.

Oblique aerial photo of Maxwells Creek (November 1998), viewed from Jedda Road upstream towards Camden Valley Way. Downstream of Jedda Road the creek consists of a formed channel with concrete invert. The creek reverts to a more natural form between Jedda Road and Kurrajong Road.

PHOTO 3
Maxwells Creek

3. ANALYSIS OF FLOOD BEHAVIOUR

3.1 METHODOLOGY

There are no long term historical flood records available within the Cabramatta Creek catchment on which flood frequency analysis can be undertaken. Consequently, the approach undertaken for this study has been to estimate flow hydrographs throughout the catchment using a hydrologic computer model, and then to input these flows into a separate hydraulic model to compute flood levels and velocities.

The RAFTS hydrologic model was adopted for the analysis of catchment flows. This was based on a model that had previously been established for the catchment, as part of earlier investigations [Kinhill, 1992]. Flood behaviour was then analysed using the RMA-2V hydraulic model. RMA-2V is a sophisticated hydraulic model capable of simulating the 2-dimensional nature of flow along and across wide floodplains.

All models require calibration and verification to be able to confidently predict flood behaviour. This involves modelling historic events and comparing computed results with observed flood levels. Model parameters are then adjusted to improve the fit between computed and recorded levels.

Following calibration, the models have been used to analyse flood behaviour for various design flood conditions. Design flood level estimates have been computed for the 20, 50 and 100 year average recurrence interval (ARI) floods, as well as a probable maximum flood.

These models then form the basis for assessing the impacts of catchment development, and for testing the effects of various flood mitigation measures to reduce flood problems within the catchment.

3.2 RAFTS HYDROLOGIC MODELLING

At the onset of this study, Liverpool City Council provided Bewsher Consulting with existing RAFTS data files that had been prepared for the Hoxton Park Total Catchment Management Study [Kinhill, 1992]. These files had been generated using an earlier version of the RAFTS program (Version 2.54), and required conversion to a form compatible with the current version of the RAFTS program (Version 4.02).

The RAFTS data files were updated by WP Software, the authors of the RAFTS program. Initial results from the updated model revealed some variation in flow estimates from the earlier model. WP Software consequently recommended that a recalibration of the RAFTS model be undertaken.

Since the model required recalibration, the opportunity was also taken to refine the subcatchment layout in the upper catchment areas. The adopted RAFTS catchment plan is included as **Figure 3.1**. It was also deemed appropriate to adjust a runoff parameter, know as the PERN value, on a subcatchment basis to better reflect the different land uses within the catchment.

The RAFTS model was calibrated against recorded data available at a DIPNR stream gauging station located on Cabramatta Creek at Orange Grove Road. Historic floods that occurred in April 1988, August 1986, April 1989, and July 1988 were considered for this purpose. Different RAFTS calibration coefficients of Bx=1,2,&3 were trialled, with the computed hydrograph from both RAFTS and RMA-2V compared against the recorded hydrograph.

A calibration coefficient of Bx=2 was considered to give the best overall fit for the four recorded floods. This was subsequently adopted for all further modelling of design flood conditions, development scenarios, and flood mitigation options.

Further details and results from the RAFTS hydrologic modelling can be found in the "RAFTS (Hydrologic) Modelling" working paper [Bewsher Consulting, 1998a].

3.3 UPDATED RAFTS MODEL

Subsequent to investigations undertaken for the draft floodplain management study, detailed flood investigations were undertaken for the Roads and Traffic Authority, in connection with the proposed WSO highway [Bewsher Consulting and WBM Oceanics Australia, 2002]. These investigations utilised the RAFTS model that was developed for the floodplain management study, and further updated this model to account for recent changes within the catchment and other improved modelling techniques.

Changes made to the RAFTS model include:

(i) it was updated to represent catchment conditions in 2001;

(ii) a split sub-area method was adopted to model the effects of catchment development, in line with current practice;

(iii) adoption of revised Intensity-Frequency-Duration rainfall data, as provided by Liverpool Council;

(iv) the areal reduction factor that had been applied to rainfall was removed, as this was less appropriate in the smaller subcatchment areas;

(v) the RAFTS calibration parameter was reduced from Bx=2 to Bx=1, as it was found that the higher value tended to underestimate flows in the smaller subcatchment areas.

Details of catchment flows provided by this updated model are provided in Appendix B. It is recommended that any future analysis of flood behaviour incorporate flows from this updated model, or other more detailed models where these are developed for specific areas.

FIGURE 3.1

RAFTS Catchment Layout Plan

3.4 RMA-2V HYDRAULIC MODELLING

Hydraulic modelling is the process of converting flows generated from the hydrologic model into flood levels throughout the river or creek system. The hydraulic modelling for this study was undertaken by the University of NSW Research Laboratory (WRL), using the RMA-2V computer model.

RMA-2V is a finite element computer model designed to simulate two dimensional flood behaviour within estuaries, rivers, and creeks. It is particularly well suited to modelling wide floodplains, as is the case in the lower reaches of Cabramatta Creek, or where flood breakouts may occur from one creek system to another. The model was originally developed in the United States by Professor I. P. King and W. R. Norton. It has since undergone further development by staff at the WRL.

A finite element mesh, consisting of elements and nodes distributed along and across the creek system, describes the topography of the creek and floodplain. Flood heights are computed at each of these nodes over the full duration of flooding. As a large number of nodes and elements were necessary to accurately simulate flood behaviour throughout the whole area of interest, it was necessary to divide the catchment into 8 individual sub-models. This consisted of a main Lower Cabramatta Creek model with over 18,000 nodes, and seven smaller models representing the upstream creek systems, with the number of nodes ranging from 360 to over 4,700. An illustration of the main Lower Cabramatta Creek model is presented on **Figure 3.2**.

The model was calibrated to flood data that was observed during the April 1988 flood. This involved comparing computed flood levels to observed flood levels, and adjusting model parameters until a satisfactory fit between computed and observed level flood behaviour was achieved. The model was then verified against data collected from the August 1986 flood, without further change to model parameters.

With the model calibrated and sufficiently verified, it was then used to evaluate flooding behaviour throughout the catchment under 1996 catchment conditions. Flood behaviour was simulated for the 20 year, 50 year, and 100 year ARI design floods, as well as a probable maximum flood.

The model was also used to assess the impact of different states of catchment development, ranging from 1989 catchment conditions to anticipated future conditions in 50 years time (i.e. 2046).

A full description of hydraulic modelling can be found in the “Flood Study Report” working paper [WRL, 1998a].

Figure 3.2

RMA-2V Finite Element Mesh for Lower Cabramatta Creek

3.5 EXISTING FLOOD CONDITIONS

Flood extents have been calculated on the basis of topographic ground data derived from the aerial mapping and spatial flood level information determined at over 35,000 nodes within the catchment's floodplains. Areas of inundation have been determined by comparing ground levels with computed flood levels on the basis of an interpolated 1m square grid over the floodplain.

Plans showing the extent of flood inundation and flood contours for the 100 year ARI flood, and the extent of the probable maximum flood, are represented on **Figures 3.3**, **3.4** and **3.5**. These plans have also been produced for Council's use as three A1 size plans at a scale of 1:10,000.

Flood level information for the 20 year, 50 year, 100 year and probable maximum flood has also been provided to both Councils in digital form, for incorporation into their respective GIS computer based systems. Further development of Liverpool Council's GENAMAP computer system is currently under consideration to facilitate reporting of flood data within a region or on an individual property basis. This could allow the generation of a detailed report for any property within the floodplain, providing:

- design flood levels at the site under Epoch 1 (1996) catchment conditions, for the 20 year, 50 year, and 100 year ARI floods, as well as the probable maximum flood;
- minimum ground level on the property, based on an interpolated 10m spatial grid determined from the aerial mapping undertaken in 1996;
- the surveyed floor level of the building on the property, where available; and
- a graphical representation of the extent of flooding and depth of flooding over the property for any nominated design flood.

The system could also be extended to cover the Fairfield part of the catchment, should Fairfield Council decide to implement a similar computer based system.

Areas of land that are currently zoned for urban development that contain significant areas of land subject to flooding include:

- **Lower Cabramatta Creek Catchment (including part of Fairfield LGA)** — Within the Liverpool LGA, the majority of the 100 year ARI floodplain is located within open space zones. However, in some areas the 100 year ARI flood extent intrudes upon adjoining urban zones, such as the Residential zoned land near the northern extent of Lawrence Hargrave Road, the central section of Williamson Crescent, parts of industrial zoned land within Warwick Farm (between the Hume Highway and the railway line) and the north-eastern extent of the industrial estates abutting Orange Grove Road. The majority of the 100 year ARI floodplain within the Fairfield LGA component is similarly within open space zoned land, although there are some residential zoned lands within the 100 year ARI floodplain such as the land to the south-west of Jasmine Crescent, Cabramatta and the land at the southern end of Church Street, Cabramatta. The small industrial area to the east and south of Church Street, Cabramatta is also located within the 100 year ARI floodplain.

- **Brickmakers Creek Catchment** — The majority of the 100 year ARI floodplain is located within Open Space zones. In many places the 100 year ARI flood extent intrudes marginally upon adjoining Residential zoned land. In some isolated sections, the 100 year ARI floodplain extends significantly into Residential zoned land, such as the area to the south-east and south-west of the intersection of the Hume Highway and Copeland Street and the Residential zoned land in the vicinity of Coolaroo Crescent and Wonga Road.
- **Hinchinbrook Creek Catchment** — This area is only partially developed comprising newly constructed roads and subdivisions and sparse detached housing. In conjunction with the residential development proposed are various flood mitigation works along Hinchinbrook Creek incorporating stormwater detention basins and wetlands. The majority of the 100 year ARI floodplain is located within open space, special use -drainage, or within the abutting future urban zone. The 100 year ARI floodplain extends into residential zones in some areas, but this is basically to a minor extent and often in locations where urban development is yet to occur, which may be accompanied by land filling or other flood mitigation works.
- **Maxwells Creek Catchment** — Within the more established northern extent of this sub-catchment, the 100 year ARI floodplain is contained primarily within a special uses drainage zone, but extends in an irregular pattern into adjoining industrial and residential zones. The Prestons Industrial Area Stage II, located to the north-west of Kurrajong and Ash Roads, is presently zoned 1(e) Future Urban but contains a significant area of the 100 year ARI floodplain. To the south of Kurrajong Road and north of the Hume Highway is located the Prestons Residential Release Area which has been zoned for residential purposes with no major development as yet, but is subject to significant flooding in the 100 year ARI event. The Cross Roads site (bounded by the Hume Highway, the Motorway and Campbelltown Road) is zoned for industrial purposes and has a significant proportion affected by the 100 year ARI flood. To the south of the Hume Highway is the existing Edmondson Park rural residential area, identified for future urban release and is partially affected by the 100 year ARI flood near the Hume Highway end and the southern extent of Croatia Avenue. The adjoining military zoned land further to the south is substantially affected by the 100 year ARI flood.
- **Upper Cabramatta Creek Catchment** — The northern extent of this catchment comprises predominantly the Cabramatta Creek and Carnes Hill Urban Release Areas containing undeveloped residential zoned land with a substantial corridor of land flanking the creek which is within the 100 year ARI floodplain. The 100 year ARI floodplain within the southern extent of this catchment cuts through allotments within the Edmondson Park and Denham Court Rural Residential Areas.

Figure 3.3

Flood Extents and 100 year ARI Flood Contours
(Sheet 1 of 2)

FIGURE 3.4

Flood Extents and 100 Year ARI Flood Contours
(Sheet 2 of 3)

FIGURE 3.5

Flood Extents and 100 Year ARI Flood Contours
(Sheet 3 of 3)

3.6 FLOOD BEHAVIOUR FOR DIFFERENT DEVELOPMENT SCENARIOS

Flood behaviour has been analysed for four different time frames, or epochs:

- *previous catchment conditions (Epoch 2)*, prior to any new release area development, corresponding to the year 1989;
- *existing catchment conditions (Epoch 1)*, based on aerial photography of the catchment taken in 1996;
- *future catchment conditions (Epoch 3)*, on completion of all development associated with the new release areas and the construction of all detention basins; and
- *ultimate catchment conditions (Epoch 4)*, based on the maximum development likely to occur over the next 50 years.

Results from the RAFTS hydrologic model indicate that between 1989 and 1996, peak flows for the 100 year ARI flood are estimated to have increased by up to 10% throughout much of Upper Cabramatta Creek and Hinchinbrook Creek. This is a result of the development that has taken place within these subcatchments, despite the construction of a number of detention basins. Little change is evident in Maxwells Creek, and towards the downstream end of Cabramatta Creek peak flows have increased by around 5%.

After ultimate catchment development, it is estimated that peak flows will be reduced to 1989 levels, or lower, throughout much of Upper Cabramatta Creek and Hinchinbrook Creek. This is largely a result of the construction of further detention basins in these areas. In Maxwells Creek, it was found that ultimate 100 year ARI peak flows would increase by as much as 15% over 1989 levels. In the downstream reaches of Lower Cabramatta Creek it was also estimated that peak flows could increase by up to 10%.

The impact of increased flow rates on flood levels vary depending on location. Throughout Lower Cabramatta Creek, the increase in flood levels between 1989 conditions and ultimate conditions is in the range of 0.1 to 0.2m.

The implication of these findings is that additional compensatory flood mitigation works are necessary within the catchment to ensure that future flood conditions are not exacerbated, in addition to flood mitigation works investigated with a view to reducing existing flood problems.

3.7 ACCURACY OF MODEL RESULTS

All flood models require calibration to be able to confidently predict flood behaviour in a particular catchment. The reliability, or accuracy of model results, is therefore dependent on the availability of recorded flood data.

Significant floods were recorded in the Cabramatta Creek catchment in August 1986 and April 1988. The 1988 flood was the larger of the two events, with a magnitude similar to the estimated 100 year ARI flood.

Streamflow data is required for calibration of the hydrologic model, whilst flood heights are required for calibrating the hydraulic model. Streamflow data was available for these two floods at the Orange Grove Road gauging station, whilst peak flood levels were available at various locations throughout the catchment.

The hydrologic model was calibrated to the Orange Grove Road streamflow data. Whilst this provides confidence in flow estimates towards the downstream end of the model, there is unfortunately no data to confirm the applicability of these same calibration parameters in the upstream areas of the model.

Substantial flood level data was recorded for the two historical floods throughout Lower Cabramatta Creek, parts of Upper Cabramatta Creek and Hinchinbrook Creek, and the lower reaches of Maxwells Creek. Within these regions, the hydraulic model was able to match the recorded data within an accuracy of ±0.2m. The accuracy of model results for floods up to the 100 year ARI event is therefore estimated to be ±0.2m in areas where flood height calibration data exists.

In other areas of the catchment, particularly the upper reaches of the catchment where there is no calibration data, the same level of accuracy can not be guaranteed. In these regions, the accuracy of model results is likely to be approximately ±0.5m.

The region of available calibration data and consequently the confidence limits for model results are represented in **Figure 3.6**.

Despite the lower confidence limits in the upper parts of the catchment, the flood level estimates are considered suitable for the purpose of this catchment-wide floodplain management study. More detailed investigations may be warranted when considering future development proposals, particularly in the upper catchment areas.

3.8 RECENT FLOOD MODELLING

There have been other flood investigations undertaken within the Cabramatta Creek catchment since the initial floodplain management study.

The investigations for the RTA on the proposed WSO highway [Bewsher Consulting and WBM Oceanics Australia, 2002] led to an updated *RAFTS* hydrologic model and a new *TUFLOW* 2D/1D hydraulic model of part of the catchment. A comparison of flood level results between the RMA-2V model used for the floodplain management study and the TUFLOW model indicated close agreement (generally within ±0.2m) for the 100 year flood. This close agreement is largely due to the fact that both models were calibrated to the same source data.

A review of flood behaviour on Brickmakers Creek, between Homepride Avenue and Memorial Avenue, was recently undertaken for Liverpool Council (see **Appendix C**). These investigations utilised the updated RAFTS hydrologic model and a new TUFLOW hydraulic model of this specific area. As no calibration data is available on Brickmakers Creek, results are sensitive to both the hydrologic flow estimates and the hydraulic model used to generate flood levels. The new results indicate higher flows and flood levels within Brickmakers Creek than previously provided by the floodplain management study, and are considered to be more reliable.

There have also been a number of site specific flood investigations associated with various development proposals within the catchment, and further investigations are likely in the near future. Council's GIS flood records will need to be constantly reviewed and updated as these investigations/catchment changes occur.

FIGURE 3.6

Confidence Limits for Model Results

3.9 FLOOD RISK MAPPING

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

Mapping of different flood risks was not undertaken during the initial floodplain management investigations, but has been undertaken as part of the updated study.

Both Liverpool and Fairfield Councils agreed that the study area should be categorised into three different grades of flood risk, namely high, medium and low. This approach is similar to that which was recently adopted by the Georges River Floodplain Management Committee for the Georges River. It is also consistent with the categorisation of other natural risks, such as bush fire risk.

The three flood risk areas, which are defined below, are shown on **Figure 3.7**.

High Flood Risk	Land below the 100 year flood that is either subject to a high hydraulic hazard (ie provisional high hazard in accordance with the criteria outlined in the *Floodplain Management Manual*) or where there are significant evacuation difficulties.
Medium Flood Risk	Land below the 100 year flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.
Low Flood Risk	All land within the floodplain (ie. within the PMF extent) but not identified as either in a high flood risk or medium flood risk area.

The high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted in this area.

The medium flood risk area is where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.

The low flood risk area is that area above the 100 year flood, where the risk of damage is low. Most land uses would be permitted within this area.

The risk mapping is intended to be ultimately incorporated in GIS computer systems of both councils. This will provide a valuable source of information for Council to manage the flood risk, and will also assist with future emergency management operations.

FIGURE 3.7

RISK MANAGEMENT PRECINCTS

4. FLOOD DAMAGE ASSESSMENT

4.1 FLOOD DAMAGES DATA BASE

A “flood damages data base” has been designed specifically for this study, in order to quantify the impacts of flooding in dollar terms and to allow an economic appraisal of floodplain management options.

The data base includes information on potential flood affected properties within the catchment up to the probable maximum flood. Property details, such as address, land use, and area of property have been extracted from both Councils’ rates data base. Property details were provided by Liverpool Council in 1997 and Fairfield Council in 1998.

The maximum flood level experienced for each potential flood affected property has been determined from the two dimensional hydraulic model. This data has been prepared in the form of flood levels over the floodplain on a regular 10m wide grid. Minimum ground levels have also been determined for each property based on the aerial mapping undertaken in 1996, also prepared in the form of the same 10m wide grid. Assumed flood depths for each property are based on a comparison of the maximum flood level with the minimum ground level for that property. This approach is suitable for most of the properties in the catchment, but may produce a conservatively high indication of flood affectation on large properties.

Separate data bases have been prepared for 11 different catchment zones. These same zones were used to analyse the results of the community questionnaires, and allows specific consideration of flooding issues within different parts of the catchment.

The flood damages data base provides the following information for each potentially flood-affected residential, commercial and industrial property:

- property details;
- flood level for a range of flood events (20 year, 50 year, 100 year ARI and a probable maximum flood);
- minimum ground level for the property, based on 1996 aerial mapping and an interpolated 10m data grid;
- floor levels for buildings, based on actual survey where available (most properties below the 100 year flood), or estimated level based on the minimum ground level and a derived relationship; and
- the potential flood damage for each flood event.

The number of properties included in the flood damages data base, for different zones within the catchment, is indicated in **Table 4.1**.

Further information on the flood damages data base is provided in the “*Flood Damages Assessment*” working paper [Bewsher Consulting, 1999c].

TABLE 4.1
Properties Included in Flood Damages Data Base

CATCHMENT ZONE			SINGLE HOUSES	FLATS UNITS TOWN-HOUSES	BUSIN.(1)
NO.	CREEK	LOCATION			
1A	Cabramatta	Georges River to Elizabeth Drive (Liverpool)	483	68	35
1B	Cabramatta	Georges River to Elizabeth Drive (Fairfield)	763	2	41
2	Cabramatta	Elizabeth Drive to Hoxton Park Road	553	110	10
3	Cabramatta	Hoxton Park Road to Jardine Drive	49	0	27
4	Cabramatta	Denham Court	156	0	0
5	Creek A	Cabramatta Creek to Cowpasture Road	66	0	7
6	Hinchinbrook	Cabramatta Creek to Cecil Hills Wetland	157	0	9
7	Maxwells	Cabramatta Creek to Campbelltown Road	152	0	76
8	Brickmakers	Cabramatta Creek to Elizabeth Drive	325	43	27
9	Brickmakers	Elizabeth Drive to Hoxton Park Road	136	175	7
10	Brickmakers	Hoxton Park Road to Graham Avenue	383	13	5
		TOTALS	**3,223**	**411**	**244**

Note: (1) Businesses include commercial, industrial and public authority properties.

4.2 TYPES OF FLOOD DAMAGE

The definitions and methodology used in estimating flood damage have been established by a number of previous investigations. The types of flood damage examined in this study are summarised in **Figure 4.1**. The two main categories are referred to as “tangible” or “intangible” flood damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are more difficult to quantify.

Tangible flood damages are divided into two subcategories - direct and indirect. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

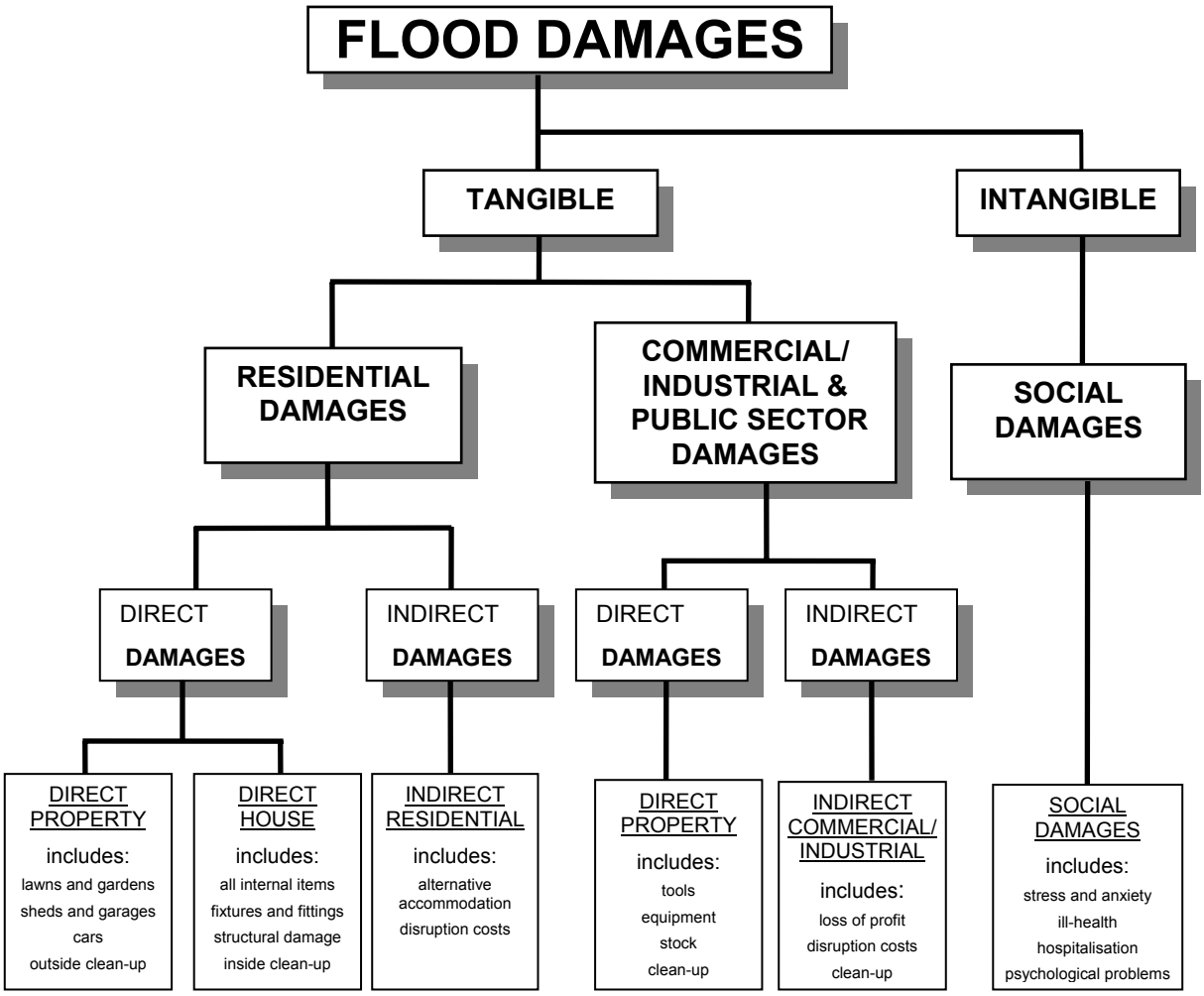


FIGURE 4.1
Types of Flood Damages

4.3 BASIS OF FLOOD DAMAGES CALCULATIONS

Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type.

The stage-damage curves for Cabramatta Creek have been based on specific consideration of the types of development within the catchment, information available from previous investigations, and flood damage surveys undertaken following recent major floods in Coffs Harbour (1996); Inverell (1991); Forbes(1990); Nyngan (1990); and the Georges River (1986).

Three different stage-damage curves have been derived for dwellings, to represent units or town houses, average houses, and more prestigious houses. External property damage curves have also been derived, which includes allowance for damage to gardens, motor vehicles and clean-up costs.

Stage-damage curves have also been derived for commercial properties, industrial properties, large retailers, industrial properties, and public authority properties. These categories have been further divided into a number of sub-categories.

Apart from the direct potential direct flood damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:

- indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- infrastructure damage, based on a percentage of the total value of residential and business flood damage; and
- intangible or social damages, based on an average cost per flood affected household.

All adopted stage-damage curves and other flood damages assumptions are provided in the "Flood Damages Assessment" working paper [Bewsher Consulting 1999c].

4.4 SUMMARY OF FLOOD DAMAGES

'Average annual damage' (AAD) and 'present value' are financial terms that are often used in the economic appraisal of flood damages and flood mitigation measures. The AAD is a measure of the cost of flood damage that could be expected each year, on average, by the community. The present value of flood damage is usually calculated to allow a direct comparison with the capital and on-going costs of proposed flood mitigation measures. This has been determined on the basis of a 7% discount rate and an expected life of 20 years, in accordance with guidelines provided by the NSW Treasury.

Flood damage calculations for each of the eleven catchment zones have been determined from the flood damages database. **Table 4.2** provides an overall summary of the "predicted actual" flood damage bill for each of the catchment zones from the flood damages database. This Table also presents the average annual damage and the present value of flood damage (assuming a discount rate of 7% and period of 20 years).

The following key points are relevant from these results:

- the ratio of predicted *actual* flood damage to *potential* flood damage throughout the Cabramatta Creek catchment is estimated to be 88%;
- The total expected flood damage estimated to occur in a 100 year flood is $21M ($16M for Liverpool Council and $4.8M for Fairfield);
- Flood damage for the PMF is estimated to be as high as $230M
- Components of average annual flood damages within the study area are estimated to be:

- Direct House Damage	$ 616,000	(23%)
- Direct Property Damage	$ 242,000	(9%)
- Indirect Residential Damage	$ 43,000	(2%)
- Direct Industrial & Commercial	$ 721,000	(26%)
- Indirect Industrial & Commercial	$ 397,000	(15%)
- Infrastructure & Public Sector Damage	$ 492,000	(18%)
- Social Damages	$ 184,000	(7%)
- TOTAL	$ 2,700,000	

- The present value of expected flood damages within the catchment is estimated at $29 M;

The different components of flood damage in Cabramatta Creek are summarized in Figure 4.2.

The flood damages database provides a valuable tool for assessing the economic merits of various flood mitigation options that may be considered for the Georges River. Flood level estimates within the flood damages database can be readily updated to reflect new conditions arising from proposed flood mitigation measures. The flood damages are then recalculated and the savings in flood damages can be calculated.

TABLE 4.2
Predicted Total Flood Damages under Existing Conditions
(1999 Estimates [Bewsher Consulting, 99b])

Location		Damage in Flood Event ($)			Average Annual Damage	Present Value of Damage
		20 Year	100 Year	PMF		
Liverpool City Council Area						
1A	Cab Ck – Georges R to Eliz Dr	10,000	950,000	54,270,000	290,000	3,100,000
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	850,000	1,070,000	32,090,000	270,000	2,810,000
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	2,390,000	4,340,000	13,700,000	380,000	4,040,000
4	Cab Ck – Denham Court	1,700,000	1,880,000	3,840,000	230,000	2,400,000
5	Creek A – Cab Ck to Cowpasture Rd	390,000	550,000	2,150,000	60,000	630,000
6	Hinchinbrook Ck	670,000	870,000	4,790,000	110,000	1,120,000
7	Maxwells Ck	3,250,000	4,570,000	17,400,000	490,000	5,230,000
8	Brickmakers Ck – Cab Ck to Eliz Dr	400,000	1,010,000	37,720,000	250,000	2,640,000
9	Brickmakers Ck – Eliz Dr to HP Rd	130,000	430,000	7,610,000	60,000	590,000
10	Brickmakers Ck – HP Rd to Graham	170,000	290,000	4,960,000	50,000	500,000
	Sub-Total	*9,960,000*	*15,960,000*	*178,530,000*	*2,190,000*	*23,060,000*
Fairfield City Council						
1B	Cab Ck – Georges R to Eliz Dr.	1,780,000	4,810,000	48,900,000	520,000	5,480,000
TOTAL (both Councils)		**11,740,000**	**20,770,000**	**227,430,000**	**2,710,000**	**28,540,000**

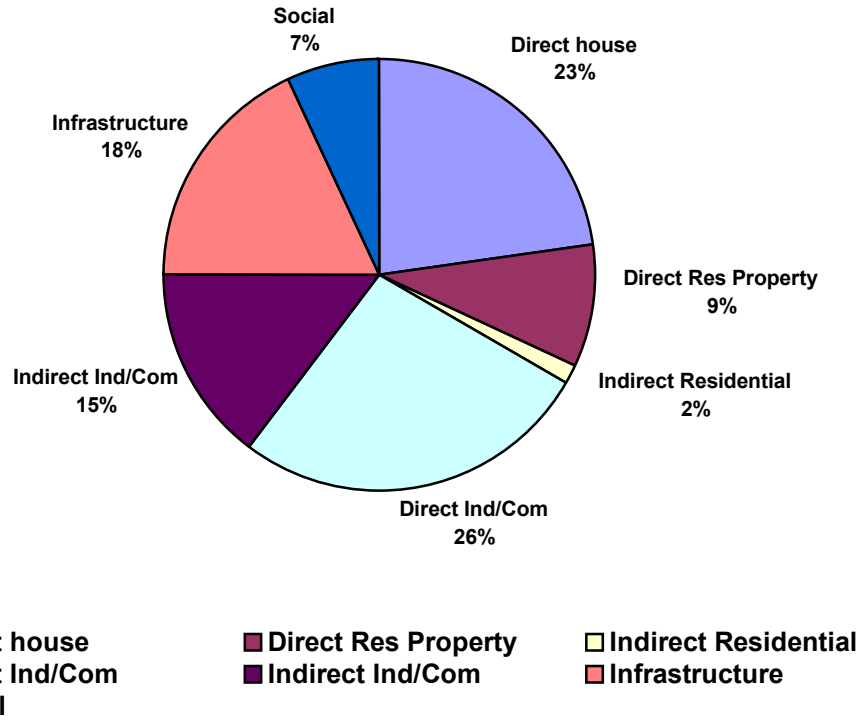


FIGURE 4.2
COMPONENTS OF FLOOD DAMAGE FOR CABRAMATTA CK
(Average Annual Damage)

4.5 SUMMARY OF PROPERTY INUNDATION

The flood damages database also provides details on properties and buildings that would be affected by various floods. **Table 4.3** provides a summary of the number of residential properties (ie yards and surrounds) and residential homes that would be inundated during a 20 year, 50 year, 100 year and PMF flood event. Similar details are provided in **Table 4.4** for industrial and commercial properties.

Results from the database show that:

- 3,258 residential properties and 223 commercial/industrial properties would be inundated in the PMF;
- 2,838 residential homes and 218 commercial/industrial buildings would be flooded above floor level in the PMF;
- 851 residential properties and 159 commercial/industrial properties would be inundated in the 100 year flood;
- 124 residential homes and 104 commercial/industrial buildings would be flooded in the 100 year flood;
- The majority of flooded homes in the 100 year flood are located in lower Cabramatta Creek (zones 1A, 1B, 2) and the lower parts of Maxwells Creek (part zone 7) and Brickmakers Creek (zone 8);

Further details on the inundation depths experienced by flood affected homes and buildings in the 100 year flood are provided on **Tables 4.5** and **4.6**. Results indicate that:

- 75 of the 124 homes that would be flooded in a 100 year flood would be inundated by less than 0.5m of floodwater;
- If the estimates for the 100 year flood levels were to increase by 0.2m, the number of flooded homes in this event would increase from 124 to 240;
- An increase of 0.5m in the estimates for the 100 year flood levels would result in the number of flooded homes in this event increasing from 124 to 416;
- Commercial and industrial buildings are generally flooded by greater depths than residential homes.

TABLE 4.3
Residential Property Inundation Details (1996 Conditions)

Location		20 Year Flood		50 Year Flood		100 Year Flood		PMF	
		Props	Homes	Props	Homes	Props	Homes	Props	Homes
Liverpool City Council Area									
1A	Cab Ck – Georges R to Eliz Dr	25	0	67	0	110	13	551	551
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	13	0	18	0	49	0	642	592
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	22	6	24	6	29	8	41	29
4	Cab Ck – Denham Court	31	7	31	7	31	8	35	27
5	Creek A – Cab Ck to Cowpasture Rd	4	0	4	0	7	0	63	20
6	Hinchinbrook Ck	14	8	15	8	25	12	117	77
7	Maxwells Ck	40	11	46	15	56	21	146	145
8	Brickmakers Ck – Cab Ck to Eliz Dr	81	1	87	1	112	3	346	344
9	Brickmakers Ck – Eliz Dr to HP Rd	69	0	76	0	107	7	286	244
10	Brickmakers Ck – HP Rd to Graham	48	1	55	2	71	2	269	114
	Sub-Total	*347*	*34*	*423*	*39*	*597*	*74*	*2496*	*2143*
Fairfield City Council									
1B	Cab Ck – Georges R to Eliz Dr.	139	14	191	28	254	50	762	695
TOTAL (both Councils)		**486**	**48**	**614**	**67**	**851**	**124**	**3,258**	**2,838**

TABLE 4.4
Commercial & Industrial Property Inundation Details (1996 Conditions)

Location		20 Year Flood		50 Year Flood		100 Year Flood		PMF	
		Props	Bldgs	Props	Bldgs	Props	Bldgs	Props	Bldgs
Liverpool City Council Area									
1A	Cab Ck – Georges R to Eliz Dr	24	0	24	1	24	1	35	35
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	3	1	3	2	4	2	10	10
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	18	10	18	12	18	13	18	17
4	Cab Ck – Denham Court	0	0	0	0	0	0	0	0
5	Creek A – Cab Ck to Cowpasture Rd	4	4	5	4	6	4	7	7
6	Hinchinbrook Ck	6	3	6	3	6	3	7	7
7	Maxwells Ck	66	50	66	50	66	56	72	71
8	Brickmakers Ck – Cab Ck to Eliz Dr	3	0	4	1	7	1	23	22
9	Brickmakers Ck – Eliz Dr to HP Rd	0	0	0	0	1	0	6	6
10	Brickmakers Ck – HP Rd to Graham	0	0	1	0	1	0	4	4
	Sub-Total	*124*	*68*	*127*	*73*	*133*	*80*	*182*	*179*
Fairfield City Council									
1B	Cab Ck – Georges R to Eliz Dr.	23	17	26	20	26	24	41	39
TOTAL (both Councils)		**147**	**85**	**153**	**93**	**159**	**104**	**223**	**218**

TABLE 4.5
Inundation Depths for Homes in the 100 Year Flood

Location		Below Floor (Number of Houses)		Above Floor Flooding (Number of Houses)				
		-.5 to -.2	-.2 to 0	0 to 0.2	.2 to .5	.5 to 1	>1.0m	Total
Liverpool City Council Area								
1A	Cab Ck – Georges R to Eliz Dr	20	10	13	0	0	0	13
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	1	0	0	0	0	0	0
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	4	1	3	1	1	3	8
4	Cab Ck – Denham Court	4	4	1	2	3	2	8
5	Creek A – Cab Ck to Cowpasture Rd	1	0	0	0	0	0	0
6	Hinchinbrook Ck	3	1	3	1	3	5	12
7	Maxwells Ck	9	8	5	8	2	6	21
8	Brickmakers Ck – Cab Ck to Eliz Dr	36	20	2	0	0	1	3
9	Brickmakers Ck – Eliz Dr to HP Rd	40	16	7	0	0	0	7
10	Brickmakers Ck – HP Rd to Graham	14	6	1	0	0	1	2
	Sub-Total	*132*	*66*	*35*	*12*	*9*	*18*	*74*
Fairfield City Council								
1B	Cab Ck – Georges R to Eliz Dr.	44	50	15	13	12	10	50
TOTAL (both Councils)		**176**	**116**	**50**	**25**	**21**	**28**	**124**

TABLE 4.6
Inundation Depths for Commercial Buildings in the 100 Year Flood

Location		Below Floor (Number of Bldgs)		Above Floor Flooding (Number of Buildings)				
		-.5 to -.2	-.2 to 0	0 to 0.2	.2 to .5	.5 to 1	>1.0m	Total
Liverpool City Council Area								
1A	Cab Ck – Georges R to Eliz Dr	3	1	0	0	1	0	1
2	Cab Ck – Eliz Dr to Hoxton Pk Rd	0	0	0	1	0	1	2
3	Cab Ck – Hoxton Pk Rd to Jardine Dr	1	1	2	1	5	5	13
4	Cab Ck – Denham Court	0	0	0	0	0	0	0
5	Creek A – Cab Ck to Cowpasture Rd	0	0	0	1	2	1	4
6	Hinchinbrook Ck	1	1	0	1	1	1	3
7	Maxwells Ck	3	3	8	13	29	6	56
8	Brickmakers Ck – Cab Ck to Eliz Dr	0	0	0	0	1	0	1
9	Brickmakers Ck – Eliz Dr to HP Rd	0	0	0	0	0	0	0
10	Brickmakers Ck – HP Rd to Graham	0	0	0	0	0	0	0
	Sub-Total	*8*	*6*	*10*	*17*	*39*	*14*	*80*
Fairfield City Council								
1B	Cab Ck – Georges R to Eliz Dr.	0	0	0	4	5	15	24
TOTAL (both Councils)		**8**	**6**	**10**	**21**	**44**	**29**	**104**

5. CHANGES IN THE CATCHMENT THAT WILL AFFECT FLOODING

There are a number of changes in the Cabramatta Creek catchment which have occurred, or which could occur in the future, that will have an impact on flooding. These changes include:

- new development within the catchment, particularly in the new release areas;
- Liverpool Council's flood detention basin strategy;
- loss of floodplain storage through filling;
- the proposed Western Sydney Orbital highway;
- floodplain management options investigated as part of this study; and
- changes in flood behaviour due to greenhouse effects.

5.1 NEW RELEASE AREA DEVELOPMENT

In the early 1980s, much of the Cabramatta Creek catchment was predominantly rural, with only the lower one-third of the catchment developed. Since that time, however, there has been significant pressure for further urban expansion within this catchment. Major urban release areas have been identified within the catchment that are integral to the Metropolitan Planning Strategy for Sydney.

In 1982, the Minister of Environment and Planning designated an area of the catchment known as the Hinchinbrook/Green Valley (Stage 1) Release Area for urban development. The release area permitted the development of 340 ha of the Cabramatta Creek catchment, which represents 5% of the total catchment area. Residential development commenced in this area in 1985, and to date the majority of an estimated 4,800 residential lots has been developed.

A second area within the catchment was later identified for urban expansion, known as the Hoxton Park (Stage 2) Release Area. The Stage 2 Release Area will see the development of 2,300 ha of the Cabramatta Creek catchment, representing a further 31% of the total catchment area. Approximately 18,400 residential lots will be developed as part of this release area. Development commenced in 1989, and will continue for a number of years to come.

During 1997 the catchment produced approximately 23% of the Sydney and Central Coast lot production, and was forecast to average 19% of the total Sydney and Central Coast UDP production from 1998 to 2003.

In 2004, Master Plans were in preparation for the development of two precincts within the Hoxton Park Release Area. These were the Edmondson Park and Southern Hoxton Park Aerodrome precincts. The master plans will provide details of proposed drainage and flood mitigation measures, such as channel works, detention basins and water quality basins, throughout the two precincts.

The development that has occurred within the Cabramatta Creek catchment, and that will continue to occur over the coming years, will result in an increase in the impervious

areas within the catchment. Without compensatory flood mitigation measures, this would result in an increase in both the rate and volume of flood runoff.

Liverpool City Council has adopted a flood mitigation strategy to compensate for the development which is occurring within the catchment. The strategy involves the construction of compensatory detention basins to temporarily store flood runoff during flood events.

5.2 LIVERPOOL COUNCIL'S BASIN STRATEGY

Council's current basin strategy incorporates 16 detention basins in the Cabramatta Creek catchment. The objective of the strategy is to ensure that downstream peak flow rates are not increased as a result of the new release area development that is occurring within the catchment. The location of the detention basins is shown on **Figure 5.1**, with specific details provided in **Table 5.1**.

TABLE 5.1
Status of Detention Basins Included in Existing Basin Strategy

Basin	Location	Storage (m^3)	Status
Basin 100	Cecil Hills, Hinchinbrook Creek	35,500	Constructed
Basin 3A	Cecil Hills, Hinchinbrook Creek	179,500	Constructed
Basin 200	Cecil Hills, Hinchinbrook Creek	13,900	Constructed
Cowpasture Rd Basin	Green Valley, Hinchinbrook Creek	36,100	Constructed
Banks Road Basin	Hinchinbrook	40,500	Constructed
Basin 10A	Carnes Hill, Creek A (Upper Cab.)	54,000	Constructed
Basin 10B	Carnes Hill, Creek A (Upper Cab.)	91,800	Constructed
Basin 11A	Horningsea Park, Creek E (Upper Cab)	18,000	Constructed
Basin 11B	Horningsea Park, Creek E (Upper Cab.)	26,700	Constructed
Daruk Park*	Casula Mall, Brickmakers Creek	49,100	Constructed
Basin 3B	Farm dam, Creek E (Hinch. Ck)	84,000	Pending Review
Basin 6	West Cecil Hills, Creek M (Hinch. Ck)	170,000	Pending Review
Basin 4	South Cecil Hills, Creek J (Hinch. Ck)	183,000	Pending Review
Basin 11C	Horningsea Park, Creek E (Upper Cab.)	35,700	Pending Review
Basin 12	Camden Valley Way, Upper Cab. Ck	89,000	Pending Review
Basin 14	Croatia Ave (Maxwells Ck catchment)	50,000	Pending Review
Basin 18	Liverpool Showground, Maxwells Creek	170,000	Pending Review

* The Daruk Park detention basin is not part of the New Release Area basin strategy

Oblique aerial photo of Hinchinbrook Creek (November 1998), viewed looking downstream towards Cabramatta Creek. New release area development in Cecil Hills is evident, along with compensatory detention basins and smaller water quality basins.

PHOTO 4
Hinchinbrook Creek

Figure 5.1
Existing Detention Basin Strategy (Liverpool Council)

Figure 5.2
Revised Detention Basin Strategy Considered in 1999

A total of 9 new release area detention basins have been constructed to date, in addition to the Daruk Park detention basin on Brickmakers Creek. The location and size of these basins have been largely based on the recommendations from previous reports [Sinclair Knight & Partners, 1983], [Kinhill, 1992].

Most of the detention basins that are included in the existing strategy are located on Hinchinbrook Creek. Four basins have already been constructed (Basins 100, 3A, 200, and Cowpasture Road), whilst another three from the original strategy are yet to be constructed.

Another basin that has been constructed near Hinchinbrook Creek is the Banks Road Basin. This basin drains through a stormwater drainage network direct to Cabramatta Creek, downstream of the confluence of Hinchinbrook Creek and Cabramatta Creek.

Four Basins have also been constructed in the Upper Cabramatta Creek area (Basins 10A, 10B, 11A, and 11B), with a further two basins from the original strategy yet to be constructed.

Two basins have been proposed as part of the original basin strategy in Maxwells Creek, but neither has been constructed to date.

The performance of the basin strategy, in mitigating the effects of new release area development, has been reviewed during this floodplain management study. Some deficiencies in the existing strategy were initially identified, mainly as a result of:

- increased development intensities than had previously been assumed;
- changes to the number and location of previously recommended basins; and
- the effects of other development other than Stage 2 Release Areas.

Several different options to improve the performance of the basin strategy for Cabramatta Creek were investigated, and are reported in a separate working paper titled “Review of Basin Strategy” [Bewsher Consulting, 1999a]. A revised strategy was proposed, as shown in **Figure 5.2**.

The revised strategy was based on the construction of a new detention basin, known as Basin 22, that was to be constructed downstream of the confluence of Cabramatta Creek and Hinchinbrook Creek. The proposed basin was considerably larger than any of the other basins already constructed or proposed to be constructed in Cabramatta Creek. The basin also had a number of components, benefiting new release area development, other ultimate catchment development, compensatory flood mitigation works for the proposed WSO highway, and providing a flood mitigation benefit for existing downstream development. The inclusion of Basin 22 in the strategy also provided the potential to remove Basins 4, 6 and 11C from the detention basin strategy.

The revised basin strategy, including Basin 22, was initially incorporated as a major component of the draft floodplain management plan for Cabramatta Creek. However, subsequent investigations undertaken for Council and the RTA have indicated that Basin 22 is likely to be much smaller than originally proposed. This is largely a result of

high land acquisition costs and a high, saline, water table that limits excavation depths in this vicinity.

The reduced storage volume available for Basin 22 means that it is unlikely to be able to act for anything other than a compensatory flood mitigation measure for the proposed WSO highway. As a result, the earlier proposal to remove Basins 4, 6 and 11C from Council's detention basin strategy will no longer be possible.

The proposed WSO highway also impacts on some of the remaining basins in Council's detention basin strategy. The most significant impact is the basin proposed on Maxwells Creek (Basin 18). The proposed route of the WSO highway was modified in November 2002 to minimise environmental impacts along Maxwells Creek. This moved the route of the highway through the middle of where Basin 18 was to be constructed.

Subsequently, the RTA agreed that a new basin would be incorporated in the design of the WSO highway that would provide for Council's detention basin strategy on Maxwells Creek and as a compensatory measure for the proposed highway. The revised basin is still referred to as Basin 18, but it is now located further upstream, just below the M5 motorway, and it is now larger than originally proposed.

Further discussion of proposed detention basins within the Cabramatta Creek catchment is presented in **Section 10.1**.

5.3 FILLING OF FLOODPLAINS

The detention basin strategy outlined above aims to mitigate the increase in catchment runoff that will occur due to an increase in the paved or impervious areas associated with new development. It does not allow for development that may be located within floodplain areas, which will result in a loss of floodplain storage volume.

The floodplains of Cabramatta Creek and its major tributaries are important for the natural temporary storage of floodwaters during flood events. When natural floodplain storage is reduced, flood peaks arrive at downstream locations more quickly and with a higher peak value.

Filling of low lying land, or floodplains, is sometimes considered to raise land above design flood levels so that it can be developed. This usually results in the natural flood storage of the site being lost or reduced, to the detriment of downstream flood behaviour.

Compensatory channel improvements are also often considered in conjunction with proposed filling activities, with the objective of maintaining existing flood levels at the site and upstream of the site. Whilst this objective may be achieved, it unfortunately overlooks the impact on downstream flood behaviour. In many cases the type of model used for the assessment (steady state models such as *HEC-2* or *HEC-RAS*) are not able to properly model the effects of loss of floodplain storage. More sophisticated dynamic models, such as *TUFLOW*, *MIKE-11* or *RMA-2V* are required to properly model these processes.

It is also important that the possible cumulative effects of site filling and/or channelisation are considered when assessing such proposals. Whilst individual proposals may produce only marginal increases in downstream flood levels, the cumulative effect of many such proposals could have a significant impact.

There are a number of areas within the floodplain that have not yet been developed, but are currently zoned for urban development. This zoning is likely to give the land holder an expectation that the land can be developed. However, full development of these sites may be restricted, either as a result of flooding implications or other constraints which may be imposed by various departments. For example, application of the Threatened Species Act or the Rivers and Foreshores Act may preclude development of substantial areas of land in the vicinity of existing creek banks.

5.4 PROPOSED WESTERN SYDNEY ORBITAL

A major national highway has been proposed by the Government for western Sydney, known as the Western Sydney Orbital (WSO). The new highway would connect the M5 Motorway at Prestons to the M2 Motorway at West Baulkham Hills. The majority of this new highway would be located within the Cabramatta Creek catchment, with a large proportion of the route within the floodplains of Maxwells Creek, Cabramatta Creek and Hinchinbrook Creek.

The proposed highway is a major development within the Cabramatta Creek catchment, which is likely to have a significant impact on flood behaviour unless compensatory flood mitigation measures are incorporated in the design. Potential impacts from the proposed highway arise from:

- a loss of floodplain storage in the three major creeks;
- a reduction in the capacity of these creeks to convey floodwaters;
- an increase in the impervious area of the catchment;
- local increases in flood levels at creek crossings; and
- the proposed route of the highway affecting the construction of several detention basins that are included in Liverpool Council's basin strategy.

Bewsher Consulting have been working with both Liverpool City Council and the RTA to determine an appropriate drainage management concept plan to ensure flooding conditions will not be exacerbated as a result of the proposed WSO Highway. This includes preliminary sizing of bridges and culverts, and the construction of a number of detention basins.

An initial water management plan was prepared in 1999, which is documented in a report titled "Western Sydney Orbital - Management of Cross Drainage and Road Stormwater" [Bewsher Consulting, 1999b]. Further investigations and detailed hydraulic modelling were undertaken in 2001-02 to determine preliminary sizes of bridges, culverts and detention basins [Bewsher Consulting and Oceanics Australia, 2002]. The recommended measures, shown on **Figure 5.3,** include detention basins located on Maxwells Creek, Cabramatta Creek and Hinchinbrook Creek.

FIGURE 5.3
WSO - Preliminary Sizing of bridges, culverts and detention basins

The basin on Maxwells Creek (Basin 18) is an amended form of the basin originally proposed for Liverpool Council's detention basin strategy in this vicinity. It has been located further upstream on Maxwells Creek and has been expanded to provide additional flood storage to mitigate any adverse impacts from the WSO in Maxwells Creek.

The basin on Cabramatta Creek (Basin 22) was originally intended to be another joint Council/WSO basin. However, its reduced size is such that it is only able to mitigate adverse impacts from the WSO.

The basin on Hinchinbrook Creek (Government Drive Basin) is a new basin with the objective of mitigating any adverse impacts from the WSO in both Hinchinbrook Creek and Cabramatta Creek.

The measures shown on Figure 5.3 are preliminary, and subject to detailed design considerations currently being formulated as part of the design of the WSO Highway by the Abigroup-Leighton Joint Venture Group.

5.5 FLOODPLAIN MANAGEMENT OPTIONS

Floodplain management options are often considered to compensate for development or other activity within the catchment that may otherwise have a detrimental impact on flood behaviour. Examples of such options are Liverpool City Council's detention basin strategy, which compensates for the new release area development. Another example is the concept water management plan developed for the proposed WSO Highway. The objective of these options is to ensure that flooding is not exacerbated as a result of future development.

Floodplain management options also have the potential to reduce existing flooding problems within the catchment. Options such as additional detention basin storage or channel improvements might be considered to lower existing flood levels, whilst other options such as levee banks might be considered to keep floodwater away from property.

The assessment of floodplain management options should be based on consideration of the whole catchment, not just a specific site or problem area. Some options by themselves, such as channel improvements, can reduce flooding at their location and further upstream at the expense of downstream flood behaviour. Other options, such as levees, can increase flooding that may be experienced in upstream areas.

Floodplain management options are further discussed in **Sections 9** and **Section 10**, with recommended options included in the draft floodplain management plan presented in **Section 11**.

5.6 GREENHOUSE EFFECTS

The term “greenhouse effect” is used to describe the build up of gases in the earth’s atmosphere, known as greenhouse gases, which restrict the radiation of heat from the earth’s atmosphere. This build-up of gasses can potentially lead to long term changes in the earth’s climatic patterns, with implications for flood behaviour.

Various scenarios for climate change due to the greenhouse effect have been presented by research organisations such as CSIRO and the Intergovernmental Panel on Climate Change (IPCC). The impacts of the greenhouse effect are likely to include an increase in sea level and more frequent heavy rainfall events. Both these impacts can potentially affect flood behaviour in Cabramatta Creek.

Although there is still considerable debate on the magnitude of potential sea level increases, it has been predicted on a global scale to be about 220 mm in 50 years time, and 440mm in 100 years time [IPCC, 1995]. This is reasonably consistent with more specific predictions by CSIRO for NSW, with estimates varying between 50 to 350mm over the next 35 years.

An increase in sea level of the magnitude predicted would affect flooding in the lower reaches of the Georges River. It has previously been shown [PWD, 1991] that a 600 mm increase in levels for Botany Bay would have less than a 100 mm influence on the 100 year ARI flood level for East Hills. In the vicinity of Cabramatta Creek this influence would be negligible.

The impact of more frequent heavy rainfall events is likely to have a more significant impact on design flood levels for Cabramatta Creek. Any future increase in design storm intensities would lead to higher flood levels, both within the Georges River and Cabramatta Creek. Unfortunately, intense rainfall associated with local storms cannot be simulated reliably with current global climatic models. As there is no current indication on how design storm intensities may vary in the future, the potential impact on flood levels in Cabramatta Creek can not be determined.

Both Liverpool and Fairfield Councils include a 0.5m freeboard allowance, above design flood levels, when specifying minimum floor level controls. This freeboard allowance largely caters for uncertainties in the estimation method, one of which can be considered to be climatic changes due to greenhouse effects. Until more definitive information becomes available on these likely changes, further allowance for these effects is not warranted.

6. COMMUNITY CONSULTATION

6.1 CONSULTATION PROCESS

The success of any floodplain management plan hinges on community acceptance of the proposal. This can be achieved by involving the local community at all stages of the decision-making process. This includes the collection of their ideas and information, together with discussing the issues and outcomes of the study with them.

The key elements of the community consultation process for this study were as follows:

- floodplain management committees
- community newsletters and questionnaires
- liaison with agencies and authorities; and
- exhibition of the draft report.

A full report on the community consultation process has been prepared as a separate working paper [Bewsher Consulting, 1998h]. A brief description of the findings from this process is included in the remainder of this Section.

6.2 FLOODPLAIN MANAGEMENT COMMITTEES

This study has been overseen by floodplain management committees established by both Liverpool and Fairfield Councils. Both committees have met separately on a number of occasions, as well as meeting together to discuss joint issues. The committees have formed a vital link between the Consultant, the two Councils, relevant Departments and interested agencies, and the local community.

The floodplain management committees have included representation from:

- Liverpool and Fairfield Councils;
- DLWC (now part of DIPNR);
- Department of Urban Affairs and Planning (now part of DIPNR);
- State Emergency Services; and
- community groups with an interest in the study, including the Elouera Nature Reserve Management Committee, Georges River Catchment Management Committee, Residents Association of Mt Pritchard, and East Fairfield Progress Association.

6.3 NEWSLETTERS AND QUESTIONNAIRES

During the course of this study, two community newsletters and questionnaires were distributed to residents and businesses in the vicinity of Cabramatta Creek and its tributaries. The objective of the newsletters was to inform the community of the floodplain management study and progress being made on the study. The objective of the questionnaire was to provide a mechanism where the concerns and views of the community could be gathered.

Nearly 5,000 questionnaires were distributed within the Cabramatta Creek catchment. Approximately 20% of residential questionnaires were completed and returned. This is considered to be quite a good response rate, given it has been almost ten years since a large flood was experienced in the catchment and nearly 1/3 of respondents have lived in their current dwelling for less than 5 years.

A detailed analysis of the results from the questionnaires is presented in the *Community Consultation* working paper [Bewsher Consulting, 1998h], with key findings represented below.

Overall, flood experience and the information obtained by residents about flooding were found to be quite low in the Cabramatta Creek catchment. The results show that:

- generally, only about 30% of respondents have experienced a flood:
  - the most flood experience was found to be from Maxwells Creek residents (54%);
  - the least flood experience was found to be from Hinchinbrook Creek residents, where only one respondent has experienced a flood;
- about one-third of respondents thought their property could not be flooded in the future, while another one-third were not sure;
- more than one-third of respondents have received no information at all about flooding, and of those who had, the most common source of information has come from 'unofficial' sources such as neighbours, relatives and friends. Only very few people have obtained information from Council, the DLWC or their Section 149 Planning Certificate; and
- of those people who have experienced a flood in the Cabramatta Creek catchment, very few people received official warning of the approaching flood from the SES, police or on the radio;

The main environmental concerns of the community were found to be:

- a need for more maintenance along the creek corridor (78%);
- a need to restore the creek to a more natural condition (72%);
- the problem of dumping of litter in the creek (72%); and
- a need for more educational programs centred around the creek (71%).

The most favoured floodplain management measures that the community thought 'could prevent damage' are listed in **Table 6.1**. The most favoured measures generally included those actions that would improve flood awareness, such as issuing flood certificates, flood markers, better public education, and improved flood warning. Other favoured measures included restoring the creek and clearing the creek of rubbish, as well as the implementation of an urban bush management plan for the creek corridor.

TABLE 6.1
Residents Most Favoured Opinion on Floodplain Management Options That Could Prevent Damage
(in order of popularity over the total catchment)

OPTION	FLOODPLAIN MANAGEMENT OPTIONS THAT COULD PREVENT DAMAGE	TOTAL CABRAMATTA CREEK
v	Ensuring that all information about the risks of flooding is available to all residents and business owners	75%
x	Ensuring that all residents and business owners have Flood Action Plans in the event of a flood	72%
w	Providing certificates to all residents stating whether or not their property is flood affected	71%
c	Restoration of the creek to a more natural looking condition	70%
a	Clearing the creek of rubbish, debris and exotic vegetation	69%
g	Investigation of works in the Georges River to help prevent floodwaters backing up into Cabramatta Creek	66%
t	Improve flood warning both before and during floods	66%
y	Install flood markers to act as constant reminders of heights of previous floods	66%
b	Develop and implement an urban bush management program for the creek corridor	60%

6.4 LIAISON WITH COMMUNITY GROUPS, AGENCIES & AUTHORITIES

Ten resident groups with an interest in the Cabramatta Creek catchment were contacted through the course of this study. Specific questionnaires were designed for these groups, seeking information on the Group's interest, any concerns that they may have for the catchment, and opinions on environmental issues and floodplain management measures.

Responses were received from:

- Elouera Nature Reserve Management Committee — Bewsher Consulting met with this group at their meeting in February 1997. Most of the discussions revolved around the proposed works in Cabramatta Creek in the vicinity of Elizabeth Drive. An inspection of parts of the reserve with members of the Committee was also undertaken.
- Orange Grove Precinct Committee — a creek walk was undertaken with a representative of this group in February 1997. The walk took place along Cabramatta Creek between Elizabeth Drive and Orange Grove Road. The Group expressed concern about illegal or unauthorised filling of the floodplain, particularly in the vicinity of the Orange Grove Golf Course.
- Liverpool (incorporating Lurnea) Precinct Committee — Bewsher Consulting met with the group at their meeting in March 1997. Most of these residents live near Brickmakers Creek. Their concerns relate mainly to lack of maintenance of the

creek and lack of community consultation about those works that have been carried out in the past.

- Georges River Catchment Management Committee — a completed questionnaire was returned.

More than twenty government agencies and authorities were also contacted and requested to provide advice on:

- the appropriate contact person in that organisation;
- the potential damage that could occur to their asset/property/service should it be inundated by floodwaters;
- whether their organisation had any planned future works that would be located close to the creeks within the catchment; and
- any other flood related issues that their organisation felt should be addressed.

6.5 PUBLIC MEETINGS AND PUBLIC EXHIBITION

Two public meetings were held during the course of the study, to advise the community of the study and to gain feedback on community concerns and opinions.

The first of these meetings was held in Ashcroft High School Hall in 26 February 1997, to discuss flooding issues in the Elizabeth Drive/Tresalam Street/ Florence Street area, and possible flood mitigation options to reduce flooding in this area.

The second meeting was a more general meeting concerning the overall study, which was held at Liverpool Catholic Club on 20 May 1997. The meeting was attended by representatives of both Councils, government agencies and about 30 residents.

The main issues raised by the public included:

- how residents can be made aware of flood-affectation on their properties, and limitations with the existing use of Section 149 certificates;
- that flooding would be made worse in the lower sections of Cabramatta Creek due to the large scale urban development that is currently taking place in the upstream areas; and
- flood markers on telegraph poles were thought to be a good idea to remind people of historical floods.

The final stage of community consultation for this study is the public exhibition of the draft floodplain management study and plan for Cabramatta Creek. Both Liverpool and Fairfield Councils exhibited the document over an 8 week period from July to September 2004. A copy of the submissions received, and a response to these submissions, is included in Appendix E.

7. ENVIRONMENTAL AND ECOLOGICAL CONSIDERATIONS

7.1 WATER QUALITY ISSUES

It has been noted that Cabramatta Creek, together with the upper estuarine section of the Georges River and Prospect Creek, has the poorest water quality in the Georges River system (Mackay and Swan, 1990). Major sources of pollution include urban runoff quality and sewage effluent quality.

Dry weather water quality monitoring during 1990-1991 found that water quality was generally poor throughout Cabramatta Creek and Maxwells Creek, although water quality improved in Cabramatta Creek downstream of the confluence with Maxwells Creek. A small tributary off Hoxton Park Road was found to be the most polluted, probably due to seepage and overflows from septic tanks. Water quality in the headwaters of Hinchinbrook Creek (which until recently was largely undeveloped), was found to be satisfactory [Mackay 1991].

Wet and dry weather monitoring in the Cabramatta Creek catchment was carried out by Australian Water Technologies [O'Connell, 1992] during 1990-1992. Adverse impacts on water quality of urbanisation/agricultural activities were apparent from the data, with the impacts of rural and market garden activities thought to be greater than water quality impacts associated with urban development [Kinhill, 1992]. It was also apparent that natural areas adjacent to creeks were effective in "treating" pollutants and reducing pollutant concentrations. Large amounts of urban litter were also present in the creek system, both in the urban areas and the rural areas, and the creeks have often been used as dumping grounds for car bodies, building materials and household waste, etc.

Data and monitoring by Sydney Water from 1993 to 1996 [Sinclair Knight Merz, 1998] in Chipping Norton Lakes at the confluence of Cabramatta Creek and the Georges River found that the majority of nutrients were contributed by stormwater, with the majority of faecal coliforms contributed by sewage overflows.

Water quality monitoring in Cabramatta Creek by Fairfield and Liverpool Councils during 1996-1998 showed elevated levels of nutrients and faecal coliforms in relation to ANZECC guidelines for recreational use and protection of aquatic ecosystems. Although mean results for dissolved oxygen (DO) were generally above the minimum guideline level, concentrations were lower than the guideline during dry weather sampling and up to about 9.6 mg/L during wet weather sampling. Turbidity levels were found to be medium.

It has also been found that stormwater entering Cabramatta and Maxwells creeks contained elevated levels of nutrients, up to one order of magnitude higher than ANZECC guidelines [Osborne at al, 1995].

7.2 RIVERINE ECOLOGY

There is little information on aquatic fauna in Cabramatta Creek. The *Urban Bushland Biodiversity Study* [NPWS, 1997] lists 21 frog species as occurring or potentially occurring in the Liverpool LGA, and nine frog species occurring or potentially occurring in the Fairfield LGA. Fifty-three reptile species have been recorded for western Sydney comprising two tortoises, four geckos, two legless lizards, four dragons, two goannas, 20 skinks and 19 snakes.

NPWS (1997) lists a total of 76 bird species for Cabramatta Creek from the RAOU Australian Bird Count, including eight introduced species, 12 migratory species and 18 regionally significant species. Similarly, Sainty and Associates (1997) recorded a total of 76 native bird species in the lower reaches of Cabramatta Creek and nine introduced species. LesryK Environmental Consultants (1996) recorded 50 native bird species at Hinchinbrook Creek and 36 in Elouera Nature Reserve.

LesryK Environmental Consultants (1996) recorded three native mammal species at both Hinchinbrook Creek and Elouera Nature Reserve. These species included Ringtail and Bushtail possums in Hinchinbrook Creek and the Common Bentwing-bat at Elouera Nature Reserve.

One of two major metropolitan Sydney maternity colonies of the Grey Headed Flying-fox is located adjacent to Cabramatta Creek in the Fairfield LGA [FCC, 1996].

7.3 AREAS OF SIGNIFICANT VEGETATION

Native vegetation communities along the Hinchinbrook and Cabramatta Creek corridors comprise Red Gum-Cabbage Gum River-flat Forest and Swamp Oak Forest. Over 50 native plant species have been recorded for the Cabramatta Creek corridor, including over 30 species in the upper catchment, upstream of Hoxton Park Road. Of these, Blue Box is considered to be of particular regional significance and Cabbage Gum and Prickly Beard-heath are considered to be vulnerable in Western Sydney. Over 50 species have been recorded for the Hinchinbrook Creek corridor. In addition to Blue Box and Cabbage Gum, Smooth Willow-herb, Native Flax and *Polymeria calycina* are considered vulnerable in Western Sydney [NPWS, 1997].

Significant areas of remnant bushland along Cabramatta Creek and tributaries are described in **Table 7.1**.

The Elouera Nature Reserve is also recognised as being of significant conservation potential [Greening Australia, 1991].

TABLE 7.1
Remnant Bushland of Conservation Significance
(Source : NPWS, 1997)

Location	Vegetation Community	Comments
Denham Court (east of Forest Lawn Memorial Park at head of tributary to Cabramatta Ck	Grey Box Woodland	Grey Box Woodland endangered at National, State and regional level Over 70 plant species recorded 10 species vulnerable in western Sydney
Hoxton Park Aerodrome (bushland to north-west of aerodrome)	Spotted Gum Forest	Spotted Gum Forest endangered at National, State and regional levels Over 60 species recorded 12 Species vulnerable in western Sydney low to moderate weed invasion
Prestons (bushland bordered by Jedda, Wonga, Bernera and Kurrajong Roads)	Grey Box Woodland (west of Maxwells Creek) Shale/Gravel Transition Forest (east of Maxwells Creek)	Both vegetation communities are of National, State and regional significance Over 200 species recorded One rare or Threatened Australian Plant (ROTAP) species found at site 11 species considered of particular regional significance 70 species considered vulnerable in western Sydney
Prout Park	Spotted Gum Forest	Spotted Gum Forest endangered at National, State and regional levels 53 species recorded high weed invasion
Bat Colony (north east of Jacqui Osmond Softball Centre)	River-Flat Forest including Swamp Oak Forest and Red Gum-Cabbage Gum Forrest	River-flat endangered at regional level 44 species recorded Two regionally significant species 12 species considered vulnerable in western Sydney important fauna habitat severe weed invasion
Chipping Norton Lakes (including Irelands Bridge Reserve and Cherrybrook Park)	River-flat Forest including Swamp Oak Forest and Red Gum-Cabbage Gum Forest	River-flat Forest wetland communities of regional significance Over 250 species recorded for the Lakes 40 species considered vulnerable in western Sydney Large number of significant species including 8 of particular regional significance Irelands Bridge Reserve contains locally rare rainforest species

7.4 AREAS OF ARCHAEOLOGICAL SIGNIFICANCE

Smith (1989) identified 21 previously unrecorded Aboriginal sites for the Liverpool Release Areas. Sites comprised 19 artefact scatters (generally containing between two and seven artefacts) and two scarred trees. In addition, five isolated artefacts were recorded, which were considered to be the remnants of destroyed sites. The occurrence of scarred trees is significant, as very few such trees have been recorded on the Cumberland Plain. The trees are located along Cabramatta Creek, one upstream of Hoxton Park Road and the other just downstream of Camden Valley Way.

Smith ranked sites in terms of disturbance, from excellent (no disturbance) to very poor (all but destroyed). Of the artefact scatters, eight were found to be in very poor condition, five in poor condition, four in fair condition and two in good condition. Both of the scarred trees were in excellent condition.

Most archaeological sites were found on creek banks and flats, with 89% found within 100 m of water. Artefact scatters were generally associated with permanent water. Accordingly, areas of high archaeological potential are permanent creek lines and swamps, as most sites would be expected to be found within 50 to 100 m of these water sources. Relatively undisturbed areas along Maxwells Creek also have high archaeological potential, as they are likely to contain relatively more sites and sites of high archaeological significance due to lack of disturbance. Although not surveyed due to access restrictions, the headwaters of permanent tributary creeks were also considered to be of high archaeological potential.

A survey undertaken for Maxwells Creek, between Kurrajong Road and Camden Valley Way, recorded six artefact scatter sites [McDonald, 1998]. Two artefacts and four open areas of potential archaeological deposits were also recorded. Only two of the artefact scatter sites were considered to be of some scientific significance with all the open sites assessed as having moderate to good potential for intact archaeological deposits.

7.5 VALUE OF CREEK CORRIDORS

Values of the Cabramatta Creek Corridor and other creek corridors within the catchment include:

- the conservation of remnant vegetation, including threatened or rare species;
- provision of habitat for the flying fox colony in the Fairfield LGA and habitat for numerous bird species;
- for sections of the creek which are in a relatively natural state, benefits to water quality through natural treatment processes;
- in urban areas, visual relief from surrounding development;
- provision of a variety of structured recreational opportunities (sports fields etc) and the potential for improved casual recreational opportunities (eg. nature trails);
- opportunities for environmental education and scientific research (eg. bush regeneration by volunteer groups, streamwatch activities by local schools and bird watching).

8. PLANNING AND FLOOD POLICY ISSUES

8.1 LOCAL ENVIRONMENTAL PLANS AND ZONING CONTROLS

A Local Environmental Plan (LEP) is a Plan prepared in accordance with the EP&A Act, which defines zones, permissible uses within those zones and specific development standards and other special matters for consideration with regard to the use or development of land. The relevant LEPs for consideration in the context of this Study are the Liverpool LEP 1997 and the Fairfield LEP 1994.

The Liverpool LEP maps which cover the study area have a broad range of zonings including Rural, Residential, Industrial, Future Urban, Special Uses and Open Space. There are no specific flood related zones.

It is noted that the previous Liverpool zoning instruments contained a Residential 2(f) Zone (Flood Liable Land Zone) which is not incorporated in the Liverpool LEP 1997. This Residential 2(f) zone basically affected pockets of land along the creek and drainage corridors which were affected by the designated flood and could not be developed for residential purposes without ameliorative works such as land filling.

The Cabramatta Creek and the majority of major drainage channels within the Liverpool urban areas, are contained in a Special Uses 5(a) Drainage zone. These drainage corridors are also often flanked by open space areas zoned 6(a) Recreation - Public. There are also a number of other zones and uses within the creek and drainage corridors such as Special Uses 5(a) TAFE College and Schools within that section of Cabramatta Creek between Hoxton Park Road and Elizabeth Drive. The majority of the creek and drainage corridors within the Future Urban zoned areas are not separately zoned and it is anticipated that this would be formalised within any future zonings which initiate the urban release.

The Fairfield LEP map which covers the Fairfield LGA part of the study area has a broad range of zonings including recreation, residential, industrial and special uses. The majority of flood affected areas are zoned either 6(a) Existing and Proposed Recreation of 6(b) Private Recreation.

Whilst the written provisions of both the Liverpool and Fairfield LEPs differ in relation to flooding, they both have the objective to minimise risk to persons and property within flood affected lands. A detailed analysis of these provisions is provided in the "Review of Planning Controls" working paper [Bewsher Consulting and Don Fox Planning, 1998b], and certain recommendations are given in **Section 8.3.4**.

8.2 OTHER FLOOD RELATED PLANNING CONTROLS

There is various legislation and other related non-statutory documents which have direct or indirect implications in regard to planning in the floodplain. This body of legislation and controls vary from state based statutes and planning documents which have indirect implications to floodplain planning in the Cabramatta Creek Catchment to site specific planning controls prepared by the Councils to provide detailed control of

development having regard to the flood hazard in the Study Area. These planning controls include:

- Environmental Planning & Assessment Act, 1979 and Regulations

  Development applications for proposals which are permissible with consent must have regard to the relevant "matters for consideration" contained in Section 79C of the Environmental Planning and Assessment Act, 1979. Of particular relevance are the Liverpool and Fairfield Local Environmental Plans, and any relevant Development Control Plan (DCP). While no DCP is presently in force which deals with the issue of flooding, such an instrument would provide a desirable mechanism for both Councils to comprehensively assess development applications with respect to the issue of flooding.

- State Environmental Planning Instruments

  A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EP&A Act by the Department of Infrastructure, Planning and Natural Resources (formerly Planning NSW) and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. The existing SEPPs which have some implications in regard to development within the Study Area include SEPP No.5 (Housing for the Aged or Disabled Persons), SEPP No. 19 (Bushland in Urban Areas), and SEPP No.21 (Caravan Parks).

- Local Government Act 1993

  The Local Government Act will have implications primarily in regard to the use of public lands for flood mitigation works. Part 2 of the Local Government Act 1993 requires that all land vested in a Council (except a road or land to which the Crown Lands Act 1989 applies) must be classified as either "community" or "operational". The purpose of the classification to clearly identify that land which should be kept for the use by the general public (community) and that land which need not (operational). The majority of the open space and drainage zoned lands in the ownership of Council will likely be classified as "community". The implication is that the development of these lands for flood mitigation works will need to be in accordance with a Plan of Management, or reclassified to operational.

- Advisory Circulars

  The Department of Infrastructure, Planning and Natural Resources is responsible for providing advice to local Councils to ensure that best practice is maintained in the planning process. Circular No. C9 was issued to assist Councils to relate the flood policy of the State Government and the *Floodplain Development Manual* (now superseded by the *Floodplain Management Manual*) to the requirements of the EPA Act and the Department's general approach to floodplain planning. The Circular states that in accordance with the *Manual*, Councils should prepare single comprehensive LEPs to implement their floodplain management plans and so avoid ad hoc, piecemeal approach to planning within the floodplains.

- Section 117 Directions

  Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local Councils must take into consideration in the preparation of LEP's. Section 117(2) Direction No. G25 (in regard to 'flood liable land') applies. The

direction is aimed specifically at enforcing the principles contained within the *Floodplain Management Manual*.

- Other Statutory Considerations

  In addition to the above, there may be other statutory matters which have an implication in regard to planning in the floodplain. These matters would include requirements in regard to the rezoning of the land (preparation of LEPs, sometimes REPs and SEPPs), Section 94 Contributions Plans and general policies of Council.

8.3 REVIEW OF LOCAL FLOODPLAIN MANAGEMENT POLICIES

One important component of any floodplain management plan is land use planning and development controls.

A review of the local floodplain management policies for both Liverpool and Fairfield Councils was undertaken during 1998-99. At this time, both Councils had in existence a combination of interim flood policies and floodplain management plans for various catchments within their area of responsibility. The discussion in Section 8.3 and 8.4 below relates to the policies in existence at that time, and recommends the adoption of a single flood risk management DCP with provision for specific controls in different catchments as separate schedules (or planning matrices) attached to the DCP.

Since this review was undertaken, further consideration of planning issues and liaison with Council officers has been undertaken as part of the Georges River Floodplain Management Study, which has been prepared for Liverpool, Fairfield, Bankstown and Sutherland Councils. A draft flood risk management DCP has been prepared for each of the four Councils as part of that study. The draft DCP prepared for Liverpool and Fairfield Councils is consistent with the recommendations that were provided from the initial Cabramatta Creek Floodplain Management Study, which are provided below.

8.3.1 Liverpool City Council

There is at present substantial inconsistency between three primary documents relating to floodplain planning in the Liverpool LGA, being:

- *Council's Interim Flood Policy* - prepared in accordance with the requirements of the State Government's Flood Policy expected to be superseded by more detailed floodplain management studies and plans in the future. This interim policy places controls on development primarily based on the 100 year ARI flood.

- *The recommendations of the Floodplain Management Committee and Council's resolution of September 25, 1995* - which adopts the PMF as the designated flood, and the 100 year ARI flood extent as the floodway for development control, for the Austral Floodplain.

- *Council's recently adopted LEP 1997* - which defines "flood liable land" for the whole of the Liverpool LGA as that area potentially affected by the 100 year ARI flood (irrespective of the requirements of the *Floodplain Management Manual* for this to be based on consideration of all floods up to the PMF).

In addition to the individual requirements of each of the above documents, when assessing applications for development, there are other statutes which refer to these documents which compound the problems arising from inconsistencies. This has implications in regard to Council's liability indemnity provided by Section 733 of the Local Government Act.

In order to resolve this situation, and to provide for long term floodplain planning direction for Council, it is recommended that an updated Floodplain Management Policy be adopted for the Liverpool LGA (in addition to associated changes to LEP 1997. This policy will need to embrace the recommendations from the current floodplain management plan for Cabramatta Creek, and should also take the opportunity to address associated floodplain management issues relevant to the whole of the Liverpool LGA.

8.3.2 Fairfield City Council

Similar to Liverpool City Council, Fairfield City Council has undertaken a number of floodplain management studies and plans. Whilst a number of these studies and plans refer to land use planning and development controls as a mechanism for flood mitigation, no specific recommendations have emanated from these documents.

Fairfield City Council currently has an Interim Floodplain Management Policy, and the adoption of a revised and updated policy for the whole of the LGA is desirable, as opposed to the piecemeal adoption of a policy relating only to Cabramatta Creek. Accordingly, it is also recommended that an updated floodplain management policy be prepared for Fairfield. This should also provide for consistent policies within both Council areas of the Cabramatta Creek catchment.

8.3.3 Recommended Floodplain Management Policies

The Environmental Planning and Assessment (EP&A) Act provides the appropriate platform for the implementation of land use planning and development controls in NSW. The most appropriate mechanism available within the EP&A Act to implement the bulk of land use and development controls that may emanate from an interim flood policy or floodplain management plan is through a Development Control Plan (DCP). Additionally, there may be a number of associated changes to both Council's Local Environmental Plans, other flood related Council policies and other DCPs, to ensure consistency between all documents.

The Floodplain Management Policies recommended for Liverpool and Fairfield City Councils have been based on the Draft Liverpool Floodprone Land Policy (prepared by Bewsher Consulting and Don Fox Planning, for Liverpool City Council in April 1998) which has been widely distributed and advocated to various Councils within the Sydney area as an appropriate basis for the formulation of a regionally consistent Policy document for the management of floodplains.

The main attributes of the recommended floodplain management policies for both Councils are as follows:

- it provides a plain English presentation so as to be effectively more accessible to the general population;
- it is structured to provide both general policies (eg. criteria for rezoning proposal) and to be adopted as a development control plan which provides detailed guidelines in regard to proposed development;
- disbands the use of a singular flood planning level (FPL) to control development. This is considered to result in a more substantial and effective means of satisfying the requirements of the *Floodplain Management Manual*;
- the document is structured to deal with both general and individual floodplain issues. The front section of the document provides general policies and objectives, and other necessary provisions required to bring the document into force as a DCP. The detailed controls are referenced through "planning matrices" attached as schedules to the document, which effectively summarise the planning controls emanating from individual floodplain management studies and plans for specific floodplains where they have been prepared, or to act as interim policies where they are yet to be prepared; and
- the structure of the document allows updating as floodplain management studies and plans are prepared, principally by amending or providing additional planning matrices for floodplains or subcatchments of floodplains.

The proposed floodplain management policy for Liverpool Council and Fairfield Council is included in the "Review of Local Flood Policies" working paper [Bewsher Consulting and Don Fox Planning, 1998f].

8.3.4 Other Associated Changes

In addition to the adoption of the above principal policy/DCP documents, there are a number of associated changes which are required to be implemented to ensure consistency and to remove any statutory constraints in the implementation of the recommended policies. These changes relate primarily to the amendment of the Councils' current DCPs, as relevant, and modification to the Liverpool and Fairfield LEPs.

Amendments to the Councils' existing DCPs primarily relate to ensuring that any reference to terms such as "flood liable land" or specific controls on development associated with the flood hazard be amended to be consistent with the proposed Floodplain Management Policy/DCP or preferably deleted and substituted with a cross-reference to the principle Floodplain Management Policy/DCP. Recommendations for standard inclusions for LEPs to deal with flood related issues and to ensure consistency with the proposed floodplain management policy, are provided in the "Review of Local Flood Policies" working paper [Bewsher Consulting and Don Fox Planning, 1998f].

8.4 THE PLANNING MATRIX APPROACH

The Planning Matrix approach is central to the proposed floodplain management policies. The Planning Matrix considers the flood hazard across the whole floodplain (i.e. up to the PMF) and manages the floodplain by the application of a graded set of planning controls which vary with the flood hazard and land use.

This approach was primarily developed as the flood hazard within floodplains is often poorly understood and appreciated by the community. Often the community considers there to be a flood hazard only on land below the FPL, which is the level below which councils place restrictions on development. This FPL is commonly the 100 year ARI flood, which is the FPL adopted for most of the Liverpool and Fairfield LGAs.

For that part of the floodplain which is situated above the FPL, where there is no flood related planning controls, the community often misinterprets this as a statement that there is no flood hazard. In reality, the flood hazard may be significant in dimension, albeit rarer in occurrence.

Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which has usually been the 100 year ARI flood level. While such an approach has often been adequate, the approach has not worked well everywhere and has led to a number of problems including:

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

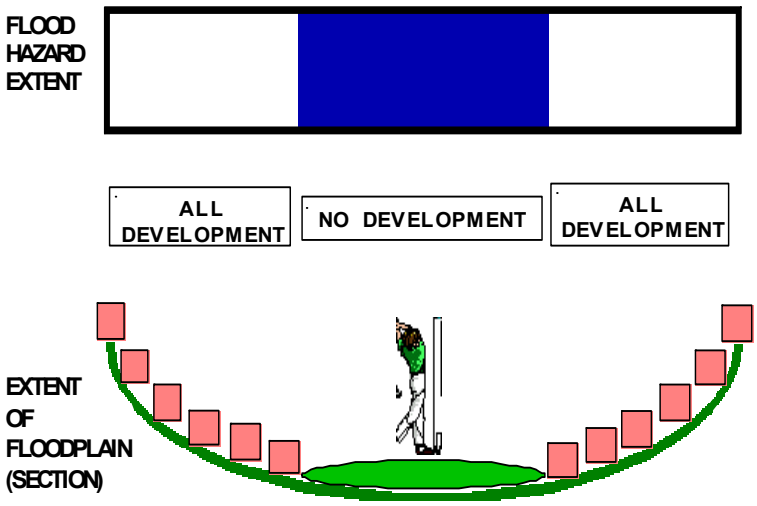
Accordingly, continuation of the sole reliance on the 100 year ARI FPL is considered inappropriate — specifically in regard to the Liverpool and Fairfield LGAs.

The current approach to floodplain planning discussed above may be typified by the example shown at the top of **Figure 8.1**. No development is permitted below the FPL (ie. 100 year ARI flood) because of an acknowledgement of the flood hazard. Above the FPL, no flood hazard is perceived and therefore there are no flood related controls on development. Thus an abrupt change in development control occurs at the FPL. In contrast, the Planning Matrix approach distributes land uses within the floodplain and controls development to minimise the consequences of flooding, as depicted at the bottom of **Figure 8.1**.

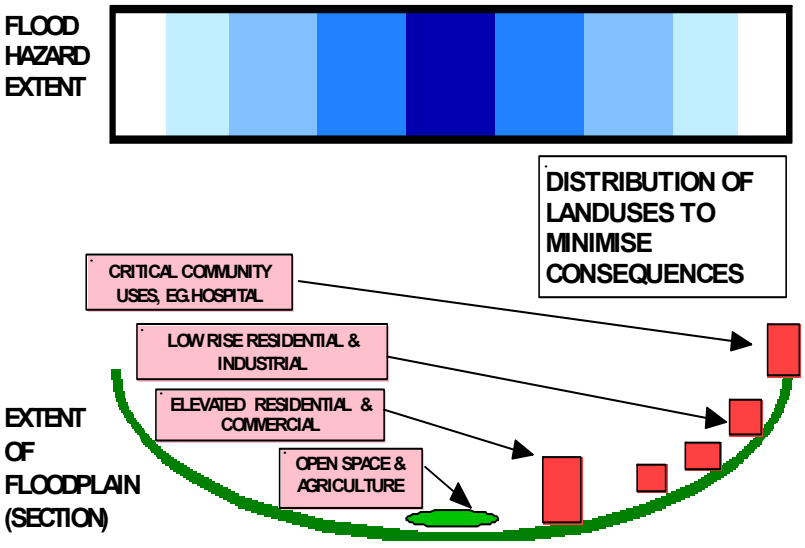
Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain. This approach has been adopted as part of the recent Hawkesbury-Nepean Flood Management Strategy and has also been previously applied within the Blacktown, Narrabri, Boundary Creek (Strathfield LGA), North Wentworthville (Parramatta LGA) and Molong Floodplain Management Plans.

The approach, summarised in **Figure 8.2**, is consistent with the principles of the *Floodplain Management Manual*.

The outcome of this approach is centred on a matrix of controls embodied within the recommended local flood policies for Liverpool and Fairfield Councils.

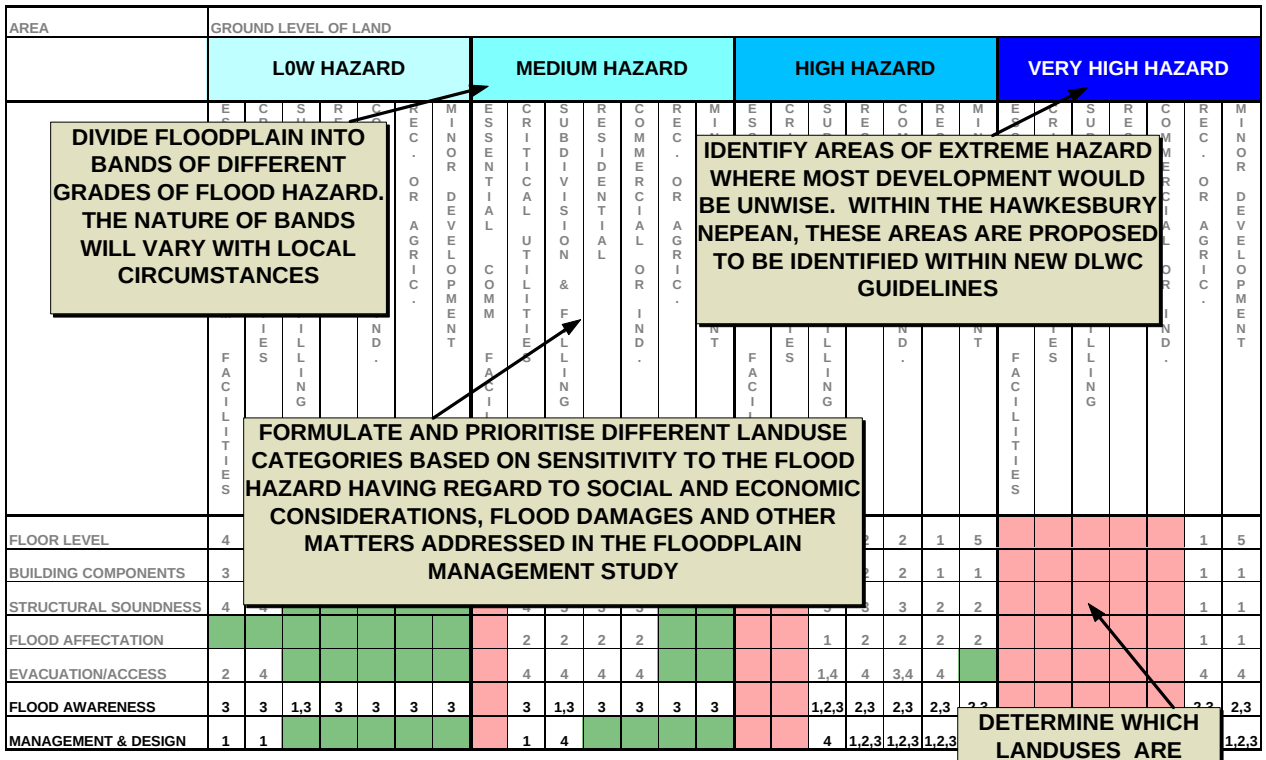


Current Floodplain Planning Approach
Derived from an inappropriate view of flood hazard and the use of a singular flood planning level



Distributing Land Uses under the Planning Matrix Approach
Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain

FIGURE 8.1
Land Use Distribution under Current and Proposed Planning Approaches



FLOOR LEVEL	4								2	2	2	2			2	2	1	5						1	5					
BUILDING COMPONENTS	3								2	2	2	2			2	2	1	1						1	1					
STRUCTURAL SOUNDNESS	4								4	5	5	5			5	5	3	2						1	1					
FLOOD AFFECTATION									2	2	2	2			1	2	2	2	2					1	1					
EVACUATION/ACCESS	2	4							4	4	4	4			1,4	4	3,4	4						4	4					
FLOOD AWARENESS	3	3	1,3	3	3	3	3		3	1,3	3	3	3	3	1,2,3	2,3	2,3	2,3	2,3					2,3	2,3					
MANAGEMENT & DESIGN	1	1							1	4					4	1,2,3	1,2,3	1,2,3						1,2,3						

NOTES

NOT RELEVANT

UNSUITABLE LAND USE

HHF — REFERS TO THE HIGHEST HISTORICAL FLOOD AS DEFINED IN THE GLOSSARY

PMF — REFERS TO THE PROBABLE MAXIMUM FLOOD AS DEFINED IN THE GLOSSARY

FLOOR LEVEL

1 ALL FLOOR LEVELS TO BE EQUAL TO OR GREATER THAN THE 1 IN 5 YEAR FLOOD PLUS 0.5M (FREEBOARD)

2 HABITABLE FLOOR LEVELS TO BE EQUAL TO OR GREATER THAN THE 1IN 100YR FLOOD PLUS 0.8M (FREEBOARD)

AND OTHER FLOOR LEVELS TO BE EQ

3 ALL FLOOR LEVELS TO BE EQUAL TO O

4 ALL FLOOR LEVELS TO BE EQUAL TO O

5 FLOOR LEVELS TO BE AS CLOSE TO THE … LOOR LEVEL WHEN AN ADDITION TO AN EXISTING BUILDING

FLOOD COMPATIBLE BUILDIN

1 ALL STRUCTURES TO HAVE FLOOD COM … D LEVEL

2 ALL STRUCTURES TO HAVE FLOOD CO

3 ALL STRUCTURES TO BE CONSTRUCTED OF FLOOD COMPATIBLE MATERIALS BELOW OR AT THE PMF LEVEL

STRUCTURAL SOUNDNESS

1 ENGINEERS REPORT TO PROVE ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE 1 IN 100 YR LEVEL CAN WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

2 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE 1 IN 100 YEAR SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

3 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCL. THE HHF SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

4 ANY STRUCTURE SUBJECT TO A FLOOD UP TO & INCLUDING THE PMF LEVEL SHOULD WITHSTAND THE FORCE OF FLOODWATER, DEBRIS & BUOYANCY

5 GEOTECHNICAL ENGINEERS REPORT REQUIRED TO SPECIFY APPROPRIATE FILLING/EARTHWORKS & THE MEANS OF RETENTION OF BATTERS AGAINST SCOURING/EROSION

FLOOD EFFECT ON OTHERS

1 ENGINEERS REPORT REQUIRED TO PROVE THAT THE DEVELOPMENT OF AN EXISTING ALLOTMENT WILL NOT INCREASE FLOOD AFFECTATION ELSEWHERE

2 THE IMPACT OF THE DEVELOPMENT ON FLOOD AFFECTATION ELSEWHERE TO BE CONSIDERED

EVACUATION/ACCESS

1 RELIABLE ACCESS FOR PEDESTRIANS REQUIRED DURIN

2 RELIABLE ACCESS FOR PEDESTRIANS & VEHICLES REQ

3 ELECTRONIC FLOOD WARNING DEVICES TO INSTALLED C

4 CONSIDERATION REQUIRED REGARDING AN APPROPRIAT

FLOOD AWARENESS

1 RESTRICTIONS TO BE PLACED ON TITLE ADVISING OF MINIMUM FLOOR LEVELS REQUIRED RELATIVE TO THE FLOOD LEVEL

2 S149(2) CERTIFICATES TO NOTIFY AFFECTATION BY THE 1 IN 100 YEAR FLOOD

3 S149(2) CERTIFICATES TO NOTIFY AFFECTATION BY THE PMF FLOOD

MANAGEMENT & DESIGN

1 FLOOD PLAN REQUIRED WHERE FLOOR LEVELS ARE BELOW THE DESIGN FLOOR LEVEL

2 APPLICANT TO DEMONSTRATE THAT THERE IS AN AREA WHERE GOODS MAY BE STORED ABOVE THE 1 IN 100 YEAR FLOOD LEVEL PLUS 0,5M(FREEBOARD) DURING FLOODS.

3 NO EXTERNAL STORAGE OF MATERIALS BELOW THE 1 IN 100 YEAR LEVEL PLUS 0.5M(FREEBOARD) WHICH MAY BE POTENTIALLY HAZARDOUS DURING FLOODS

4 APPLICANT TO DEMONSTRATE THAT POTENTIAL DEVELOPMENT AS A CONSEQUENCE OF A SUBDIVISION PROPOSAL CAN BE UNDERTAKEN IN ACCORDANCE WITH THIS POLICY

FIGURE 8.2

Example Planning Matrix and Explanation

8.5 POLICY FOR THE RELEASE OF FLOOD DATA

8.5.1 Legal Issues

The State Government Flood Policy and the *Floodplain Management Manual* establish a basis for ensuring exemption from liability as provided for by Section 733 of the Local Government Act, 1993. Section 733 of the Act provides that Councils do not incur any liability in respect of advice furnished or anything done or omitted to be done in good faith by Council which relates to the nature and extent of flooding provided that Council acts in good faith. Unless the contrary is proved, Council is taken to have acted in good faith if it has acted substantially in accordance with the *Manual*.

Section 3.2 of the *Manual* outlines the specific areas of responsibility of Councils in regard to floodplain management and flood awareness.

The release of accurate, comprehensive and consistent flood data, between different Council officers, to other government authorities, to the general public and to consultants and developers, is essential in exercising Council's duties as specified by the *Manual* in a manner which limits liability.

In a recent court case involving *Mid Density Development Pty Ltd -v- Rockdale MC (1993) 81 LGERA 104*, the concept of acting in good faith when releasing flood data was examined in detail. The responsible officer, in completing Section 149 Certificates had relied on his own knowledge and had not searched Council's records which would have revealed that the property was subject to the risk of flooding. The Court concluded that the lack of personal dishonesty was not determinative of action "in good faith" as provided for by Section 733 of the LG Act. The Court also held that in the circumstances, the disclaimer on the Certificate was not sufficient to absolve the Council of liability for its negligence. As a result Council was found liable for damages exceeding $1 million.

Recent legal advice provided in association with the preparation of other floodplain management plans revealed two important considerations:

- before Council can rely on a good faith defence, it must conscientiously apply itself in the exercise of its duties; and
- Council should disclose the possibility that a land may be subject to a flood in a PMF event upon a Section 149(2) Certificate, and presumably when providing flood data by any other means.

8.5.2 Policy Development

The comprehensive and orderly dissemination of accurate flood data, is important both because of its implications for Council's legal liability, and as an important flood awareness tool to mitigate the impacts of flooding. Accordingly, there are clear benefits in seeking to streamline and safeguard the release of flood data to the public.

Bewsher Consulting and Don Fox Planning were commissioned by Liverpool City Council during 1998 to review existing procedures and recommend a framework and

policy for the use and release of flood information. This was undertaken and a report was prepared providing relevant recommendations, entitled “Policy for Release of Flood Data” [Bewsher Consulting and Don Fox Planning, 1998j]. Whilst the policy was developed specifically for Liverpool, it has a generic framework and could be applied within Fairfield with only minor modifications.

The abovementioned document identified relevant issues and recommended strategies for dealing with these issues, as well as providing a general policy for the collection and dissemination of flood related information.

The main objectives of the Policy are as follows:

1. To ensure that those handling or receiving flood information understand the distinction between risks associated with flooding and controls imposed by Council to mitigate against the consequences of select flood events.
2. To maximise the potential to increase flood awareness amongst the general community and Council personnel involved in the land management and development processes.
3. To ensure that flood related information released is consistent.
4. To ensure that flood related information is released in an orderly and efficient manner.
5. To advise the public of restrictions that may be imposed by Council on development due to flood affection.
6. To provide a flood related information service to all relevant sections of Council
7. To provide a mechanism to increase public awareness of flood risks, to minimise consequences of flooding, by increasing the preparedness of the community and to increase the capacity of the community to recover subsequent to being flooded.
8. To ensure that Council meets its statutory obligations in regard to the dissemination of flood-related information.

8.5.3 Components of the Policy for Liverpool

The major components of the Policy for Release of Flood Data are summarised within **Figure 8.3**. The Policy provides for two levels of flood related information to be made available, being:

- Standardised flood data — which refers to documented information prepared by Flood Investigation Engineers and may include a flood information brochure, flood reports, flood certificates, attachments to S. 149 Certificates, flood policies and floodplain management plans, flood studies, and standard conditions of consent.

- Non Standardised flood data — this refers to information requests which are not able to be satisfied by reference to documented data (standardised flood data) and will require a specialised response by the flood investigation engineers.

The Policy also provides a basis for establishing Council's position in regard to the following:

- who should have ownership of data?
- what is the process for updating the information? and
- who is to have access to and be able to use the information?

The overall responsibility for the compilation, management and release of flood data will be vested with the Flood Investigation Engineers. Flood Investigation Engineers will be responsible for setting up various mechanisms to allow release of standardised information without their involvement, which would include:

- flood brochure;
- standard question and answers booklet for staff;
- flood certificates;
- flood reports;
- attachments for Section 149 Certificates;
- input into the LIS and Corporate data base;
- specifications for site/development specific flood studies and management, control and acceptance of the study;
- catchment wide flood studies, floodplain management studies and floodplain management plans prepared in accordance with the FPDM; and
- standard conditions of consent.

The availability of standardised information will increase efficiencies and consistency of data released and should be continually monitored and reviewed in the objective of minimising the involvement required of flood investigation engineers in satisfying individual flood related information requests. However, where limited information outputs are not sufficient to handle the specific nature of a flood related question, then this question must be referred onto the Flood Investigation Engineers.

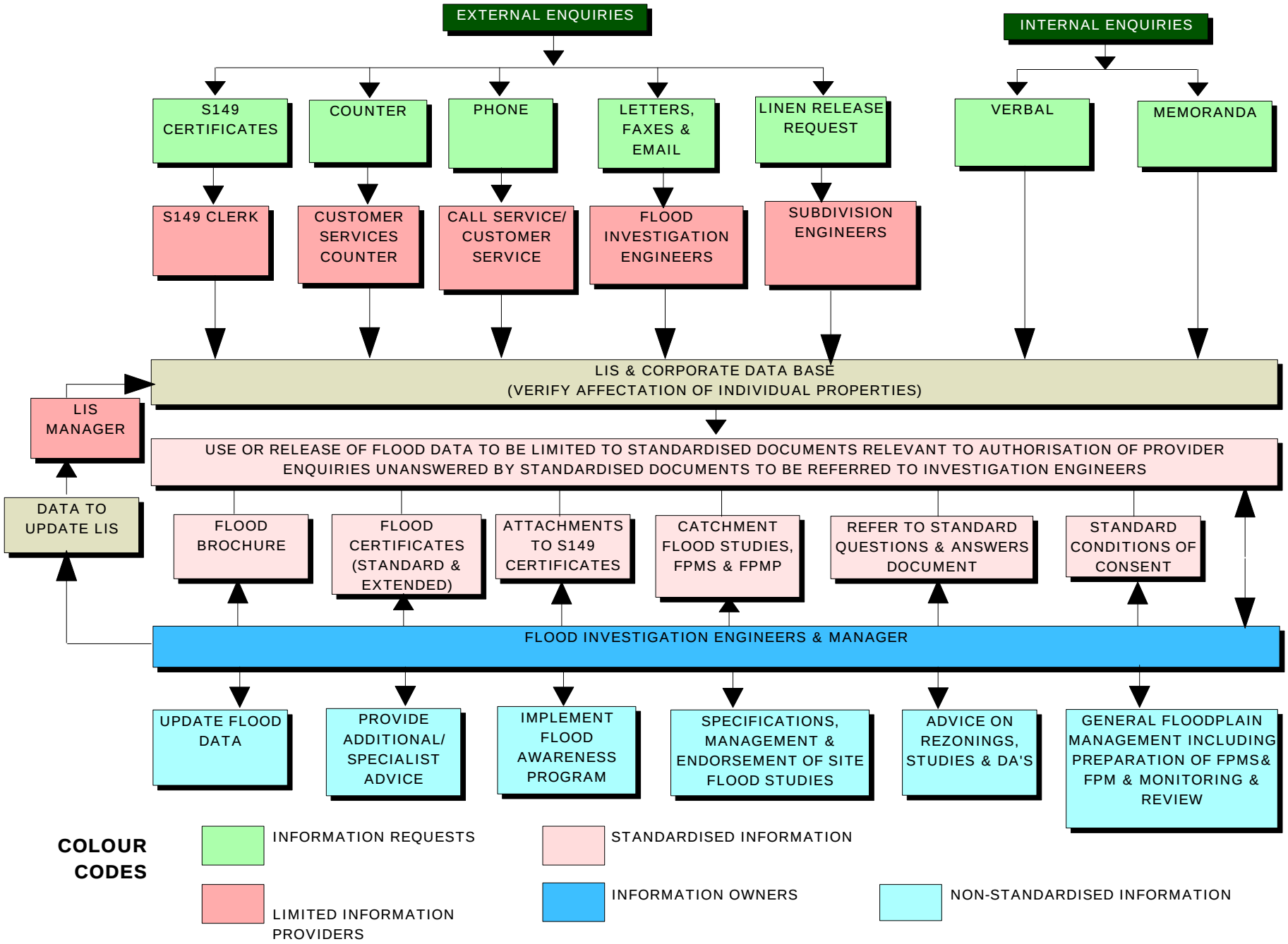


FIGURE 8.3
Processing Requests for Flood Data

9. OVERVIEW OF FLOODPLAIN MANAGEMENT

9.1 SELECTION OF THE FLOOD PLANNING LEVEL

The flood planning level (FPL), previously known as the 'designated flood' level or 'flood standard', is the flood level selected for planning purposes, and will directly determine the area of land that should be subject to flood-related building and development controls.

Selection of the FPL is one of the most critical decisions in floodplain management, and is not an easy one. It should be based on an understanding of the flood behaviour, together with the balancing of social, economic and environmental consequences of flooding, including the potential for property damage and the risk to human life. Traditionally, only one FPL has been selected for a particular area, but current thinking is to consider more than one FPL for different types of developments or locations within the floodplain.

The adoption of a singular FPL may be unduly restrictive for some types of land uses. For example, whilst it may be appropriate for some land uses, such as a hospital, to be located above a PMF flood, it could be argued that residential, industrial or recreational land uses do not require such restrictive controls.

Also, the adoption of a singular FPL causes misconceptions by the community regarding flood risk. Most importantly, residents within the floodplain (i.e. the area below the PMF) but above the FPL, often mistakenly believe they are not at risk from flooding.

To overcome the shortcomings of a singular FPL, a 'graded' set of controls which consider the variation of damage risk with flood frequency and land use, have been proposed for Cabramatta Creek. These are contained in the 'Planning Matrix' approach discussed in Section 8.4. This is also consistent with the approach adopted in other floodplain management studies that are being prepared for both Councils.

The planning matrix approach does not rely on the definition of a singular FPL. In essence, the approach makes use of a range of FPL's for various land uses within the flood prone land below the PMF, without specifically referring to this term.

Within the planning matrix, the selection of the controls and the various flood conditions at which the controls apply, has been based on:

- the procedures and philosophy espoused in the Government's *Floodplain Management Manual*;
- consideration of the social, economic and environmental impacts of flooding and the proposed controls;
- investigations carried out within the current study;
- community attitudes expressed during the current study;
- minimising Council's exposure to legal actions in relation to flooding;
- Council's existing interim flood policy and flood planning level;

- views expressed by the Floodplain Management Committee and various senior officers within Council and the Department of Infrastructure Planning and Natural Resources; and
- experience gained from the development of planning controls and flood policies for various communities across NSW in recent years.

9.2 RANGE OF FLOODPLAIN MANAGEMENT MEASURES

Floodplain management measures can be divided into three categories:

9.2.1 Options that Modify the Way a Flood Behaves

These include:

- improving the conveyance of the creek to carry floodwaters, through clearing of rubbish, debris, or other obstructions, and the development of programs to ensure the creek corridor remains free from these items;
- enlarging the channel to increase its capacity by widening or deepening;
- construction of bypass channels or floodways;
- straightening the channels or lining with rock, gabions or concrete;
- carrying out works in the Georges River to help prevent floodwaters backing up into Cabramatta Creek;
- constructing upstream dams or detention storages;
- enlarging bridges and culverts to improve the flow of water under roads; and
- the construction of levees to keep floodwaters away from property.

9.2.2 Options which Minimise Damage by Modifying the Property

These include:

- voluntary purchase of the most flood-liable houses and conversion of land to open space;
- raising of houses above the 100 year ARI flood;
- redevelopment of flood prone houses to a form more compatible with the flood hazard;
- flood-proofing of individual residential and business properties with small floodwalls and deflector banks;
- relocating flood liable houses to areas of higher ground; and
- providing consistent, equitable controls on development in flood-liable areas

9.2.3 Options Which Reduce Damages by Improving the Response of People and Organisations to Floods

These include:

- improving flood warning before and during floods;
- improving evacuation procedures and emergency assistance during floods;
- making sure all information about the potential risks of flooding is available to all residents and business owners;
- providing Section 149 certificates stating whether or not properties are flood affected;
- making sure residents and business owners have flood action plans;
- installing some flood markers to act as constant reminders of the height of previous floods; and
- promoting public education, community participation and flood awareness programs.

9.3 COMMUNITY CONCERNS AND SUGGESTIONS

Results from the community consultation process for this study have been presented in a separate document [Bewsher Consulting, 1998h]. Key findings have also been presented in Section 6 of this report, including a list of favoured floodplain management measures that the community felt 'could prevent damage', in their order of popularity across the Cabramatta Creek catchment.

It is interesting to note that there was high community support for improved flood warning and programs to increase community awareness of flood issues, including the provision of some form of certificate to every resident defining the flood status of their property.

Other options that were favoured by the community involved works to improve or restore the condition of the creek corridors, including the eradication of rubbish and exotic vegetation, and the implementation of a bush management program.

Options involving the raising of houses, voluntary purchase of flood prone houses, and the construction of levees received less support.

9.4 CRITERIA FOR EVALUATION OF OPTIONS

In evaluating potential floodplain management options within the study area, a range of assessment criteria has been used. These include:

9.4.1. Financial Feasibility

Options proposed within the floodplain management plan must be capable of being funded. There are various sources of funding that may be utilised, including funding related to the development of new release areas (Section 94 contributions), funding assistance from the RTA for construction of works necessary to compensate for loss of

floodplain storage from the proposed WSO Highway, and funding from both Liverpool and Fairfield Councils, with assistance from the Department of Infrastructure, Planning and Natural Resources, for the alleviation of existing flood problems.

9.4.2 Economic Merit

The ratio of the benefit divided by the cost (i.e. the benefit–cost ratio) is a common measure of assessing economic feasibility. Theoretically, no investment should be made on an option if the benefit/cost ratio does not exceed unity (i.e. if the benefits do not exceed the costs). However, traditionally many floodplain management options have been undertaken where this is not the case because the intangible benefits, (i.e. those not able to be quantified), are considerable.

9.4.3 Community Acceptance

Assessment of possible community attitudes towards any proposed floodplain management option is essential. If community attitudes are strongly negative, this is often enough to deter the implementation of the proposals which otherwise may have significant merit.

9.4.4 Environmental Impact

Floodplain management options involving structural works may often have significant environmental impacts. Impacts on vegetation, visual amenity and soil erosion/sedimentation, are issues which must commonly be addressed when evaluating works within watercourses.

9.4.5 Impact on Flood Behaviour

The impact on flood behaviour caused by the option needs to be considered for upstream and downstream locations. These impacts can include such things as changes in flood levels, changes in velocities or alteration of flow directions.

9.4.6 Performance during Large Floods

All options must be assessed in the knowledge that large floods, i.e. larger than the 100 year ARI flood, or larger than any known historical flood, will happen at some time in the future. It is therefore imperative that the options do not expose the community to unacceptable risks by providing a false sense of security.

9.4.7 Technical Feasibility

If the proposed options involve structural works, these works must be able to be constructed and be free from major technical constraints.

9.4.8. Political/Administrative Impact

Any recommended option will have more chance of success if it involves little if any disruption to current political and administrative structures, attitudes and responsibilities.

10. ASSESSMENT OF FLOODPLAIN MANAGEMENT MEASURES

Possible floodplain management options for Cabramatta Creek are discussed below in terms of the evaluation criteria presented in **Section 9.4**. Each option has been included in a qualitative assessment matrix (**Table 10.3**) in order to assess its relative merits, and whether or not the option should be included in the floodplain management plan for Cabramatta Creek.

The options are discussed in three general groups; those that modify flood behaviour, those that modify the property in order to minimise flood damage, and those that modify people's response to flooding.

10.1 MEASURES THAT MODIFY FLOOD BEHAVIOUR

10.1.1 Clearing the Creek of Rubbish, Debris, Exotic Vegetation and Man-Made Obstructions

Recommended for further consideration.

One of the key findings from the community questionnaire was that many people regarded litter and debris in the Creek to be a significant problem. There are also some examples where gross pollutants, such as abandoned car bodies, have been dumped in the middle of the Creek. One case was recently observed in Hinchinbrook Creek, where a dumped car body occupied much of the available space within the creek banks, leaving very little room for the conveyance of floodwaters. There are also a number of fallen trees and other snags throughout the creek system. Although these reduce the waterway area of floodwaters to some degree, they also provide aquatic habitat.

Not only do these obstructions reduce the available capacity of the creek to convey floodwaters, but many of these objects will be carried downstream during floods, resulting in increased damage to buildings and other structures that may be in their path. The obstructions are also likely to result in localised increases in velocities around these objects, leading to scouring of river banks, slumping, and subsequent siltation of the downstream creek system. This will then lead to further reductions in the conveyance capacity of the creek system, with resulting increases in flood levels.

An initial program of works to selectively clear the creeks of major obstructions is warranted. However, this should not be undertaken as a once-off activity. It is important that it is part of a co-ordinated plan to manage the creek corridors and existing vegetation.

Selective clearing and de-snagging works are recommended throughout Cabramatta Creek and Hinchinbrook Creek.

School, community and landcare groups should be encouraged to participate in a well co-ordinated program of works. Total cost for the initial activities are estimated at $300,000.

10.1.2 Developing an Urban Bushland Management Program for the Creek Corridor

Recommended for further consideration.

A vegetation survey [Mount King Ecological Surveys, 1990] has previously been undertaken for Cabramatta Creek, as well as a Bushland survey report for the Elouera Nature Reserve [Greening Australia, 1991]. Both these reports emphasised that the existing creek system represents a significant natural resource in the Cabramatta Creek catchment, and that it contained a unique stand of native bushland within the Western Sydney Region. The North-South Hinchinbrook-Cabramatta Creek system and the East-West Cabramatta Creek system are also important wildlife corridors that span the catchment. A number of management plans have also been prepared for Fairfield City Council.

The implementation of an urban bushland management program in accordance with the above management plans which have already been implemented, plus specific actions to cover additional areas, would preserve and improve the ecological and aesthetic quality of the creek corridors. It would also ensure that debris and exotic species are controlled and do not result in severe weed infestation that reduces the hydraulic conveyance of the creeks themselves.

The program will necessarily be long term and ongoing, involving monitoring and maintenance on a regular basis to gauge the success of various measures and impacts on the environmental qualities of the creek corridors. A planned and co-ordinated approach is needed to ensure that major weed infestations do not become seed sources which impact on rehabilitated areas.

An urban bushland management program would include;

- bush regeneration program;
- community education on noxious and problem species;
- consolidation of bushland through supplementary planting to link pockets of remnant communities;
- staged revegetation with native species;
- weed eradication program;
- support and encouragement of volunteer bush regenerators; and
- selected creek bank stabilisation works including reducing creek bank grades where possible.

The estimated cost to prepare an Urban Bushland Management Program is $60,000. Implementation of the program would be several hundreds of thousands of dollar, although some volunteer labour would be available to reduce costs. It is anticipated that initial works would be spread over about 5 years.

Over the last few years, Liverpool and Fairfield Councils have been developing an integrated management plan for Lower Cabramatta and Brickmakers Creek that includes weed removal, litter control and revegetation. The project recently received funding of $250,000 through DIPNR for these activities.

10.1.3 Restoring the Creek to a More Natural Condition

Recommended for consideration as part of the Urban Bush Management Program.

This was another option favoured by the community. Development and implementation of the above bushland management program will ensure that the environmental quality of the creek system is enhanced, allowing large portions of the existing creek system to be maintained in a more 'natural' condition, rather than being allowed to deteriorate.

In some areas of the catchment, such as sections of Brickmakers Creek and Maxwells Creek, the natural creek has been replaced by a grassed trapezoidal channel, resulting in a loss of most of the previous creek corridor vegetation. Whilst this presents an efficient channel for the conveyance of floodwaters, it is less satisfactory from an ecological or environmental view.

A difficulty in restoring artificial channels to a more natural form is that it is likely to be accompanied by an increase in flood levels. In fact the reason why the channels were constructed in this form in the first place was probably in an effort to lower flood levels, although this was not a very environmentally friendly solution. It may be possible to convert some of these channels back to a more natural form if other compensatory measures can also be provided. For example, there is some scope for the reach of Brickmakers Creek between Memorial Avenue and Hoxton Park Road to be converted to a more natural channel, provided an upstream detention basin is also provided in the Amalfi Park area to compensate for the likely increases in flood level. The costs of these works are high, and little or no flood benefit will be obtained. For these reasons, this option has not been recommended apart from works identified in the urban bushland management program.

In other areas, where channel amplification measures may be recommended, opportunities to incorporate a natural channel form should be incorporated in these designs wherever possible.

10.1.4 Enlarging the Creek by Widening or Deepening

Selected areas recommended for further consideration.

Extensive creek widening upstream of Jedda Road has previously been considered for Maxwells Creek, which would allow further industrial development in accordance with Council's Local Environmental Plan. This would also include reconstruction of the Jedda road crossing. A reserve width of 100m and an excavation volume of 55,000 m^3 would be necessary. Total cost is estimated at $1.4M. A revised form of this scheme that incorporates additional detention storage and limited land fill west of Ash Road has been proposed.

Further upstream on Maxwells Creek, between Kurrajong Road and Camden Valley Way, additional channel works have been proposed, in association with proposed detention basin storage, the proposed Western Sydney Orbital and other areas that have been zoned for development. A concept drainage plan for this reach of the Creek was recently prepared for the RTA, and is the subject of further detailed design. The proposed channel works is being designed around a number of constraints, including areas of significant vegetation and other areas of archaeological significance.

A significant restriction on Lower Cabramatta Creek occurs in the vicinity of the Elizabeth Drive Bridge, which restricts the full capacity of the bridge from being utilised. It is proposed that this waterway area be increased to improve the conveyance under the bridge. These works are proposed in conjunction with other works recommended in Blamfield Oval and the Tresalam Street levee.

A reach of Brickmakers Creek, between Orange Grove Road and Memorial Avenue, is significantly inadequate compared to the channel capacity both upstream and downstream. Throughout much of this reach the creek is little more than an undersized ditch that has been constructed within a relatively wide reserve. The capacity of the creek will be exceeded in very minor flood events, with significant flows escaping from the creek and travelling overland away from the creek towards the Liverpool CBD area and other residential areas. Further investigation of the flood problem of this area, and recommended measures to alleviate the flooding, was recently undertaken [Bewsher Consulting, 2003], with results provided in **Appendix C**.

10.1.5 Construction of Bypass Channels or Floodways

Selected areas recommended for further consideration.

A large high level floodway adjacent to Cabramatta Creek was built in the 1950-60s, which provides protection to property located between Elizabeth Drive and Hoxton Park Road at the Miller TAFE College. Further modifications to this floodway have been proposed in the past.

Preliminary investigations have been undertaken into the extension of the existing floodway upstream from Miller TAFE College to the confluence with Creek A, and up into Hinchinbrook Creek. Such works would prevent about 250ha of land being inundated in a 100 year ARI flood, and would prevent the occurrence of the Wilson Road breakout. Works would include 2 six lane crossings of Hoxton Park Road, about 700,000 m³ of excavation and the likely removal of riparian vegetation in the area. Total cost has been estimated at over $12M. It has not been recommended in this study due to the high cost and the environmental consequences of such works.

A floodway channel has recently been constructed in Orange Grove Golf Course, to improve overland flow to the high level culverts under Orange Grove Road. These works are estimated to marginally improve flood behaviour in this vicinity.

A smaller floodway was investigated beside Lower Cabramatta Creek, just upstream of the Main Southern Railway line. These works are estimated to cost less than $0.1M although the flood benefits are minimal. There are also likely to be environmental concerns with this proposal, and it has therefore not been considered further.

A more significant floodway was previously proposed between the Hume Highway and the Main Southern Railway [Kinhill, 1991]. This consisted of selected vegetation removal and limited earthworks to provide a clearer flowpath during times of flooding. However, the flood benefit of these works is low, and there would be considerable environmental concerns in undertaking these works. In particular, the area contains maternity colonies of the Grey-Headed Flying Fox. This is one of only two major colonies within Sydney. As such, this proposal has not been considered further.

10.1.6 Straightening the Creek or Lining with Rock, Gabions or Concrete

Not recommended for further consideration.

Concrete lining of Maxwells Creek, between Hoxton Park Road and Jedda Road, has been proposed in earlier studies to reduce the extent of flood liable land and allow further industrial development up to the creek banks. The total cost of the works has been estimated at $20M. This solution is considered to result in adverse environmental impacts, and would be aesthetically unpleasing. It would also result in a loss of natural floodplain storage, leading to an increase in downstream flood levels.

This type of solution was not regarded well by the community, with only 30% of questionnaire respondents favouring such measures. The option is not recommended for further consideration.

10.1.7 Works in the Georges River to Lower Flood Levels

Not recommended for further consideration

A preliminary investigation of major flood mitigation works on the Georges River was carried out by the DLWC and Liverpool City Council in March 1998. Potential flood mitigation works upstream of Liverpool were assessed with the objective of lowering design flood levels throughout the Lower Georges River.

The following flood mitigation options on the Georges River were investigated:

- a diversion channel, on the southern side of the East Hills railway line, to divert high flows from the Georges River to Harris Creek;
- a major flood mitigation dam across the Georges Valley; and
- the provision of flood mitigation storage areas adjacent to the banks of the river.

The above works on the Georges River could lower flood levels at Liverpool by up to 1.0m. A similar reduction would occur at the confluence of the Georges River with Cabramatta Creek. As flood levels in Lower Cabramatta Creek are heavily influenced by flood conditions in the Georges River, there is potential for significant reduction of flood levels in Cabramatta Creek, as far up as Orange Grove Road.

The magnitude of works necessary on the Georges River to achieve these flood level reductions is large, and the costs associated with these works extremely high ($100M plus). The works can not be justified by flood benefits along Cabramatta Creek alone, and may even be difficult to justify on flood savings throughout the entire Georges River Valley.

A major flood mitigation dam on the Georges River was further investigated as part of the Georges River Floodplain Risk Management Study and Plan [Bewsher Consulting, 2004]. The study found that the proposal was expensive ($60M to $100M for two different options) and difficult to justify based on the reduction in flood damages. There were also significant environmental issues associated with the proposed dam, and the proposal was not recommended.

10.1.8 Construction of Upstream Dams or Detention Basins

Recommended for further consideration.

Detention basins offer the opportunity for the temporary storage of floodwaters during and prior to the peak of the flood. The peak flood discharge can therefore be reduced downstream of the basin.

The new release area development that has occurred within the Cabramatta Creek catchment, and that will continue to occur over the coming years, will result in an increase in the impervious areas within the catchment. Without compensatory flood mitigation measures, such as the construction of detention basins, this would result in an increase in both the rate and volume of flood runoff.

10.1.8.1 Liverpool's Existing Strategy

Liverpool City Council has adopted a flood mitigation strategy to compensate for the new release area development within the catchment. The strategy, which has been discussed in Section 5.2, involves the construction of up to 16 detention basins located within the catchment to ensure that downstream peak flow rates are not increased as a result of this development. Nine of the new release area basins have already been constructed. Implementation of the new release area basin strategy is being funded through Section 94 developer contributions.

A thorough review of the basin strategy was undertaken as part of the floodplain management study, with the findings discussed in **Section 5**, and further reported in the "Review of Basin Strategy" working paper [Bewsher Consulting, 1999a]. The initial review indicated that the existing strategy was not completely achieving its objectives of maintaining pre-developed flood flows throughout the catchment. A revised basin strategy was proposed (**Figure 5.2**) which recommended a large detention basin, known as Basin 22, be constructed near the confluence of Hinchinbrook Creek and Cabramatta Creek. In addition, certain recommendations were provided for the other basins in the strategy that are yet to be built.

Basin 22 was subsequently revised as part of recent investigations undertaken for the RTA and Council. The size of Basin 22 is now considerably smaller than that which was originally proposed in the draft floodplain management study in 1999.

10.1.8.2 Initial Proposal for Basin 22

Basin 22 was initially proposed to be the largest basin in Cabramatta Creek. As it is located towards the middle of the catchment, it had the potential to have a significant impact on flood behaviour throughout Lower Cabramatta Creek. A large basin at this location could potentially satisfy the following objectives:

- make up any shortfall in the existing basin strategy throughout the lower reaches of Cabramatta Creek;
- allow some other detention basins that are included in the existing basin strategy to be omitted (Basins 4, 6, & 11C);
- compensate for any adverse impacts arising from the proposed Western Sydney Orbital (**Section 5.4**);

- reduce existing flood problems that are experienced in the lower catchment (a reduction of up to 0.3m for the 100 year ARI flood); and
- assist in alleviating problems towards the lower end of Hinchinbrook Creek, arising from the Wilson Road flood breakout.

Construction of the basin was to be staged, in accordance with available funding and the particular objectives of the basin at any particular time.

The most immediate objective of Basin 22 was to make up for any shortfall in the existing basin strategy. The total active storage volume (in addition to the natural floodplain storage volume that exists at the site) of up to 650,000m³ was proposed to cover any shortfall in the existing strategy, and to allow some other smaller basins to be omitted from the strategy.

Additionally it was estimated that 100,000 m^3 storage volume would be required to satisfy the anticipated ultimate catchment development, which is outside the new release area. It is unlikely that this storage would be required in the immediate future.

A further 100,000m³ of storage volume was estimates to be required to compensate for loss in floodplain storage should the proposed Western Sydney Orbital proceed. This storage may or may not need to be provided at some time in the future, pending the outcome of this proposal.

The proposed Basin 22 is shown on **Figure 10.1**.

10.1.8.3 Staging of Basin 22

Construction of Basin 22 was divided into 3 stages. The first stage of construction involved the partial acquisition of the site, and excavation of some 380,000m³ of earth to form the northern pond of the basin. A temporary low level embankment was proposed immediately downstream of the excavation to maintain existing 100 year ARI design flood levels. As it is not intended to increase flood levels throughout the site, it is not necessary to acquire the southern portion of the basin site at this stage.

The second stage of Basin 22 included further land acquisition and the construction of the main embankment around the basin site to raise flood levels, and thus increase flood storage within the site. An additional 270,000m³ of flood storage was to be provided by this means, giving a total active flood storage volume of 650,000m³.

The final stage of construction was tied in with the proposed Western Sydney Orbital and possible further catchment development. It included modification to the southern embankment, final land acquisition, and the excavation of up to 200,000m³ of earth to form the southern pond, giving a total active flood storage volume of 850,000m³.

10.1.8.4 Cost of Basin 22

The estimated construction cost for Basin 22 was estimated at $13.6M (excluding land acquisition costs). However, there were cost savings for not having to construct Basins 4, 6, and 11C (a saving of $3.3M plus land acquisition savings). There were also a number of sources of funding for this project due to the wide range of benefits

that it was to provide. Sources of funding include Section 94 Contributions from future development, RTA funding associated with the proposed Western Sydney Orbital, Council flood mitigation funding, and State and Commonwealth funding assistance through the DIPNR.

10.1.8.5 Revised Proposals for Basin 22

Land acquisition costs for Basin 22 increased dramatically as the proposed WSO highway became more of a certainty. The land that the basin was to be located is zoned industrial, and its close proximity to entry and exit ramps to the highway made this land valuable for freight and other transport purposes. The extent of the original basin proposed at this location became less economically viable as a result.

Other technical problems emerged as further investigations were undertaken in relation to a basin at this location. A high saline water table was found to be present close to the surface in this vicinity, which limited the excavation depth that could be practically achieved within the basin.

Subsequently, only the RTA showed any real interest in constructing a reduced size basin at this location. The most recent proposal, which is still subject to detailed design by the consortium designing the WSO highway, has a much smaller basin that is only able to achieve the objective of mitigating any adverse flood impacts from the highway. The likely footprint of the revised basin is indicated on **Figure 10.1**.

As Basin 22 is now much smaller than originally envisaged, it is most unlikely that any of the basins from Council's original strategy can be omitted. That is Basins 4, 6 and 11C should now be added back into the detention basin strategy.

10.1.8.6 *Other WSO Basins*

Two other basins, apart from Basin 22, have been proposed throughout the catchment to ensure that there are no adverse flood impacts from the proposed WSO highway.

A new basin on Hinchinbrook Creek at Government Road Drive has been proposed by the RTA. The main Basin on Maxwells Creek (Basin 18) has also been relocated further upstream and expanded to provide for compensation for the proposed highway and also for Liverpool Council's basin strategy. The basin is currently being designed and constructed as part of the WSO highway design.

10.1.8.7 *Brickmakers Creek*

Apart from the new release area detention basin strategy and the WSO highway basins, another basin has been proposed to be constructed at the top end of Amalfi Park, on Brickmakers Creek.

A proposed layout for the Amalfi Park detention basin is included as **Figure 10.2**. The objective of this basin is solely to reduce existing flood problems in Brickmakers Creek. It has been estimated that the basin will reduce the 100 year ARI flood levels throughout much of Brickmakers Creek by approximately 0.3m. This will significantly reduce flood problems associated with some 100 properties adjacent to Brickmakers Creek.

Figure 10.1

Proposed Basin 22

Figure 10.2

Proposed Amalfi Park Basin

10.1.8.8 Summary of Basins to be Constructed

A list of detention basins that are proposed to be constructed in the Cabramatta Creek catchment, and not yet constructed, is provided in **Table 10.1**. Each of these basins is subject to further evaluation and detailed design. Wherever possible, opportunities for off-line detention basins should be pursued, in consultation with DIPNR, to enhance aquatic and riparian environments.

Further basin details are provided in the "Review of Basin Strategy" working paper [Bewsher Consulting, 1999a].

TABLE 10.1
Detention Basins Proposed to be Constructed in the Catchment
(Does not include detention basins already constructed)

Detention Basin	Type of Basin	Storage (m3)	Cost* ($)
Basin 22[2]	WSO basin (RTA)	336,000	Included in WSO Cost
Government Dr[2]	WSO basin (RTA)	205,000	Included in WSO Cost
Basin 18[2]	WSO basin (RTA) New Release Area	405,000	Included in WSO Cost
Basin 3B	New Release Area	184,000	600,000
Basin 4	New Release Area	183,000	1,800,000
Basin 6[3]	New Release Area	170,000	1,100,000
Basin 11C	New Release Area	35,700	400,000
Basin 12[4]	New Release Area	89,000	2,100,000
Basin 14[4]	New Release Area	45,000	300,000
Amalfi Park	Existing Flood benefit	75,000	1,400,000

[1] Costs exclude land acquisition costs and additional excavation to form permanent wet storage areas
[2] Subject to detailed design by the consortium designing the WSO highway
[3] Subject to Hoxton Park Aerodrome Master Plan
[4] Subject to Edmondson Park Master Plan

10.1.9 Enlarging Bridges and Culverts to Improve their Flood Capacity

Recommended for consideration for the purpose of improving flood access.

Enlargement of the Main Southern Railway Line crossing of Cabramatta Creek has been investigated in the past. However, minimal flood benefits are obtained by increasing the waterway area at this location, as flood waters are largely controlled by flooding in the Georges River. This option has a very low benefit/cost ratio, and is not recommended for further consideration.

There are several bridges and culverts throughout the catchment that are overtopped during flood events. Amplification of these structures, to improve flood access, is recommended for various locations throughout the catchment. These measures are discussed below.

10.1.10 Improving Flood Access of Roads

Recommended for further consideration.

There are a number of arterial roads throughout the catchment that are subject to flooding, even during relatively minor flood events. Previously identified problem areas [Kinhill, 1993] are indicated in **Table 10.2**.

TABLE 10.2
Main Problem Areas for Inundation of Roads at Creek Crossings

LOCATION	FREQUENCY OF OVERTOPPING (ARI)	DEPTH OF OVERTOPPING IN 100 YEAR (ARI) FLOOD	PROPOSED FOR UPGRADING
Cabramatta Creek			
▸ Elizabeth Drive	20 years	0.5m	No
▸ Hoxton Park Road	1 year	2.2m	Recently upgraded
Hinchinbrook Creek			
▸ Hoxton Park Road	1 year	0.8m	Recently upgraded
▸ Cowpasture Road	1 year	1.2m	Yes
Maxwells Creek			
▸ Hoxton Park Road	20 year	0.5m	Recently upgraded
▸ Jedda Road	1 year	0.7m	Yes
Brickmakers Creek			
▸ Homepride Ave	20 year	0.4m	No
▸ Orange Grove Rd	50 year	0.2m	Yes
▸ Elizabeth Drive	50 year	0.2m	Yes
▸ Moore Street	1 year	0.5m	Yes
▸ Memorial Avenue	10 year	0.3m	No

Hoxton Park Road has very limited capacity along Cabramatta Creek, Hinchinbrook Creek and Maxwells Creek. Raising this road to provide a high level of service (20 years plus) is unlikely to be feasible without adversely impacting on flood behaviour through various parts of the study area. This issue was investigated by the RTA and

some upgrading of the road has recently been undertaken. It is understood that there has been some amplification of culverts at Cabramatta Creek and Maxwells Creek, and also minor adjustments to the road crest to reduce the frequency of road closure. Whilst these measures may reduce the frequency of road closure, it is still likely to occur at relatively frequent intervals.

The potential upgrading of Cowpasture Road to prevent overtopping and road closure has recently been investigated by the RTA. It is understood that measures are proposed by the RTA, in conjunction with the proposed WSO highway, to reduce the frequency of overtopping of this road.

Most of the bridge crossings on Brickmakers Creek will benefit from the proposed detention basin at Amalfi Park, if subsequent investigations into the feasibility of this basin site prove satisfactory. However, it is still likely that the Orange Grove Road culvert will need to be amplified, as other proposed channel improvement works upstream of this culvert will result in additional flows being carried in the creek and additional flows that have to pass under the culvert (refer to **Appendix C** for further details). It is also recommended that consideration be given to updating the Elizabeth Drive culvert, although the actual size could vary pending the review of the Amalfi Park basin. Amplification of the Moore Street culvert should also be considered.

The current system for signposting road closures should also be reviewed. The SES consider that much of the road congestion which occurs during flood periods could be reduced by signposting road closures well before the actual closure point. For example, road closures on Hoxton Park Road should be notified at the Hume Highway. The additional signposting would allow motorists to select alternative routes well before reaching the closure point.

10.1.11 Construction of Levees to Protect Property

Minimal regrading to existing Tresalam Street levee recommended.

Levees are often used to prevent flooding of populated areas on the floodplain. However, in some circumstances they can make flooding worse for people outside or upstream of the levee, and can also give a false sense of security as overtopping or breaching of the levee can occur in large floods.

An existing levee has been built to provide protection to existing houses in the Tresalam Street area. There have been problems associated with this levee, including:

- inadequate allowance for drainage of the local area behind the levee;
- flood flows crossing Elizabeth Drive and entering the area “protected” by the levee; and
- whether the levee provides a sufficient level of protection.

Separate investigations have been undertaken for this area. Recommendations include, the construction of a small deflector levee in Blamfield Park to eliminate floodwaters spilling into the “protected” area, improvements to the capacity of the Elizabeth Drive bridge, and possible minor regrading of the height of the levee. An earlier investigation also recommended consideration of local flood pumps behind the levee to minimise internal drainage problems during large floods.

One of the benefits of the original proposal for Basin 22 was a reduction in downstream flows and therefore an increase in the level of protection afforded by the Tresalam Street levee. However, as only a reduced size basin is now likely to be constructed, the level of protection provided by the levee will remain unchanged. A comparison of a recent longitudinal survey of the levee crest with the most up-to-date design flood levels for this area [Water Research laboratory, 1998b] indicates that the levee provides protection to about the 100 year flood (without freeboard). Increasing the height of the levee is unlikely to provide further protection, as the deflector levee in Blamfield Park has been limited to the 100 year flood to avoid increases in upstream flood levels. Therefore, floodwaters are likely to inundate the area behind the Tresalam Street levee at about the 100 year flood from floodwater overtopping Elizabeth Drive, regardless of whether the Tresalam Street levee is raised or not. Some benefit would be obtained from installing an early warning system, in the form of an automated siren, to warn residents should potential overtopping of the levee become likely.

A levee has also previously been proposed further downstream at Garden Street. Again, Basin 22 was to significantly reduce flood problems experienced in this vicinity, and a levee was thought to be no longer required. With the smaller Basin 22 now proposed, further consideration of the Garden Street levee, or other measures such as house raising, may now need to be reconsidered.

10.2 MEASURES THAT MODIFY THE PROPERTY

10.2.1 Voluntary Purchase of the Most Flood-Liable Houses

Not generally recommended.

Under a voluntary purchase scheme, Council would offer to purchase flood liable properties if and when they became available for purchase, subject to the availability of funds at the time. Voluntary purchase is not compulsory acquisition and affected property owners can expect to receive market values, or higher than market values, for their properties (i.e. values assume no voluntary acquisition scheme is in place and disregards development constraints that may apply on that land due to its flood prone nature.

Voluntary purchase schemes, by their very nature, cannot be implemented immediately. To be successful, the majority of owners in the area need to take up the offer and a suitable allocation of funds must be available to purchase the properties. There needs to be an ongoing commitment from Council to continue to purchase properties into the future as they become available, in spite of changes to Council's elected officers and senior staff.

Only those houses that are subject to extreme flood hazard are usually considered for inclusion in voluntary purchase schemes. Such houses would typically be well below the 20 year ARI flood, or may be inundated by over 1m of floodwaters in a 100 year ARI flood. It is not anticipated that any houses in the catchment would experience flooding of this magnitude.

As well as residential properties, there are a number of commercial premises affected by flooding. State Government funding is not available for voluntary purchase of commercial properties, so Council would have to meet the full cost of these purchases if a voluntary purchase scheme involving commercial property was considered.

The cost of this option is high and does not address flooding problems elsewhere in the catchment. The nature of flooding is such that expenditure of this nature would be difficult to justify. In addition the option was not favoured by respondents to the community questionnaire.

10.2.2 Voluntary House Raising

Recommended for further consideration.

The raising of timber and fibro houses has proved to be an effective floodplain management option for various locations throughout NSW. Fairfield City Council has been implementing a successful house raising program in Prospect Creek for many years now, with over 100 house being successfully raised. House raising has also been carried out in the Lake Macquarie City Council area, and in other parts of northern New South Wales. It has also been proposed in several recently completed floodplain management plans, such as the Woronora River, Manly Lagoon and Wyong River floodplain management plans.

There are various forms of house raising schemes that can be considered. Obviously, the easiest form of house raising will be where houses are of either timber or fibro construction. Experience by Fairfield Council in Prospect Creek has shown that most houses can be raised by 1-2m for a cost typically in the range of $40,000 to $80,000.

Where houses are of a brick veneer, or full brick construction, the physical raising of these houses will be more costly, and in most cases impractical. Under these circumstances, variations to the traditional house raising concept may need to be considered. One solution is to build a first floor extension on top of the existing building, and convert the lower floor to a non-habitable form. A disadvantage of this option is that there will be a temptation by the owner to occupy both floors, and the objective of minimising flood damage may be lost. A second solution is to completely rebuild the house at higher level, which may or may not be accompanied by a change in home ownership. With a change in home ownership, Council would acquire the property (if offered for sale), demolish the existing house, and sell the vacant building lot with appropriate floor level controls. Typical net costs for these options are likely to range from $60,000 to $80,000 per house.

The State Government has provided two forms of financial subsidy for house raising schemes in the past. The usual form of the scheme involves a subsidy based on the full cost of house raising, where this is shown to be economically justified. This is generally the case for timber or fibro houses that are located below or close to the 20 year ARI flood level. In some other cases, a partial subsidy limited to $10,000 has been offered, with the homeowner expected to pay the difference in cost. The alternative scheme can be useful for houses where there is marginal economic flood benefit from house raising, either because the house is flooded infrequently or because it is expensive to raise.

There are various disadvantages associated with house raising, for example:

- steps to gain access to the house may not be suitable for older people or those with disabilities;
- other property damage within the property, e.g. damage to parked cars and equipment, may still occur;
- after raising, residents may 'close in' any downstairs area to create further habitable areas (without Council approval) and thus increase future damage potential;
- there may be aesthetic and town planning restrictions associated with raising some houses. For example, isolated raising of some properties in a street may not be appropriate, and it may be necessary to raise a group of properties in a street.

The above problems aside, a number of houses in Cabramatta Creek would benefit from house raising. Whilst final lists are still to be determined, they are likely to include residential homes that are below the 100 year flood in Lower Cabramatta Creek, on both the Fairfield and Liverpool Council areas.

A preliminary list of property that could be considered by Fairfield Council is provided in Appendix D. A property list for Liverpool Council is still to be formulated.

10.2.3 Flood-Proofing of Individual Residential and Business Properties

Recommended for further consideration.

Individual properties can be modified to reduce the impacts of flooding by the construction of flood retaining walls outside the house (similar to levees in function), waterproofing walls of houses and by placing shutters across doors and other openings. This option would be most effective for short duration floods as extended periods of inundation would increase the likelihood and extent of leaks through the waterproofing measures.

Properties which may be suited to flood proofing are largely limited to commercial properties. Flood-proofing options may be appropriate for Liverpool Catholic Club where the floor level is only just above the 100 year flood level. This could be in the form of landscaping mounds and/or speed humps about 0.3-0.5m high around the perimeter of the building, supplemented by readily available sandbagging equipment. Other properties that could benefit include a number of unit blocks in Brickmakers Creek which have ground floor levels or entry foyers just below the 100 year ARI flood level.

For such measures to be effective when the premises are unattended, it would be necessary for flood gates and similar structures to be erected. It is recognised that this may be a labour intensive process and therefore owners may only erect these structures when wet weather is imminent. As many flood events may occur in the night or on weekends, such measures could not be relied upon to provide total protection for commercial properties.

The works could be at no cost to Council, or with some Council contribution.

10.2.4 Relocation of Flood Liable Houses to Areas of Higher Ground

Not recommended for further consideration.

This can be considered as a special form of house raising, except it also involves a relocation of the house to higher ground. It may sometimes be possible to move the house to higher ground within the property boundaries, although in most cases there will not be sufficient area of high ground for this purpose. More usually it involves the relocation of the house to a new vacant property, which could be in the same street, or possibly a nearby street.

Such a scheme was successfully implemented by Lake Macquarie City Council in the early 1980's. It involved Council acquiring vacant flood free lots in several streets where there were flooding problems, and arranging a “land swap” with owners of flood liable houses in the same street. This allowed the flood liable houses to be relocated further up the street, away from the river. The flood liable lots then passed into Council’s ownership.

It is unlikely that a similar scheme will be successful in Cabramatta Creek, as only a few of the existing houses would be suitable for relocation, there are limited vacant lots within the existing developed area, and the cost of acquiring flood free vacant lots in the study area would be high.

10.2.5 Building and Development Controls

Recommended for further consideration.

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

A review of flood related planning controls in Cabramatta Creek has been presented in **Section 8**. Specific amendments to existing planning controls have been proposed, and a revised floodplain management policy for both Councils has been recommended.

A ‘planning matrix’ approach forms the main basis of the proposed floodplain management policy, which is proposed to be adopted as a development control plan for each Council. The planning matrix provides guidance as to the location and appropriate land uses within the floodplain. These planning matrices should be monitored and reviewed and updated as future floodplain management plans are prepared, or existing ones reviewed.

A brief summary of the principal findings and recommended planning measures is provided below:

- a graded set of planning controls to be applied to the study area (as proposed in the planning matrix in **Figure 10.5**) which are tailored to the proposed land use and flood level, and which recognise flood risks up to and including the PMF;

- amendments to Local Environmental Plans (in particular major consolidating planning instruments) applicable to the study area to contain objectives to restrict development in high hazard areas, and control the form of development in the floodplain to ensure it is compatible with flood risk;

- a proposed flood prone land policy to be adopted by both Councils for the catchment, as a Development Control Plan in accordance with the EP&A Act.

Figure 10.3
Proposed Planning Matrix for Cabramatta Creek

Planning & Development Controls

Templat V4.0

Planning Consideration	Flood Risk Precincts (FRP's)																							
	Low Flood Risk								Medium Flood Risk								High Flood Risk							
	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Subdivision	Residential	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3		2,6,7	5,6,7	2,6,7	1,6	4,7				2,6,7	5,6,7	2,6,7	1,6	4,7							1,6	4,7
Building Components		2		1	1	1	1	1				1	1	1	1	1							1	1
Structural Soundness		3		2	2	2	2	2				1	1	1	1	1							1	1
Flood Effects		2	2	2	2	2	2	2			1	2	2	2	2	2							1	1
Car Parking & Driveway Access		1,3,5, 6,7		1,3,5, 6,7	1,3,5, 6,7	1,3,5, 6,7	2,4,6, 7	6,7,8				1,3,5, 6,7	1,3,5, 6,7	1,3,5, 6,7	2,4,6, 7	6,7,8							2,4,6, 7	6,7,8
Evacuation		2,3,4	6	2,3	1 or 2, 3	2,3	4,3	2,3			6	2,3	1,3	2,3	4,3	2,3							4,3	2,3
Management & Design		4,5	1		2,3,5	2,3,5	2,3,5	2,3,5			1		2,3,5	2,3,5	2,3,5	2,3,5							2,3,5	2,3,5

COLOUR LEGEND: Not Relevant Unsuitable Land Use

General Notes

1	Freeboard equals an additional height of 500mm.
2	The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. This matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.
3	Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
4	Refer to Section 2.5 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and Structural Soundness planning considerations of the applicable landuse category.
5	Refer to section 2.7 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
6	Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.
7	From time to time, Council may adopt mapping showing the *Boundary of Significant Flow* and/or *Flood Storage Areas* for this floodplain. Refer to Council to find out if these areas have been defined and mapped for this floodplain.

Floor Level

1	All floor levels to be no lower than the 20 year flood unless justified by site specific assessment.
2	*Habitable floor* levels to be no lower than the 100 year flood level plus freeboard.
3	*Habitable floor* levels to be no lower than the *PMF* level. Non-*habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
4	Floor levels to be no lower than the *design floor level*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing floor level.
5	The level of *habitable floor areas* to be equal to or greater than the 100 year *flood* level plus *freeboard*. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.
6	Non-habitable floor levels to be no lower than the 20 year flood unless justified by site specific assessment.
7	A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed.

Building Components & Method

1	All structures to have *flood compatible building components* below the 100 year flood level plus *freeboard.*
2	All structures to have *flood compatible building components* below the *PMF* level.

Structural Soundness

1	Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below).
2	Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard,* or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
3	Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF* An engineers report may be required.

Flood Effects

1	Engineer's report required to certify that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Note: (1) If a *Boundary of Significant Flow* has been defined for this floodplain, any development inside this area will normally be unacceptable as it will reduce flood conveyance and increase flood effects elsewhere. (2) If a *Flood Storage Area* has been defined for this floodplain, any filling of the floodplain inside this area (except where this occurs by compensatory excavation), will normally be unacceptable as it will reduce the volume of flood storage available on the floodplain and increase flood effects elsewhere. (3) Even where a *Boundary of Significant Flow* and/or a *Flood Storage Area* have been defined, development outside these areas may still increase flood effects elsewhere and therefore be unacceptable.

Car Parking and Driveway Access

1	The minimum surface level of open car parking spaces or carports shall be as high as practical, but no lower than the 20 year flood or the level of the crest of the road at the location where the site has access. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 20 year flood.
2	The minimum surface level of open car parking spaces, carports or garages, shall be as high as practical.
3	Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking,* must be protected from inundation by floods equal to or greater than the 100 year flood.
4	The driveway providing access between the road and parking space shall be as high as practical and generally rising in the egress direction.
5	The level of the driveway providing access between the road and parking space shall be no lower than 0.3m below the 100 year flood or such that the depth of inundation during a 100 year flood is not greater than either the depth at the road or the depth at the car parking space. A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
6	*Enclosed car parking and car parking areas accommodating more than 3 vehicles (other than on Rural zoned land), with a floor level below the 20 year flood or more than 0.8m below the 100 year flood level, shall have adequate warning systems, signage and exits.*
7	Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood
8	Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not practical , a lower level may be considered. In these circumstances, the level is to be as high as practical, and, when undertaking alterations or additions, no lower than the existing level.

Note: (1) A flood depth of 0.3m is sufficient to cause a typical vehicle to float. (2) *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood.
2	Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level.
3	The development is to be consistent with any relevant *flood evacuation strategy, Flood Plan adopted by Council* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Reliable access for pedestrians or vehicles required to a publicly accessible location above the *PMF*.
6	Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development flowing from the subdivision proposal.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this DCP.
2	*Site Emergency Response Flood Plan* required where floor levels are below the *design floor level,* (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year flood level plus *freeboard.*
4	Applicant to demonstrate that area is available to store goods above the *PMF* level.
5	No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.

10.3 MEASURES THAT MODIFY THE RESPONSE TO FLOODING

10.3.1 Improved Flood Warning

Recommended for further consideration.

Actual flood damages can be reduced if there is sufficient warning time for the community to take appropriate damage reduction measures.

10.3.1.1 Role of Bureau of Meteorology

The Bureau of Meteorology is the government agency responsible for issuing flood warnings throughout Australia. Dissemination of flood warning and action to evacuate or otherwise assist people in the event of flooding is the responsibility of the State Emergency Services (SES).

As the Bureau's resources are limited, they are only able to provide a complete flood warning service in those catchments that would benefit most from these warnings. As a general guide, the Bureau will only provide a formal flood warning service in catchments where there is likely to be at least 6 hours warning of impending flooding. Whilst this is the case for the Georges River, the response time to flooding in Cabramatta Creek is likely to be much more rapid due to its smaller catchment size.

The Bureau of Meteorology provides a formal flood warning service for the Georges River, with the main reference point being the Liverpool weir. Whilst these flood warnings will be a benefit to residents in Lower Cabramatta Creek, who can be affected by backwater flooding from the Georges River, there is no other site specific flood warning advice issued within the Cabramatta Creek catchment.

The Bureau also provides a range of meteorologically-based warning services, including:

I. ***Flood Watches*** – typically provide 24 to 48 hour notice. These are issued by the NSW Flood Warning Centre and are a "heads up" that flooding is possible based upon current catchment conditions and future rainfall that is predicted by computer models of the atmosphere.

II. ***Severe Thunderstorm Warnings*** – typically provide 0.5 to 2 hours notice. These short range forecasts are issued by the Bureau's Severe Weather Team and are based upon radar, data from field stations, reports from storm spotters as well as an analysis of the synoptic situation.

III. ***Severe Weather Warnings***. For synoptic scale events that can cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low pressure systems off the NSW coast which produced the 1986, 1988 and 1990 floods in the Georges River catchment, including Cabramatta and Prospect Creeks.

10.3.1.2 Issues for Cabramatta Creek

Whilst the response time to flooding in Cabramatta Creek is low, and typically of the order of 2-3 hours, it would nevertheless benefit from a flood warning system for the lower to middle part of the catchment, where most of the existing flood problems are

encountered. The existing procedures could be augmented with a separate flood warning system specially designed for Cabramatta Creek. This is particularly important if a large detention basin, such as Basin 22, is built towards the middle of the catchment. The system could monitor water levels within the basin, in addition to catchment rainfall, and provide flood warnings for residents in the lower catchment. A key feature of the warning system would be a prediction on the likelihood of overtopping of the basin spillway, which is likely to occur in floods greater than a 100 year ARI event.

Given the short time between rainfall and flooding, an improved flood warning system for Cabramatta Creek should strategically incorporate the meteorologically-based warning services provided by the Bureau of Meteorology. Installation of an "Alert" system that incorporates a number of rain and river height recorders with telemetry equipment to transfer the data in real time to a base station could also be considered. A personal computer at the base station would record the data, and with the aid of several algorithms provide a prediction of future flood conditions. The base station could warn of impending flooding through the sounding of one or more sirens, or through automated telephoning of advice to SES Officers or other key individuals.

Whilst the Bureau will provide assistance in installing and maintaining the necessary rain gauges, Council would be responsible for the river gauges and base station. Existing river gauges on Cabramatta Creek at the Hume Highway (Manly Hydraulics Laboratory), and at Orange Grove Road (Department of Land and Water Conservation) could be incorporated in the system at little cost to Council. The SES would have the main responsibility for receiving and disseminating flood warnings, as well as organising evacuations and other emergency response management activities.

As a minimum, it is recommended that an automated flood siren be installed in the Tresalam Street levee area, to warn residents prior to potential overtopping of the levee.

10.3.1.3 Composition of Proposed Warning Scheme

Components of the flood warning scheme are likely to include:

- two new rain gauges located in Upper Cabramatta Creek and Hinchinbrook Creek ($10,000);
- one rain/river station inside Basin 22 ($20,000);
- conversion of existing river stations at Orange Grove Road and Hume Highway ($5,000);
- base station with computer ($10,000); and
- software development ($5,000).

The total cost of the above system is estimated to be $50,000, with maintenance costs estimated as $5,000 per annum.

Further discussions between both Councils, the Bureau of Meteorology, SES, and the DIPNR are recommended to establish a preferred flood warning system for Cabramatta Creek, and to establish sources of funding and responsibilities for the system.

10.3.2 Improved Evacuation Procedures and Emergency Assistance

Recommended for further consideration.

The SES is the State's 'combat' agency for flooding and fulfils a vital role in emergency planning and management.

As part of the current study, the SES has been made aware of the existing flood problems in the study area and has participated in the floodplain management committee meetings held to discuss potential floodplain management options. Further details of the frequency and depth of inundation of arterial roads throughout the catchment will shortly be provided to the SES, together with details of the most severely affected properties.

These measures will assist the SES develop an improved Local Flood Plan for Cabramatta Creek, comprising preparedness measures, the conduct of response operations, and the coordination of immediate recovery measures.

The SES will also fulfil an important role in the development and operation of the flood warning system proposed for Cabramatta Creek. Continued and increased cooperation with the SES, such as that initiated during the current study, will have significant benefits to Cabramatta Creek.

10.3.3 Flood Awareness Programs

Recommended for further consideration

Actual flood damages can be reduced if community awareness of flood issues is raised.

The last significant floods that occurred in Cabramatta Creek were the 1986 and 1988 flood events. Whilst community awareness of flooding would have been high immediately following these floods, much of this awareness will have faded over the subsequent years. There will also be a significant number of new residents that have since moved into the catchment, who have probably never experienced a flood, at least not in Cabramatta Creek. Thus the community awareness of the risks of flooding in Cabramatta Creek is now likely to be limited. This conclusion is also supported by results from the community questionnaire, which indicated that 58% of residents that live close to the creek have received no information about flooding.

The development and implementation of an effective flood awareness and education program in the study area has the opportunity to improve the knowledge and experience of residents to mitigate flood hazards. A flood awareness and education program is proposed that incorporates the following components:

- **Updating Section 149 Certificates**. The questionnaire responses indicate that only 5% of residents have obtained information about flooding at their property from Council. Council should continue to advise prospective property purchasers that a property is flood liable by notification on Section 149(2) certificates. These certificates should be updated from information from the current flood study modelling. In addition, a proposed flood certificate (discussed below) could be appended to the Section 149(2) certificate;

- **Issuing Flood Certificates**. A flood certificate issued to individual property owners would inform them of the flood situation at their particular property. This certificate would contain vital information such as the expected flood levels in a range of storm events. When combined with ground levels and floor levels, depths of flooding over the property could be determined. It could be issued with Council rates notices on either a yearly or biennial basis. The community questionnaire indicated that most people in the catchment (71%) were in favour of flood certificates being issued. In fact, this measure was the third most popular flood mitigation measure supported by the community.

- **Community Education Programs**. Contact with local schools and community groups is an excellent means of improving community education of flooding issues. A prime example is the "flood icon" project undertaken by Fairfield City Council for Prospect Creek. This program involved schools and other groups in a competition to design an appropriate reminder of past floods, to be constructed in one of the local parks. The project received an Institution of Municipal Engineers Australia award. Other programs could include talks given by Council staff and handouts containing general flood information. Public displays on flooding could be set up in public buildings such as the Council chambers, library or shopping centre. Such displays could contain information about the Floodplain Management Plan as well as information from the SES;

- **Construction of Flood Markers**. Flood markers act as reminders of the height of previous floods. The marking of past flood levels on telephone poles (or on specially constructed flood totem poles) will also provide constant reminders of flooding risks. Appropriate locations for flood markers include parks or reserves which are readily accessible by the general public. They should be clearly visible both prior to flooding and during flood events.

For the flood awareness program to be successful and cost-effective, it should be implemented by both Councils over the whole catchment. To ensure the program is on-going, responsibilities need to be identified and allocated to key individuals within each Council.

Such a program could cost approximately $100,000 to develop and implement, and about $10,000 per annum to maintain.

10.3.4 Encouraging Flood Action Plans for Residents and Business Owners

Recommended for further consideration.

Flood action plans comprise instructions for people at individual properties telling them what they should do before, during and after a flood, where they should go and who they should contact if there is a flood. They may be formulated for single residential properties or may apply to blocks of units or town houses. They could also be developed for commercial properties located within the catchment.

The plans would be simple instructions, similar to those for fire emergencies or first aid, and would be posted at noticeable locations within buildings.

TABLE 10.3 SUMMARY OF FLOODPLAIN MANAGEMENT OPTIONS — QUALITATIVE ASSESSMENT MATRIX (1999 Draft Report)

OPTION NO.	DESCRIPTION OF OPTION	AIM OR CRITERIA OF OPTION	COMMENTS AND RELATIVE SCORE FOR EACH CRITERIA									RECOMMENDED FOR INCLUSION IN PLAN
			Financial feasibility	Economic merit	Community acceptance	Environmental Impacts	Impacts on flood behaviour	Consequences in extreme flood	Reduction in number of buildings flooded in 100 yr ARI flood	Technical feasibility / difficulty	Administrative / political / legal impacts	
1	**OPTIONS WHICH MODIFY FLOOD BEHAVIOUR**											
1.1	Clearing the creek of rubish, debris, Exotic vegetation and man made obstructions	Improve creek conveyance and to avoid the exacerbation of flooding over time	$0.3M + +	O	+ +	+ +	+	+	+	+ +	+	yes
1.2	Developing an urban bushland management program for the creek corridor	To preserve and improve the ecological and aesthetic quality of the creek corridors, and maintain the conveyance capacity of the creeks	$0.1M + +	O	+ +	+ +	O	O	O	+ +	+	yes
1.3	Restoring the creek to a more natural looking condition	Improve aesthetic quality of the creek system	n.a – –	– –	+	+ +	– –	–	–	–	O	no
1.4	Enlarging the creek by widening or deepening -											
	Maxwells Ck between Jedda Rd and Kurrajong Rd	Improve creek conveyance to lower flood levels	$1.4M –	O	– –	– –	–	–	+	O	O	no
	Maxwells Ck between Kurrajong Rd and Camden Valley Way	Improve creek conveyance and tie in with other proposals	$2.0M O	O	O	O	+	O	O	+	O	yes
	Elizabeth Drive bridge	Improve flow of water under Elizabeth Drive Bridge	$0.1M + +	+	+	O	+	+	+	+	O	yes
1.5	Construction of bypass channels or floodways											
	Extend existing floodway from Miller TAFE college to Creek A, including into Lower Hinchinbrook Ck	Lower flood levels and prevent the Wilson Road flood breakout	$12M – –	– –	–	– –	+ +	+	+ +	–	O	no
	Floodway channel across Orange Grove Golf Course	Improve conveyance of floodwaters to high level culverts under Orange Grove Rd	$0.4M +	+	O	–	+	+	+	+	O	yes
	Floodway channel upstream of Main Southern Railway	Lower flood levels upstream of Main Southern Railway	$0.1M +	O	O	–	O	O	O	+	O	no
1.6	Straightening sections of Maxwells Ck or lining with rock, gabions or concrete	Reduce extent of flooding between Hoxton Park Road and Jedda Road	$20M – –	– –	– –	– –	+	O	+	–	O	no
1.7	Investigate major flood mitigation works for the Georges River (investigation only at this stage)	Major works could lower flood levels in Lower Cabramatta Creek by up to 1.0m	$0.2M +	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	O	yes
1.8	Construction of upstream dams or detention basins											
	Basin 3B	Mitigates impact of upstream development	$0.6M O	+	O	+	+	O	+	+	O	yes
	Basin 12	Mitigates impact of upstream development	$2M O	+	O	+	+	O	+	+	O	yes
	Basin 14	Mitigates impact of upstream development	$0.4M O	+	O	O	+	O	+	+	O	yes
	Basin 18	Mitigates impact of upstream development and Western Sydney Orbital	$4.1M O	+	O	+	+	O	+	+	O	yes
	Basin 22	Mitigates impacts of upstream development, Western Sydney Orbital, and existing flood problems in Lower Cabramatta Ck	$14M +	+	O	+	+ +	O	+	–	O	yes
	Amalfi Park Basin	Reduces existing flood problems in Brickmakers Creek	$1.4M +	+	O	O	+	O	+	+	O	yes
1.9	Enlarging Bridges and culverts to improve their flood conveyance	Enlarge Main Southern Railway to reduce upstream flood levels	$6.5M – –	– –	O	–	O	O	O	O	O	no

TABLE 10.3 SUMMARY OF FLOODPLAIN MANAGEMENT OPTIONS — QUALITATIVE ASSESSMENT MATRIX (1999 Draft Report)

OPTION NO.	DESCRIPTION OF OPTION	AIM OR CRITERIA OF OPTION	COMMENTS AND RELATIVE SCORE FOR EACH CRITERIA									RECOMMENDED FOR INCLUSION IN PLAN
			Financial feasibility	Economic merit	Community acceptance	Environmental Impacts	Impacts on flood behaviour	Consequences in extreme flood	Reduction in number of buildings flooded in 100 yr ARI flood	Technical feasibility / difficulty	Administrative / political / legal impacts	
1.10	Improving flood access of roads by culvert amplification and/or road raising											
	Cabramatta Ck - Hoxton Park Rd	Improve trafficability up to 100 year ARI flood	$1.0M +	O	+	O	O	O	O	+	O	yes
	Hinchinbrook Ck - Hoxton Park Rd	Improve trafficability up to 100 year ARI flood	$0.5M +	O	+	O	O	O	O	+	O	yes
	Maxwells Ck - Hoxton Park Rd	Improve trafficability up to 100 year ARI flood	$0.5M +	O	+	O	O	O	O	+	O	yes
	Maxwells Ck - Jedda Rd	Improve trafficability up to 100 year ARI flood	$0.5M +	O	+	O	O	O	O	+	O	yes
	Brickmakers Ck - Moore St	Improve trafficability up to 100 year ARI flood	$0.3M +	O	+	O	O	O	O	+	O	yes
1.11	Construction of levees to protect property	Minor regrading of top of Tresalam Street levee to provide consistent freeboard	$0.2M +	+	O	O	O	O	+	+	O	yes
2	OPTIONS WHICH MINIMISE THE DAMAGE BY MODIFYING THE PROPERTY											
2.1	Voluntary purchase of severely flood affected properties	Purchase & demolition of residential properties which are severely flood affected (up to 20 houses)	$4.0M – –	– –	–	+	O	+ +	+	O	O	no
2.2	Voluntary House Raising	Modify existing houses so that floor levels are raised to above the 100 year flood level (up to 50 houses)	$2M –	–	O	O	O	+	+	O	O	yes
2.3	Flood proofing of individual properties	Reducing the impacts of flooding on individual properties by waterproofing walls, putting shutters across doors and using materials that are relatively unaffected by submersion etc.	No cost to Council n.a.	n.a.	–	O	O	+	n.a.	O	O	yes
2.4	Relocation of flood liable houses to areas of higher ground	Similar to house raising, but also involving relocation to a higher site	Not available –	– –	O	+	O	+ +	+	O	–	no
2.5	Building and development controls	Controlling future impacts, for example by setting minimum floor levels for future development and extensions to existing dwellings	No capital cost n.a.	n.a.	+ +	O	+	+ +	n.a.	+ +	–	yes
3	OPTIONS WHICH MODIFY PEOPLE'S RESPONSE TO FLOODING											
3.1	Improved flood warning systems	To provide an indication to the SES, Council or the Police of conditions likely to cause flooding.	$0.05M +	n.a.	+ +	O	O	+	O	+	–	yes
3.2	Improved evacuation procedures and emergency assistance	SES to upgrade current emergency assistance plans	No capital cost n.a.	n.a.	+ +	O	O	+	O	+	O	yes
3.3	Flood awareness Programs	To make the public more aware of flooding issues	$0.15M +	n.a.	+ +	O	O	+	O	+	–	yes
3.4	Preparation of flood action plans for individual properties	To tell residents WHAT they should do, WHERE they should go and WHO they should contact if there is a flood	No capital cost n.a.	n.a.	+ +	O	O	+	O	+	O	yes

Notes: For description for relative scores for each criteria refer to Table 13b.
n.a. = not assessed, not available or not applicable.

TABLE 10.4 EXPLANATION OF ASSESSMENT SCORES FOR QUALITATIVE ASSESSMENT MATRIX

CRITERIA	– –	–	O	+	+ +
FINANCIAL FEASIBILITY	Very unlikely to receive funding	May not receive funding	Neutral	Would possibly receive funding	Very likely to receive funding
ECONOMIC MERIT	B/C less than 0.1	B/C = 0.1–0.3	B/C = 0.3–0.7	B/C = 0.7–1.0	B/C greater than 1.0
COMMUNITY ACCEPTANCE	Strongly against	Generally against	Neutral	Some support	Strongly supported
ENVIRONMENTAL IMPACT	Significant negative impact	Some negative impact	No impact	Some positive impact	Significant positive impact
IMPACT ON FLOOD BEHAVIOUR	Significantly increase flood levels and/or velocities	Some increase in flood levels and/or velocities	No change	Some reduction in flood levels and/or velocities	Significantly reduces flood levels and/or velocities
PERFORMANCE DURING LARGE FLOODS	Significantly increases risk	Some increase in risk	No change in risk	Some reduction in risk	Significant reduction in risk
TECHNICAL FEASIBILITY	Very difficult	Difficult	Neutral	Easy	Very easy and straight forward
POLITICAL/ ADMINISTRATIVE / LEGAL IMPACT	Significant changes required which are very unlikely to be supported	Some changes required which may not be supported	No changes or impact	Some changes required are likely to be supported	Significant changes required which are likely to be strongly supported

B/C = Benefit Cost Ratio

11. RECOMMENDED FLOODPLAIN MANAGEMENT PLAN

A draft floodplain management plan showing preferred floodplain management measures for Cabramatta Creek is presented in this Chapter. The preferred measures have been determined from the range of available measures that were discussed in **Sections 9** and **10**, after an assessment of the impacts on flooding, as well as environmental, social, and economic considerations.

Measures that were originally assessed in the draft floodplain management study [Bewsher Consulting, 1999] have been re-evaluated in light of more recent evaluations and other changes within the catchment, including the reduced size of Basin 22 and other changes associated with the proposed WSO highway.

The draft Floodplain Management Plan is presented in **Table 11.1**, and is also represented on **Figure 11.1**. The principal components of the Plan are discussed below.

Timing of the proposed works will depend on each Council's overall budgetary commitments, and the availability of funds from other sources. Funding will be available through a number of sources, as identified in **Table 11.1**. Components of the Plan will be able to be carried out directly by either Liverpool Council or Fairfield Council, whilst other components that affect both Council areas will need to be carried out jointly.

11.1 OPTIONS WHICH MODIFY FLOOD BEHAVIOUR

The major structural option that is recommended for the Cabramatta Creek catchment is a revised new release area detention basin strategy for Liverpool City Council. This basin strategy is principally aimed at ensuring that new release area development does not increase flooding elsewhere in the catchment. This includes the construction of Detention Basins 3B, 4, 6, 11C, 12, 14, and a major component of the dual purpose Council/WSO Basin 18.

The WSO component of Basin 18, in addition to a reduced size Basin 22 and Government Road Basin will provide compensatory storage for the proposed WSO highway. Design and funding for the three basins have been included as part of the WSO project.

In addition, a new basin has been proposed in Brickmakers Creek at Amalfi Park. The objective of this basin is to reduce existing flood problems in Brickmakers Creek below the basin site, in conjunction with other channel improvement measures. Further detailed modelling of Brickmakers Creek, between Amalfi Park and Memorial Avenue, is recommended to fully evaluate these measures.

Channel works are included in the Plan on Maxwells Creek, upstream of Kurrajong Road. These works are to replace a small artificial channel that currently exists by a more "natural" watercourse, incorporating part of the detention storage requirements for Basin 18. A concept design report for these works was recently undertaken, and further detailed design is anticipated to be included in the WSO project.

There are a number of arterial roads throughout the catchment which are affected by flooding, and which result in traffic disruption and other access difficulties during relatively minor floods. The RTA has recently commenced upgrading Hoxton Park Road in the vicinity of the Cabramatta Creek and Maxwells Creek crossing. Whilst these works will reduce the frequency of overtopping of this road, it can not be expected to eliminate flooding problems along the road. To do so would require significant raising of the road, which would then likely result in an adverse impact on nearby properties. Raising of Cowpasture Road is also currently being considered by the RTA in conjunction with the WSO project.

Culvert amplification on Brickmakers Creek at Orange Grove Road, Elizabeth Drive and Moore Avenue have been recommended as part of subsequent investigations (**Appendix C**).

A package of flood mitigation works has been developed in the Elizabeth Drive area to reduce flooding problems experienced in the Tresalam Street area. The works include the construction of a low embankment upstream of Elizabeth Drive to prevent floodwaters overtopping this road and entering the area "protected" by the Tresalam Street levee. Compensatory measures for this embankment include improvements to the waterway area under Elizabeth Drive and the removal of debris and selected exotic vegetation from the creek corridor. The installation of pumps behind the Tresalam Street levee has also been recommended in other studies to reduce local drainage problems. There is little benefit in raising the Tresalam Street levee, which provides a level of protection close to the 100 year flood (with no freeboard), as overtopping from Elizabeth Drive is expected to occur at the 100 year flood level. However, an automated flood warning siren is recommended to provide residents with added warning prior to potential overtopping of the levee.

A number of individual bushland management reports have been prepared for particular areas of Cabramatta Creek. Development of an overall bushland management program covering Cabramatta Creek, Hinchinbrook Creek, Upper Cabramatta Creek, Maxwells Creek and Brickmakers Creek is recommended in the floodplain management plan. An initial program to clear the creek corridors of existing debris and other man-made obstructions is also included in the Plan.

The potential to lower flood levels in the Georges River, and consequently the lower reaches of Cabramatta Creek, is the subject of concurrent investigations. This Plan encourages further consideration of such flood mitigation works on the Georges River.

11.2 PROPERTY MODIFICATION OPTIONS

The options described above improve flooding in the Cabramatta Creek catchment, however, it is not economically feasible to offer a complete level of protection for the whole catchment that may be expected by the community. For this reason, a number of property modification options are proposed to provide the extra level of protection required within the catchment.

Voluntary house raising is proposed as part of the Cabramatta Creek Floodplain Management Plan for those residential property that are below the 100 year ARI flood

after other flood mitigation measures are implemented. Further review of the properties to be included in both schemes should be undertaken prior to establishing final lists.

Floodproofing of ground floor blocks of units and commercial properties is also included in the Plan to minimise damage that may be sustained from flooding. Funding assistance for these works is not usually provided by the Government.

Controls on new development and redevelopment at residential/commercial properties will ensure that the flooding problem is not made worse and that the development itself is not affected by flooding. A review of flood related planning controls has been undertaken for Cabramatta Creek. Specific amendments to existing planning controls are recommended as part of the floodplain management plan, and a revised floodplain management policy is proposed.

A "planning matrix" approach forms the main basis of the proposed floodplain management policy, which is proposed to be adopted as a development control for both Councils (**Figure 10.5**). The planning matrix provides guidance as to the location and appropriate land uses within the floodplain.

11.3 OPTIONS WHICH MODIFY PEOPLE'S RESPONSE TO FLOODING

Raising the community's awareness of flooding can significantly reduce the impacts of flooding. Analysis within the current study has shown this to be a viable option, which was strongly supported by the community.

Key features of the proposed flood awareness program include:

- Updating Section 149 Certificates;
- issuing flood certificates to property owners on a regular basis;
- establishing a community education program; and
- installing flood markers to act as reminders of the height of previous floods.

An improved flood warning system for Lower Cabramatta Creek is included in the floodplain management plan. This could provide additional warning time typically of 2-3 hours, allowing the community to undertake some damage reduction measures, thereby reducing actual flood damages. It is likely that the warning system would be developed in conjunction with the construction of Basin 22.

An improved flood warning system, in conjunction with additional information on flood behaviour, will allow the SES to improve their existing emergency management and response procedures during floods.

Finally, the Plan encourages the preparation of flood action plans for flood affected buildings. Ideally these would be prepared for blocks of units, townhouses or commercial property, but could also apply to individual residential buildings. These plans would be simple instructions informing people what to do, who to contact, and where to go, in the event of a flood.

Table 11.1 Recommended Floodplain Management Measures

Item	Description	Responsibility	Capital Cost ($Mill)*	Maintenance Cost($000)	Source of Funds	Priority
	Measures that Modify the Flood					
1	Liverpool Council Detention Basin Strategy					
	• Basin 3B	LCC	0.6	5	S94	high
	• Basin 4	LCC	1.8	10	S94	medium
	• Basin 6	LCC	1.1	5	S94	medium
	• Basin 11C	LCC	0.4	5	S94	high
	• Basin 12	LCC	2.1	10	S94	high
	• Basin 14	LCC	0.3	5	S94	high
	• Basin 18 (included as dual purpose WSO basin)	RTA	N/A	N/A	RTA	high
2	WSO Compensatory Flood Storage Basins					
	• Basin 18	RTA	N/A	N/A	RTA	high
	• Basin 22	RTA	N/A	N/A	RTA	high
	• Government Road Basin	RTA	N/A	N/A	RTA	high
3	Amalfi Park Detention Basin (Brickmakers Ck) and/or channel improvement measures	LCC	1.4	5	LCC/DIPNR	medium
4	Additional 2D computer modeling of Brickmakers Creek, including review of flood mitigation options (Memorial Ave to Amalfi Park)	LCC	0.1	Nil	LCC/DIPNR	high
5	Brickmakers Creek FM Works (Homepride Ave to Memorial Ave)					
	• Creek rehabilitation	LCC	1.9	5	LCC/DIPNR	medium
	• Upgrade Orange Grove Road Culvert	LCC	0.4	Nil	LCC/DIPNR	high
	• Upgrade Elizabeth Road Culvert	LCC	0.6	Nil	LCC/DIPNR	high
	• Channel improvements (Orange Grove Rd to Elizabeth Dr)	LCC	2.0	5	LCC/DIPNR	high
	• Floodwall to prevent overflows to CBD area	LCC	0.1	Nil	LCC/DIPNR	medium
6	Maxwells Ck channel works (Kurrajong Rd to Camden Valley Way)	RTA	N/A	N/A	RTA	high
7	Culvert amplification/road raising to improve access					
	• Hoxton Park Road (Cabramatta Creek)	RTA	1.0	Nil	RTA	Completed
	• Hoxton Park Road (Hinchinbrook Ck)	RTA	0.5	Nil	RTA	Completed
	• Hoxton Park Road (Maxwells Ck)	RTA	0.5	Nil	RTA	Completed
	• Jedda Road (Maxwells Ck)	LCC	0.5	Nil	LCC/DIPNR	medium
	• Moore Street (Brickmakers Ck)	LCC	0.3	Nil	LCC/DIPNR	medium

Item	Description	Responsibility	Capital Cost ($Mill)*	Maintenance Cost($000)	Source of Funds	Priority
8	Works at Elizabeth Drive					
	• Construction of low embankment upstream of Elizabeth Dr, improve effective waterway area under bridge, removal of rubbish and selective clearance of exotic vegetation	FCC/LCC	0.7	2	FCC/DIPNR	Completed
	• Install pumps for local drainage behind levee (subject to evaluation)	FCC	0.4	4	FCC/DIPNR	medium
	• Install automated flood warning siren (subject to evaluation)	FCC	0.1	Nil	FCC/DIPNR	medium
9	Develop an urban bushland management plan for existing creek corridors (Cabramatta Ck, Hinchinbrook Ck, Brickmakers Ck)	LCC/FCC	0.1	Nil	LCC/FCC/DIPNR	high
10	Clear Creek of existing debris and other man-made obstructions	LCC/FCC	0.3	3	LCC/FCC/DIPNR	high
11	Further investigation of flood mitigation works on the Georges R.	LCC/FCC	N/A	Nil	N/A	Completed
	Measures that Modify the Property					
12	Voluntary House Raising					
	• Liverpool City Council	LCC	TBA	Nil	LCC/DLWC	low
	• Fairfield City Council	FCC	TBA	Nil	FCC/DLWC	high
13	Flood proofing individual commercial properties					
	• Liverpool City Council	Individual owners	N/A	Nil	N/A	medium
	• Fairfield City Council		N/A	Nil	N/A	medium
14	Improve existing building and development controls	LCC/FCC	Nil	Nil	N/A	high
	Measures that Modify People's Response to flooding					
15	Flood Awareness Program					
	• Updating Section 149 Certificates	LCC/FCC	Nil	Nil	N/A	high
	• Issue flood certificates to property owners on regular basis	LCC/FCC	Nil	Nil	N/A	high
	• Establish a community education program	LCC/FCC	0.1	10	LCC/FCC/DIPNR	medium
	• Install flood markers to remind of previous floods	LCC/FCC	0.05	1	LCC/FCC/DIPNR	medium
16	Improve flood warning before and during floods	LCC/FCC	0.05	5	BoM/LCC/FCC	medium
17	Improve evacuation procedures and emergency assistance	LCC/FCC	Nil	Nil	N/A	medium
18	Prepare flood action plans for individual properties	LCC/FCC	Nil	Nil	N/A	Medium
	TOTAL		**17.4**	**80**		

* Costs exclude land acquisition, and voluntary house raising costs (to be advised)

FIGURE 11.1

Develop Urban Bushland Management Plans.
Clear Creeks of Rubbish

Culvert amplification/Road raising works
to improve flood access at various locations

Elizabeth Drive works including
upstream wall and waterway improvements
(COMPLETED)

Install Flood Warning Siren
for Residents of Tresalam St

Construct Detention
Basin No.3b

Construct Detention
Basin No.4

Construct Detention
Basin No.6

Construct Government
Road Basin
(Included in W.S.O.)

Construct reduced size
Detention Basin No.22
(Included in W.S.O.)

Construct Detention
Basin No.11c

Construct Detention
Basin No.12

Construct Detention
Basin No.14

Creek Rehabilitation
Orange Grove Rd - Homepride Ave

Upgrade Orange Grove Rd Culvert

Channel Improvement Works and Floodwall
Orange Grove Rd - Elizabeth Drive

Upgrade Elizabeth Drive Culvert

Establish revised 2D Model
and review potential options
(Memorial Ave to Amalfi Park)

Construct Amalfi Park
Detention Basin

Maxwells Creek Channel
Improvement Works
(Included in W.S.O.)

Construct Detention Basin No.18
Dual Purpose W.S.O./Council Basin
(Included in W.S.O.)

Further investigate flood mitigation
works on the Georges River
(COMPLETED)

Measures that Modify Property

- Voluntary House Raising
- Flood Proofing Commercial Buildings/Units
- Improved Building and Development Controls

Measures that Modify People's Response

- Comprehensive Flood Awareness Program
- Improved Flood Warning System
- Improved Evacuation Procedures
- Preparation of Flood Action Plans

LEGEND

- Catchment Boundary
- Local Government Boundary
- Existing Detention Basin
- Proposed Detention Basin

0 1 2km
Scale

RECOMMENDED FLOODPLAIN MANAGEMENT PLAN

CABRAMATTA CREEK FLOODPLAIN MANAGEMENT STUDY

FLOODPLAIN MANAGEMENT CONSULTANTS

BEWSHER CONSULTING PTY LTD
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Plot file name: J1150-fig11.1
Plot scale 50 (=1:50000 @ a3)
Date : May 2004

11.4 FUNDING AND IMPLEMENTATION

Liverpool City Council is currently collecting Section 94 Contributions from development within the new release areas, which is required for drainage and other compensatory flood mitigation measures necessary as a result of this development. Components of the Cabramatta Creek Floodplain Management Plan required for this purpose include the construction of Basins 3B, 4, 6, 11C, 12, 14 and part of Basin 18. Whilst a number of detention basins have already been constructed through this source of funding, it is now appropriate to revise the amount of Section 94 Contributions that are being collected in view of the revised detention basin strategy presented in this Plan.

The Roads and Traffic Authority (RTA) or the consortium selected to design/construct/manage the WSO project, are another source of funding towards implementation of part of the floodplain management plan associated with these works. The RTA would be required to contribute to all or part of the costs for the Government Road Basin and Basins 18 and 22, which will be required to compensate for loss in floodplain storage along Maxwells Creek, Cabramatta Creek and Hinchinbrook Creek.

Both Councils could also expect assistance with implementing parts of the Plan that contribute to reducing existing flood problems, from the State Government. Funding assistance is normally on a 2:1 basis (State:Council). Special grant money may also be available in some cases.

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

The steps in progressing the floodplain management process from this point are as follows:

- both Councils allocate priorities to components of the Plan, based on available sources of funding and budgetary constraints;
- both Councils submit an application for funding assistance to DIPNR, and negotiates other sources of funding such as through the “Natural Disaster Mitigation Package” (NDMP) or through the RTA;
- as funds become available, implementation of the Plan proceeds in accordance with established priorities.

11.5 ON-GOING REVIEW OF PLAN

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, changes to the area's planning strategies, or the outcome of any further review of Liverpool Council's detention basins strategy. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

Implementation of the Plan should also be monitored by each Council's Floodplain Management Committee.

It is also imperative that flood risk maps and other maps showing flood extents and flood levels are updated as further development occurs within the catchment, particularly for Liverpool Council where the majority of development will occur. Much of this information will be contained in Liverpool Council's GIS computer system. This will require continual updating as further studies and other assessments are undertaken in connection with ongoing development within the catchment.

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13. GLOSSARY

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

100 year flood	A **flood** that occurs on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year flood	A **flood** that occurs on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year flood	A **flood** that occurs on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe **flood** size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a **flood** that occurs or is exceeded on average once every 100 years. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **average recurrence interval (ARI)**.
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All **flood levels**, floor levels and ground levels in this study have been provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe **flood** size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms **100 year flood**, **50 year flood**, **20 year flood** etc, have been used in this study. See also **annual exceedance probability (AEP)**.
catchment	The land draining through the main stream, as well as tributary streams.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
design flood level	A flood with a nominated probability or average recurrence interval, for example the 100 year flood.
DIPNR	Department of Infrastructure, Planning and Natural Resources. Now incorporates the floodplain management responsibilities of the former Department of Land and Water Conservation.
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.

DLWC	Department of Land and Water Conservation. This was the name given to the Department of Water Resources (DWR), the Department of Conservation and Land Management (CALM) and flood sections of the Public Works Department (PWD) from May 1995. DLWC was incorporated into the Department of Infrastructure, Planning and Natural Resources (DIPNR) from 1 July 2003. DLWC has been used in this report, except for work and/or studies carried out by the departments prior to May 1995.
DUAP	The former Department of Urban Affairs and Planning (NSW). Previously the Department of Planning (NSW). Superseded by **Planning NSW**, which was incorporated into the Department of Infrastructure, Planning and Natural Resources from 1 July 2003.
DWR	The former Department of Water Resources. This department became a major component of the Department of Land and Water Conservation (DLWC) in May 1995.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the *Local Government Act 1993*.
effective warning time	The time available after receiving advice of an impending **flood** and before the floodwaters prevent appropriate flood response actions being undertaken. The **effective warning time** is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.
extreme flood	An estimate of the **probable maximum flood (PMF)**, which is the largest flood likely to occur.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 7.8m AHD). Terms also used include **flood stage** and **water level**.

flood liable land	Land susceptible to flooding up to the **probable maximum flood (PMF)**. Also called **flood prone land**. Note that the term flood liable land now covers the whole of the **floodplain**, not just that part below the **flood planning level**, as indicated in the superseded Floodplain Development Manual (NSW Government, 1986).
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain management studies** and incorporated in **floodplain management plans**. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the **probable maximum flood (PMF**). Also called **flood liable land**.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a **flood**.
flood stage	see **flood level**.
Flood Study	A study that investigates flood behaviour, including identification of flood extents, **flood levels** and flood velocities for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Management Risk Study**.
Floodplain Risk Management Study	The current study. These studies are carried out in accordance with the *Floodplain Management Manual* (NSW Government, 2001) and assess options for minimising the danger to life and property during **floods**. These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a **Floodplain Risk Management Plan**.
floodway	Those areas of the **floodplain** where a significant discharge of water occurs during **floods**. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in **flood levels**.
flow	see **discharge**
freeboard	A factor of safety expressed as the height above the **design flood level**. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such 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.
high flood hazard	For a particular size **flood**, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and **velocity**.

hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
km	kilometres. 1km = 1,000m = 0.62 miles.
km^2	square kilometres. $1km^2 = 1,000,000m^2 = 100ha \approx 250$ acres.
LGA	Local Government Area, or Council boundary.
local catchments	Local catchments are river sub-catchments that feed river tributaries, creeks, watercourses and channelised or piped drainage systems.
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
local overland flooding	Local overland flooding is inundation by local runoff within the local catchment.
local runoff	local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Management Manual, 2001.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m	metres. All units used in this report are metric.
m AHD	metres **Australian Height Datum (AHD)**.
m/s	metres per second. Unit used to describe the **velocity** of floodwaters. 10km/h ≈ 2.8m/s.
m^2	square metres. $1m^2 \approx 10.8$ square feet.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek flows or **discharges**. It is the rate of flow of water measured in terms of volume per unit time.
MHL	Manly Hydraulics Laboratory, formerly a branch of the NSW Public Works Department.
ML	Megalitre. 1ML = 1,000 m^3.
merit approach	The principles of the merit approach are embodied in the *Floodplain Management Manual* (NSW Government, 2001) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.
MIKE-11	The software program used to develop a computer model that analyses the **hydraulics** of the waterways within a **catchment** and calculates water levels (flood levels) and flow **velocities**. Known as a hydraulic model.
mm	millimetres. 1m = 1,000mm

overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum **flow** or **discharge** during a flood.
Planning NSW	Formerly the **Department of Urban Affairs and Planning (NSW)** and the Department of Planning (NSW), at present DIPNR (since March 2003)
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
PWD	Public Works Department. Formerly the State Government Department responsible for floodplain management matters in tidal waterways.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
REP	Regional Environmental Plan. A plan prepared in accordance with the EP&A Act that provides objectives and controls for a region, or part of a region. For example, the Georges River REP.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RAFTS	The software program used to develop a computer model that analyses the **hydrology** (rainfall–**runoff** processes) of the **catchment** and calculates hydrographs and **peak discharges**. Known as a hydrological model.
RMA-2V	A two dimensional hydraulic model used to calculate flood levels and extents in creeks and floodplains.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in **m/s** (metres per second). 10km/h = 2.7m/s.
water level	see **flood level**.
water surface profile	A graph showing the height of the **flood** (**flood stage**, **water level** or **flood level**) at any given location along a watercourse at a particular time.

APPENDIX A

FREQUENTLY ASKED QUESTIONS

FLOODPLAIN MANAGEMENT STUDIES

FREQUENTLY ASKED QUESTIONS

Why do flood levels change over time?

There is a chance that floods of various magnitudes will occur in the future. As the size of a flood increases, the chance that it will occur becomes rarer. Because some of these rare floods have never been experienced since European settlement, the height of future floodwaters is normally predicted using computer models. These computer models simulate flood levels and velocities for a range of flood sizes and flood probabilities. Given the importance of estimating flood levels accurately, councils and the Department of Infrastructure Planning and Natural Resources (formerly DLWC) engage experts to establish and operate the computer models.

From time to time the computer models are revised and predicted flood levels can change. The resultant change in flood levels however is normally very small. The reasons why the computer models are revised can include:

- new rainfall or ground topography information becomes available;
- new floods occur which provide additional data from which to fine-tune the models;
- better computer models become available as the science of flood modelling improves and computer capabilities increase; or
- flood mitigation works may have been carried out, or development within the catchment may have occurred, that was not previously simulated in the models.

How are these studies funded?

These types of studies are normally carried out under State Government guidelines and are funded on a 2:1 basis between the State Government and councils. This funding arrangement is also available for the construction of flood mitigation works.

My property is in a Low Flood Risk Precinct. What does this mean?

The classification of a 'Low Flood Risk Precinct' can differ slightly between councils. Generally it means that your property would not be inundated in a 100 year flood but still has a very slight risk of inundation from larger (i.e. rarer) floods.

If you are a residential property owner, there will be virtually no change to how you may develop your property. However, there may be controls on the location of essential services such as hospitals, evacuation centres, nursing homes and emergency services.

My property is in a Medium Flood Risk Precinct. What does this mean?

The classification of a 'Medium Flood Risk Precinct' can differ slightly between councils. Generally it means that your property is inundated in a 100 year flood, however conditions are not likely to be hazardous. If you are a residential property owner development controls will probably be similar to those that currently exist.

My property is in a High Flood Risk Precinct. What does this mean?

The classification of a 'High Flood Risk Precinct' can differ slightly between councils. Generally it means that your property will be inundated in a 100 year flood and that hazardous conditions may occur. This could mean that there would be a possible danger to personal safety, able bodied adults may have difficulty wading to safety, evacuation by trucks may be difficult, or there may be a potential for significant structural damage to buildings. This is an area of higher hazard where stricter controls may be applied.

Will my property value be altered if I am in a Flood Risk Precinct?

Any change in a council's classification of properties can have some impact on property values. Nevertheless, councils normally give due consideration to such impacts before introducing a system of flood risk classifications or any other classification system (e.g. bushfire risks, acid sulphate soil risk, etc). If your property is now classified as being in a Flood Risk Precinct, the real flood risks on your property have not changed, only its classification has altered. A prospective purchaser of your property could have previously discovered this risk if they had made enquiries themselves.

If you are in a Low Flood Risk Precinct, generally there will be no controls on normal residential type development. Previous valuation studies have shown that under these circumstances, your property values will not alter significantly over the long term. Certainly, when a new system of classifying flood risks is introduced, there may be some short-term effect, particularly if the development implications of the precinct classification are not understood properly. This should only be a short-term effect however until the property market understands that over the long-term, the Low Flood Risk Precinct classification will not change the way you use or develop your property.

Ultimately, however, the market determines the value of any residential property. Individual owners should seek their own valuation advice if they are concerned that the flood risk precinct categorisation may influence their property value.

My property was never classified as 'flood prone' or 'flood liable' before. Now it is in a Low Flood Risk Precinct. Why?

The State Government changed the meaning of the terms 'flood prone', 'flood liable' and 'floodplain' in 2001. Prior to this time, these terms generally related to land below the 100 year flood level. Now it is different. These terms now relate to all land that could possibly be inundated, up to an extreme flood known as the probable maximum flood (PMF). This is a very rare flood.

The reason the Government changed the definition of these terms was because there was always some land above the 100 year flood level that was at risk of being inundated in rarer and more extreme flood events. History has shown that these rarer flood events can and do happen (e.g. the 1990 flood in Nyngan, the November 1996 flood in Coffs Harbour, the August 1998 flood in Wollongong, the 1998 flood in Katherine, the 2002 floods in Europe, etc).

Will I be able to get house and contents insurance if my house is in a Flood Risk Precinct?

In contrast to the USA and many European countries, flood insurance is generally not available for residential property in Australia. Following the disastrous floods in Coffs Harbour in November 1996 and in Wollongong in August 1998, some insurance companies are now offering very limited flood cover. The most likely situation is that your insurer does not offer you flood cover. If limited flood cover is offered, the classification of your property within a Flood Risk Precinct is unlikely to alter the availability of cover. Obviously insurance policies and conditions may change over time or between insurance companies, and you should confirm the specific details of your situation with your insurer.

Will I be able to get a home loan if my land is in a Flood Risk Precinct?

Most banks and lending institutions do not account for flood risks when assessing home loan applications unless there is a very significant risk of flooding at your property. The system of Flood Risk Precinct classification will make it clear to all concerned, the nature of the flood risks. Under the previous system, if a prospective lending authority made appropriate enquiries, they would have identified the nature of the flood risk and considered it during assessment of home loan applications. As a result, it is not likely that the classification of your property within a Flood Risk Precinct will alter your ability to obtain a home loan. Nevertheless, property owners who are concerned about their ability to obtain a loan should clarify the situation with their own lending authority.

How have the flood risk maps been prepared?

Because some large and rare floods have often not been experienced since European settlement commenced, computer models are used to simulate the depths and velocities of major floods. These computer models are normally established and operated by flooding experts employed by local and state government authorities. Because of the critical importance of the flood level estimates produced by the models, such modelling is subjected to very close scrutiny before flood information is formally adopted by a council. Maps of flood risks (e.g. 'low', 'medium' and 'high') are prepared after consideration of such issues as:

- flood levels and velocities for a range of possible floods;
- ground levels;
- flood warning time and duration of flooding;
- suitability of evacuation and access routes; and
- emergency management during major floods.

What is the probable maximum flood (PMF)?

The PMF is the largest flood that could possibly occur. It is a very rare and improbable flood. Despite this, a number of historical floods in Australia have approached the magnitude of a PMF. Every property potentially inundated by a PMF will have some flood risk, even if it is very small. Under the State Government changes implemented during 2001, councils must now consider all flood risks, even these potentially small ones, when managing floodplains. As part of the State Government changes, the definitions of the terms 'flood liable', flood prone' and 'floodplain' have been changed to refer to land inundated by the PMF.

What is the 100 year flood?

A 100 year flood is the flood that will occur or be exceeded on average once every 100 years. It has a probability of 1% of occurring in any given year. If your area has had a 100 year flood, it is a fallacy to think you will need to wait another 99 years before the next flood arrives. Floods do not happen like that. Some parts of Australia have received a couple of 100 year floods in one decade. On average, if you live to be 70 years old, you have a better than even chance of experiencing a 100 year flood.

Why do councils prepare floodplain management studies and plans?

Under NSW legislation, councils have the primary responsibility for management of development within floodplains. To appropriately manage development, councils need a strategic plan which considers the potential flood risks and balances these against the beneficial use of the floodplain by development. To do this, councils have to consider a range of environmental, social, economic, financial and engineering issues. This is what happens in a floodplain management study. The outcome of the study is the floodplain management plan, which details how best to manage flood risks in the floodplain for the foreseeable future.

Floodplain management plans normally comprise a range of works and measures such as:

- improvements to flood warning and emergency management;
- works (e.g. levees or detention basins) to protect existing development;
- voluntary purchase or house raising of severely flood-affected houses;
- planning and building controls to ensure future development is compatible with the flood risks; and
- measures to raise the community's awareness of flooding so that they are better able to deal with the flood risks they face.

Will the Flood Risk Precinct maps be changed?

Yes. All mapping undertaken by council is subjected to ongoing review. As these reviews take place, it is conceivable that changes to the mapping will occur, particularly if new flood level information or ground topography information becomes available. However, this is not expected to occur very often and the intervals between revisions to the maps would normally be many years. Many councils have a policy of reviewing and updating floodplain management studies and plans about every five years. This is the likely frequency at which the maps may be amended.

Appendix B

Updated RAFTS Flow Estimates for 2001 Catchment Conditions

[Bewsher Consulting and WBM Oceanics, 2001]

Table B.1 Updated 2001 Peak Flow Estimates
Cabramatta Creek – Down to Hinchinbrook Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)
1.00A	Denham Court	3	120	2	120	13	60
1.00B	Denham Court	8	120	6	120	36	60
1.00C	Denham Court	12	120	8	120	51	60
1.00D	Denham Court	15	120	10	120	65	60
1.00G	Denham Court	5	120	3	120	20	60
1.00E	Denham Court	4	120	3	120	15	60
1.00F	Denham Court	12	120	9	120	53	60
1.00H	Denham Court	29	120	21	120	129	60
1.00I	Denham Court	35	120	25	120	154	60
1.00J	Denham Court	4	120	3	120	17	60
1.00K	Denham Court	8	120	6	120	31	60
1.00L	Denham Court	47	120	34	120	201	60
1.00M	Denham Court	50	120	36	120	216	60
1.01	Cab Ck J'dine Dr	59	120	42	120	257	60
1.02	Cab Ck J'dine Dr	65	120	46	120	286	60
1.03	Cabramatta Creek	72	120	51	120	312	60
2.00A	Lawn Cemetery	3	120	2	120	13	60
2.00B	Lawn Cemetery	6	120	4	120	33	60
2.00C	Lawn Cemetery	10	120	7	120	55	60
2.00D	Lawn Cemetery	6	120	4	120	27	60
2.00E	Lawn Cemetery	17	120	12	120	90	60
2.01A		3	120	2	120	15	60
2.01B		6	120	4	120	31	60
2.01C		24	120	17	120	123	60
2.02		26	120	19	120	133	60
1.04	Cam. Valley Way	94	120	67	120	403	60
1.05	Cabramatta Creek	95	120	68	120	404	60
25.00		13	90	11	90	42	15
1.06	Cabramatta Creek	96	120	69	120	403	120
26.00		11	90	8	90	33	15
1.07	Cab Ck. Bazaar	97	120	70	120	412	120
1.08A	Cabramatta Creek	98	120	71	120	420	120
3.00A	Creek E	5	120	4	120	24	60
3.00B	Ck E C'psture Rd	8	120	6	120	37	60
3.01	Creek E	12	120	9	120	52	60
4.00A	Ck E C'psture Rd	8	90	6	90	25	60
4.00B	Creek E	10	120	8	120	36	60
3.02	Creek E	13	120	10	120	72	60
3.03A	Ck E C'psture Rd	11	90	9	90	37	15
3.03B	Ck E C'psture Rd	13	90	10	90	42	15
3.03C	Ck E Golf Course	18	90	14	90	91	60
3.04		24	120	19	120	107	120
1.08B	Cabramatta Creek	111	120	81	120	527	120
1.09A		10	90	8	90	31	15
1.09B		12	90	10	90	43	15
1.09C	Cab Ck K'jong Rd	113	120	83	120	545	120
1.10A		6	90	4	90	21	60
1.10B		8	90	6	90	33	60
1.10C	Cab Ck Y'nga Rd	117	120	85	120	581	120
1.10D		118	120	87	120	598	120
5.00A	Creek A	3	120	2	540	15	120
5.00B	Creek A	9	120	6	120	47	60
5.01A	Creek A	5	120	3	120	24	60
5.01B	Creek A	5	120	4	120	25	60
5.01C	Creek A	14	120	10	120	74	60
5.01D	Creek A	16	120	12	120	81	60
5.02	Creek A	21	120	15	120	90	120
27.00	Creek A	4	120	3	120	27	60
5.03	Creek A	24	120	18	120	106	120
5.04	Ck A C'psture Rd	22	90	17	90	114	120
5.05	Ck A 19th Ave	20	720	16	90	118	240
5.06	Ck A 1st Ave	23	90	18	90	121	240
1.11	Cabramatta Creek	130	120	98	120	673	120

Note: For detention basins, critical duration is shown for inflow only

Table B.2 Updated 2001 Peak Flow Estimates
Hinchinbrook Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit Dur. (min)
11.00	Creek J	9	90	7	90	28	60
11.01	Creek J	13	90	10	90	45	60
12.00A	Creek J	16	90	13	90	46	15
12.00B	Ck J C'psture Rd	25	90	20	90	78	60
11.02	Creek J	26	90	21	90	119	60
11.03	Creek J	28	90	23	90	124	60
9.00A	Creek K	6	120	4	120	27	60
9.00B	Creek K	8	120	6	120	36	60
9.00C	Creek K	6	120	4	120	26	60
9.00D	Creek K	16	120	12	120	72	60
9.00E	Creek K	4	120	3	120	18	60
9.00F	Ck K Liv. R'voir	12	120	9	120	48	60
9.00G	Creek K	19	120	13	120	79	60
9.00H	Creek K	33	120	24	120	141	60
10.00A	Creek K	6	120	4	120	22	30
10.00B	Creek K	9	120	6	120	35	60
9.01	Ck K Ex. Dam	44	120	32	120	184	60
9.02	Creek K	49	120	35	120	194	60
6.00A	Elizabeth Dr.	8	120	5	120	35	60
6.00B	Creek K	15	120	11	120	61	60
7.00A	Elizabeth Dr.	8	540	6	540	40	120
7.00B	Creek K	24	90	19	90	65	15
6.01	Creek K	29	90	23	90	115	120
6.02	Creek K	35	90	28	90	128	120
8.00C	Creek K	6	120	4	120	22	30
8.00A	Creek K	7	120	5	120	22	30
8.00B	Creek K	9	120	7	120	31	30
8.00D	Creek K	17	120	12	120	59	30
8.00E	Creek K	22	120	16	120	75	60
6.03	Cecil Hls Wetland	47	90	38	90	188	60
6.04	Hinchinbrook Ck	36	540	28	540	185	120
6.05	Hinchinbrook Ck	81	120	55	540	362	60
6.06A		2	90	2	90	8	60
6.06B		5	90	4	90	19	60
6.06C	Hinchinbrook Ck	84	120	58	540	392	120
6.07	Hinchinbrook Ck	105	120	70	120	490	60
13.00A	Creek M	4	120	3	120	20	60
13.00B	Creek M	9	120	7	120	45	60
13.01	Creek M	12	120	9	120	59	60
14.00A	Creek M	3	120	2	120	17	60
14.00B	Creek M	6	120	4	120	30	60
13.02	Creek M	18	120	12	120	87	60
13.03	Ck M H Pk A'drme	21	120	15	120	99	60
6.08	Hinchinbrook Ck	126	120	84	120	589	60
6.09	Hinchinbrook Ck	129	120	86	120	596	60
28.00	C'psture Rd	33	90	27	90	94	15
6.10	Hinchinbrook Ck	139	120	94	120	619	120
6.11	Hinchinbrook Ck	140	120	94	120	631	120
6.12	Hinchinbrook Ck	141	120	95	120	638	120
15.00A	Creek N	4	120	3	120	19	60
15.00B	Ck N Mciver	7	120	5	120	35	60
15.01	Creek N	11	120	8	120	51	60
15.02	Ck N C'psture Rd	18	120	13	120	85	120
16.00A	Creek L	7	120	5	120	36	60
16.00B	Ck L 2nd Ave	10	120	7	120	48	60
16.01	Ck L C'psture Rd	18	120	13	120	86	60
15.03		36	120	25	120	164	60
6.13	Hinchinbrook Ck	167	120	112	120	781	120
6.14A		8	90	7	90	27	15
6.14B	Hinchinbrook Ck	168	120	113	120	792	120
6.14C		18	90	15	90	58	15
6.14D	Hinchinbrook Ck	172	120	116	120	826	120
17.00A	Creek C	7	90	5	90	28	60
17.00B	Ck C 2nd Ave	13	120	9	90	61	60
17.01	Ck C C'psture Rd	23	90	18	90	79	60
17.02B	Creek C	3	90	3	90	18	60
17.02A	Creek C	30	90	23	90	114	60
6.15	Hinchinbrook Ck	189	120	131	120	926	120
6.16		189	120	130	120	937	120

Note: For detention basins, critical duration is shown for inflow only

Table B.3 Updated 2001 Peak Flow Estimates Cabramatta Creek – Hinchinbrook Creek to Maxwells Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit Dur. (min)
1.12	Cab Ck I'roo Rd	301	120	218	120	1565	120
1.13	Cab Ck H. Pk Rd	304	120	219	120	1586	120
1.14C	Miller Creek	13	90	10	90	44	30
1.14A	Miller Ck Banks Rd	36	90	29	90	121	15
1.14B	Miller Creek	21	90	17	90	95	60
1.14D	Miller Ck Cart. Ave	30	90	24	90	139	60
1.14E	Miller Ck Cart. Ave	33	90	26	90	147	60
1.14F	Miller Ck Cart. Ave	310	120	225	120	1653	120
1.14G	Miller Ck Cart. Ave	311	120	225	120	1661	120
1.15	Miller Ck Cart. Ave	311	120	226	360	1666	120

Note: For detention basins, critical duration is shown for inflow only

Table B.4 Updated 2001 Peak Flow Estimates Maxwells Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit Dur. (min)
23.00A	Creek I	10	90	8	90	32	60
23.00B	Creek I	11	90	9	90	41	60
23.01A	Creek I	17	90	13	90	78	60
23.01B	Creek I	19	90	14	120	87	60
22.00A	Creek B	4	120	3	120	20	60
22.00B	Ck B Skipton Lane	5	90	4	90	22	60
20.00A	Creek D	4	120	3	120	20	60
20.00B	Ck D Croatia Ave	7	120	5	120	37	60
20.01	Ck D C V Way	17	120	12	120	73	120
20.02	Ck D Ash Rd	19	120	13	120	83	120
21.00	Ck D Bernera Rd	20	90	16	90	55	15
21.01	Ck D Ash Rd	25	90	20	90	73	60
20.03		36	120	27	120	126	60
18.00A	I'burn Army Camp	9	90	7	90	26	60
18.00B	I'burn Army Camp	16	90	13	90	60	60
18.00C	I'burn Army Camp	23	90	17	90	88	60
18.00D	C'town Road	26	120	19	90	101	60
19.00A	I'burn Army Camp	5	90	4	90	20	60
19.00B	I'burn Army Camp	10	120	7	120	45	60
19.01A	I'burn Army Camp	18	120	13	120	78	60
19.01B	C'town Road	21	120	15	120	92	60
18.01	Maxwells Creek	47	120	33	120	191	60
18.02	Max Ck SW F'way	56	120	39	120	236	120
18.03A		12	90	9	90	38	60
18.03B	Max Ck C V Way	60	120	42	120	250	120
18.04A	Max Ck M5	59	120	42	120	250	120
18.04B	Maxwells Creek	61	120	43	120	256	120
18.05	Maxwells Creek	79	120	56	120	336	120
29.00A	Ck B M5	14	90	11	90	38	15
29.00B	Creek B	15	90	12	90	41	15
18.06	Maxwells Creek	81	120	58	120	345	120
18.07	Maxwells Creek	80	120	59	360	346	120
18.08	Maxwells Creek	81	120	60	360	356	120
18.09A		5	90	4	90	17	60
18.09B	Max Ck K'jong Rd	84	360	65	540	377	240
18.10	Max Ck Showgrnd	92	90	71	540	406	240
18.11	Max Ck Jedda Rd	94	90	74	540	417	240
18.12	Maxwells Creek	94	90	75	540	419	240
18.13	Max Ck Lyn Pde	108	120	88	120	500	60
18.14A	Maxwells Creek	112	120	94	120	512	120
18.14B	Max Ck Hox Pk Rd	116	120	100	120	542	120
18.15	Maxwells Creek	116	120	100	120	547	120

Note: For detention basins, critical duration is shown for inflow only

Table B.5 Updated 2001 Peak Flow Estimates Cabramatta Creek – Maxwells Creek to Brickmakers Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit Dur. (min)
1.16	Cabramatta Creek	407	360	306	360	2133	120
1.17	Cab Ck Eliz Dr	416	360	312	360	2148	120
1.18A	Prout Ck	22	90	17	90	61	30
1.18B	Prout Ck	26	90	20	90	72	30
1.18C	Cabramatta Ck	423	360	317	360	2159	120
1.18D	Cab Ck O Grve Rd	428	360	320	360	2170	120
1.19	Cabramatta Creek	432	360	323	360	2175	120

Note: For detention basins, critical duration is shown for inflow only

Table B.6 Updated 2001 Peak Flow Estimates Brickmakers Creek

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit Dur. (min)
24.00C		5	90	4	90	15	60
24.00A		15	90	12	90	40	15
24.00B	Casula Mall Basin	23	90	18	90	82	60
24.00D	B'mkrs Ck K'jng Rd	13	90	12	90	93	60
24.01A	B'makers M5	22	90	19	90	111	60
24.01B		29	90	24	90	120	60
24.02D		25	90	20	90	72	60
24.02		44	90	35	90	148	120
24.02F	B'm Ck Reilly Rd	50	90	39	90	176	60
24.02A		23	90	18	90	63	60
24.02B		30	90	23	90	94	60
24.02C	Hoxton Pk Road	35	90	27	90	111	60
24.02G	B'mkrs Ck H P Rd	78	120	60	120	288	60
24.03A	B'm Ck Memorial	84	120	64	120	301	60
24.03B	B'mkrs Ck Eliz Dr	89	120	67	120	308	60
24.04A	B'm Ck H'pde Ave	91	120	69	120	319	120
24.04B	Brickmakers Ck	93	120	72	120	340	120

Note: For detention basins, critical duration is shown for inflow only

Table B.7 Updated 2001 Peak Flow Estimates Cabramatta Creek - Brickmakers Creek to Georges River

Link No.	Subcatchment Description	100 YEAR		20 YEAR		PMF	
		Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)	Flow (m^3/s)	Crit. Dur. (min)
1.20	Cabramatta Creek	470	360	353	720	2403	120
1.21	Cab Ck Railway	473	360	355	720	2414	240
1.22	Cabramatta Creek	475	360	358	720	2424	240
1.23	Cab Ck George R	479	360	361	720	2440	240

APPENDIX C

BRICKMAKERS CREEK
(Homepride Ave to Memorial Ave)

Review of Flood Behaviour

Liverpool City Council

Brickmakers Creek
(Homepride Ave to Memorial Ave)

Review of Flood Behaviour

December 2003

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1. INTRODUCTION

Brickmakers Creek is a tributary of Cabramatta Creek in Sydney's south-west. It has a catchment area of approximately 790ha, and drains a largely developed area of Liverpool. The creek commences near Casula to the south; flows adjacent to the Liverpool CBD area; and joins Cabramatta Creek near Warwick Farm.

Flood behaviour in Brickmakers Creek was investigated as part of the original Cabramatta Creek Floodplain Management Study [Bewsher Consulting, 1999] and is reported in more detail in the flood study report prepared as part of that study [Water Research Laboratory, 1998].

Since this time, Liverpool Council has been faced with increasing re-development pressures in the area immediately north of the Liverpool CBD area. Significant flooding was also experienced near the intersection of the Hume Highway and Orange Grove Road in January 2001 and again in February 2002. Council subsequently sought more detailed information on flooding in this area.

The objectives of the current investigation were to:

(i) provide more detailed modelling of the reach of Brickmakers Creek, between Memorial Avenue and Homepride Avenue;

(ii) provide revised flood extents and flood contours for the 20 year, 100 year and PMF floods, if these need to be revised;

(iii) investigate flood mitigation works to reduce the impact of flooding on affected properties in this reach of Brickmakers Creek, particularly creek rehabilitation works previously proposed by other consultants.

2. PREVIOUS MODEL RESULTS

Flood behaviour for Brickmakers Creek was previously assessed using the RAFTS hydrologic model to determine catchment flows and the RMA-2 hydraulic model to determine flood levels and the extent of flood inundation. The model represented flood behaviour over the entire Cabramatta Creek catchment, and subsequently was unable to include all areas in fine detail. On inspection of model results in the vicinity of lower Brickmakers Creek, and recent observations of flooding in this area, it was thought that the RMA-2 model might not contain sufficient detail to accurately represent flood behaviour within this area.

More recently, Patterson Britton & Partners developed a HEC-RAS hydraulic model of the lower reaches of Brickmakers Creek to assess potential creek rehabilitation works immediately downstream of Orange Grove Road. These rehabilitation works involved the removal of four 1.2m diameter low-flow pipes located below a grassed trapezoidal channel between Orange Grove Road and Homepride Avenue. The objective of these works was to increase the capacity of this channel, by lowering its invert level, and to re-instate a more 'natural' creek system through this part of Brickmakers Creek.

The HEC-RAS model is a one-dimensional hydraulic model that is capable of simulating flow conditions in the main channel. However, it is less appropriate for

modelling the potential overflow of floodwater out of the creek and the flow paths which could potentially occur through the residential area to the north of the Liverpool CBD.

Detailed flood investigations were also undertaken within the Cabramatta Creek catchment for the Roads and Traffic Authority, in connection with the proposed Western Sydney Orbital (WSO) highway [Bewsher Consulting and WBM Oceanics Australia, 2002]. Whilst these investigations did not include hydraulic modelling on Brickmakers Creek, they did involve a review of the RAFTS hydrologic model. The RAFTS model was subsequently updated to account for the following issues:

(i) it was updated to represent catchment conditions in 2001;

(ii) a split sub-area method was adopted to model the effects of catchment development, in line with current practice;

(iii) adoption of revised Intensity-Frequency-Duration rainfall data, as provided by Liverpool Council;

(iv) the areal reduction factor that had been applied to rainfall was removed, as this was less appropriate in the smaller subcatchment areas;

(v) the RAFTS calibration parameter was reduced from Bx=2 to Bx=1, as it was found that the higher value tended to underestimate flows in the smaller subcatchment areas.

3. REFINED FLOOD MODELLING ON BRICKMAKERS CREEK

3.1 RAFTS Hydrologic Model

There were two choices for the hydrologic model to be used for the current Brickmakers Creek flood investigations:

(i) the RAFTS model adopted for the Cabramatta Creek Floodplain Management Study; or

(ii) the updated RAFTS model that was used in association with investigations for the proposed WSO highway.

A comparison of flow estimates from both models is provided in **Table 1**

TABLE 1
Comparison of Flow Estimates (m^3/s) in Brickmakers Creek

Link	Location	Floodplain Management Study			WSO Investigations		
		PMF	Q_{100}	Q_{20}	PMF	Q_{100}	Q_{20}
24.02G	Hoxton Park Rd	318	60	43	288	78	60
24.03A	Memorial Ave	328	65	47	301	84	64
24.03B	Elizabeth Dr	332	68	49	308	89	67
24.04A	Homepride Ave	333	70	52	319	91	69

The choice of hydrologic models is important on Brickmakers Creek, as there is no historic data available to calibrate the flood models. If flow estimates increase, then computed flood levels can also be expected to increase. This is contrary to the behaviour elsewhere on Cabramatta Creek where substantial calibration data does exist. In these areas, the calibration process will 'mask' any small variations in flow estimates and design flood levels are unlikely to change significantly.

As Brickmakers Creek is a relatively small subcatchment of the Cabramatta Creek catchment (representing only 10% of the total catchment area) it was regarded that the results from the WSO investigations are likely to be more applicable on Brickmakers Creek. This is due to the parameters in the floodplain management study tending to underestimate flows in the smaller subcatchment areas.

3.2 TUFLOW Hydraulic Model

A new, more detailed hydraulic model was selected for modelling flood behaviour in the lower reaches of Brickmakers Creek. The model chosen was a combined 2D/1D hydraulic model, known as TUFLOW. This type of model has the advantage that it is able to accurately define the main creek channel as a one-dimensional section, and includes the overland flow paths through a fine scale two-dimensional grid. This type of model was also chosen to model the flood impacts of the WSO highway, although its extent did not include Brickmakers Creek.

The one-dimensional portion of the model covers the main creek, from 200m upstream of Memorial Avenue to just upstream of the confluence with Cabramatta Creek. This portion of the model is controlled by a series of culvert structures at locations listed in Table 2. The definition of channel cross sections and other culvert details have been based on the HEC-RAS originally provided by Council for the Paterson Britton investigations. This information is consistent with the details used to define the original RMA-2 model for the Cabramatta Creek Floodplain Management Study.

TABLE 2
Details of Culverts included in the TUFLOW model

Location	Structure Descriptions	Remarks
Memorial Avenue	3 x 3.3m x 1.8m RCBC	
Moore Street	2 x 2.7m x 1.8m RCBC plus 1 x 3.7m x 1.8m RCBC	
Elizabeth Drive	2 x 3.3m x 2.7m RCBC	
Orange Grove Road	3 x 3.0m x 2.4m RCBC	
Homepride Avenue	2 x 3.0m x 2.7m RCBC plus 2 x 3.3m x 2.4m RCBC	
Between Orange Grove Road and Homepride Avenue	4 x 1.2m RCP	Anticipate seriously blocked during major storms.

A blockage factor of 75% has been assumed for the four 1.2m diameter low flow pipes between Orange Grove Road and Homepride Avenue. This is based on observations of debris build-up at the trash rack covering the inlet to these pipes that was observed

during a site inspection in October 2003. This is also consistent with evidence from photographs taken at this location following recent floods.

The extent of two-dimensional portion of the model covers the area from north of Memorial Avenue to approximately 450m downstream of Homepride Avenue. A grid size of 2m was selected for simulating overland flow conditions. The fine grid size allows the assessment of the flood impact of any future development proposal within the modelled area.

A digital elevation model (DEM) has been developed using the data from the 1996 photogrammetry survey of the Cabramatta Creek catchment. It is assumed that no major earthworks have occurred within the study area since this date.

Buildings have been represented in the model by digitising the footprint of the structure and assigning a very high roughness coefficient to the building footprint. This has the effect of eliminating the flow of floodwater through the building, but preserves the flood storage within the building. Building footprints have been determined from aerial photos of the site taken in 2002.

Other barriers to overland flow paths were identified by inspection of the 2002 aerial photos and by field inspection. The following structures were included in the model:

(i) sound barrier along Copeland Street (Hume Highway) between Campbell Street and Lachlan Street;

(ii) continuous boundary wall along Sydney Road (Hume Highway) between Lachlan Street and Pioneer Memorial Park; and

(iii) landscape short wall structures at either sides of Orange Grove Road near the intersection of Hume Highway.

Boundary conditions for the TUFLOW model were based on the 'total' RAFTS hydrograph at Memorial Avenue, input at the upstream end of the TUFLOW model, and 'local' RAFTS hydrographs representing the remainder of the downstream catchment, evenly distributed over the 'wet' area of the model. A stage-discharge relationship was adopted at Lawrence Hargrave Road to represent tailwater conditions near the confluence with Cabramatta Creek.

3.3 Comparison with Previous Flood Level Estimates

Results for the 100 year flood were compared with results from the Cabramatta Creek Floodplain Management Study and the more recent HEC-RAS modelling of Brickmakers Creek. The results of this comparison are shown in Table 3.

Both the RMA-2 and HEC-RAS model results are based on flow estimates provided from the original RAFTS model developed for the floodplain management study. A valid comparison with results from the current investigation should also be on this basis. Results for the TUFLOW model, shown in Table 3, therefore include results for both the floodplain management study RAFTS flows and the updated RAFTS model adopted for the current investigations.

TABLE 3
Comparison of Flood Level Estimates in a 100 year Flood (m AHD)

Location	Comparison of Flood Level Estimates			ADOPTED TUFLOW[2]
	RMA-2	HEC-RAS	TUFLOW [1]	
Memorial Ave US	15.4	15.9	15.9	16.0
Memorial Ave DS	15.1	15.8	15.3	15.5
Moore St US	14.7	13.9	14.6	14.7
Moore St DS	14.0	14.2	14.1	14.2
Elizabeth Dr US	13.2	12.8	13.2	13.3
Elizabeth Dr DS	12.9	12.1	12.9	13.0
Park Rd	12.0	11.6	11.6	11.7
Orange Grove Rd US	11.2	11.1	11.4	11.6
Orange Grove Rd DS	10.9	10.5	10.9	11.0
Homepride Ave US	9.1	9.6	9.7	10.0
Homepride Ave DS	9.0	9.3	9.7	9.9
Lawrence Hargrave Rd US	7.8	7.9	7.7	7.9

1. TUFLOW estimate based on RAFTS flows from the Cabramatta Creek Floodplain Management Study
2. TUFLOW estimate based on updated RAFTS model for the WSO highway investigations (adopted for these investigations)

The comparison of flood levels shown in Table 3 indicates some variability in results between all three models. However, as the TUFLOW model is the most detailed model developed for the study area, and is best suited for modelling the overland flow component of flooding in this vicinity, results from this model are anticipated to be the most reliable.

4. EXISTING FLOOD BEHAVIOUR

Flood behaviour throughout the study area, based on the updated RAFTS flow estimates, has been assessed for existing conditions. Figures 1 to 3 provide details of flood conditions for the 20 year, 100 year and PMF events. Information on the extent of flood inundation, flood contours, depth of flooding and flood velocities are included for each of the flood events.

The modelling results exhibit a fairly complex flow regime for the study area. The key points are noted as follows:

- Hillier Road becomes an established flow path in the 100 year flood, with floodwater flowing parallel to Brickmakers Creek. Several properties at the intersection of Anderson Avenue are likely to be inundated.
- The Moore Street culvert appears to be significantly under-sized. This restriction contributes to floodwater spilling out of the channel upstream of the culvert and being redirected down Park Road and Carboni Street. This occurs in both the 100 year and 20 year floods. More than 20 properties west of Park Road are likely to be affected in the 100 year event.

- Elizabeth Drive appears to be seriously deficient in both the 100 year and 20 year floods. The channel capacity upstream and downstream of Elizabeth Drive also has limited capacity. Elizabeth Drive is estimated to be inundated over a length of approximately 300m in a 100 year flood. In some places, the depth over the road is estimated to be at least 0.6m. Significant floodwater flows are diverted to the east along Elizabeth Drive towards the Hume Highway (Copeland Street) and into the residential area to the north of the Liverpool CBD.
- The channel between Orange Grove Road and Elizabeth Drive is severely limited. A recent inspection revealed that the creek is undersized and heavily overgrown. There is also a sharp bend in the creek at the eastern end of Park Road, which would contribute to the flood flows leaving the creek and flowing onto the highway and into the residential area to the east.
- The model results also show that floodwater at the Orange Grove Road and Hume Highway intersection return to the main creek on either side of the Orange Grove Road culvert. This is contrary to past opinion that flooding in this area was due to the limited capacity of the Orange Grove Road culvert and downstream channel. That is, the problems are caused from floodwater spilling out of the creek further upstream, principally at Elizabeth Drive.
- The Hume Highway is located in a natural depression on the eastern floodplain, particularly in the vicinity of the Orange Grove Road intersection. Flood inundation depths of at least 1.0m are predicted in the 100 year flood along the road.
- Landscaping features near this intersection, presumably to restrict floodwater from overflowing from the creek onto the Hume Highway, could in fact be exacerbating flood conditions in this vicinity, as floodwater which has already left the creek system further upstream is restricted in getting back to the creek.
- The overland flow on the eastern floodway that does not return to Brickmakers Creek, travels in a north-easterly direction through the residential area north of the Liverpool CBD area. This floodwater is then trapped by the highway sound barriers and other brick fences from spilling over the highway to re-enter the creek downstream of Orange Grove Road. Much of the floodwater collects in Lachlan Street, where inundation depths of up to 1m can be expected in the 100 year flood.

5. POTENTIAL FLOOD MITIGATION MEASURES

A number of flood mitigation options have been considered to alleviate flooding problems within the study area. These options are shown on Figure 4, and include:

(i) Option 1 – Upgrade the Orange Grove Road culvert. The existing three cell 3.0m x 2.4m box culverts would be supplemented by an additional 3.0 x 2.4m box culvert.

(ii) Option 2 – Upgrade the Orange Grove Road culvert (as per Option 1) plus undertake channel rehabilitation works on the channel between Orange Grove Road and Homepride Avenue. The objective of the channel works would primarily be for environmental restoration of this reach of the creek, by removing the four 1.2m diameter low flow pipes and restoring the creek to a more 'natural'

condition. These works would also provide some improvement in the capacity of the creek (although this is not a major concern for this reach of the creek).

(iii) Option 3 – In addition to those works identified in Option 2, channel improvement works would be carried out between Orange Grove Road and Elizabeth Drive, including the construction of a low flood wall, approximately 200m long, on the west side of the highway. The culvert under Elizabeth Drive would also be amplified from a two cell 3.3m x 2.7m box culvert to a four cell 3.3m x 2.7m box culvert.

Results of model runs for each of the three options are shown on Figures 5 to 7. Flood level comparisons at key locations are summarised in Table 4.

TABLE 4
Flood Levels Comparison for Mitigation Options (100 year flood levels m AHD)

Location	Existing	Option 1	Option 2	Option 3
Memorial Ave US	16.0	16.0	16.0	16.0
Memorial Ave DS	15.5	15.5	15.5	15.5
Moore St US	14.7	14.7	14.7	14.7
Moore St DS	14.2	14.2	14.2	14.2
Elizabeth Dr US	13.3	13.3	13.3	12.4
Elizabeth Dr DS	13.0	13.0	13.0	12.0
Park Rd	11.7	11.7	11.7	11.5
Orange Grove Rd US	11.6	11.5	11.0	11.2
Orange Grove Rd DS	11.0	11.1	10.5	10.5
Homepride Ave US	10.0	10.0	9.7	10.2
Homepride Ave US	9.9	9.9	9.8	9.8
Lawrence Hargrave Rd US	7.9	7.9	7.8	7.8

Option 1 results in a slight drop in flood level at the upstream side of Orange Grove Road as a result of the amplified culvert. Inundation at Crimson Crescent would be alleviated with this option. However there is little or no reduction in flood levels elsewhere. (Refer Figure 5)

The channel rehabilitation works downstream of Orange Grove Road (Option 2) Option 2 provides a more significant reduction in flood levels upstream of Orange Grove Road, as shown on Figure 6. However, the benefit rapidly diminishes further upstream, and by Park Road there is negligible change in flood conditions.

The main benefits are evident for Option 3, which are primarily due to the channel improvement works upstream of Orange Grove Road and the culvert amplification at Elizabeth Drive. Significant flood level reductions are evident from Elizabeth Drive to Orange Grove Road for the 100 year flood. All overland flow to the east of Brickmakers Creek has now been eliminated in the 100 year flood, as shown on Figure 7. The Hume Highway is no longer inundated and the Liverpool CBD and residential area to the

north is no longer affected by floodwater spilling out of Brickmakers Creek. It should be noted that this area might still be subject to stormwater flooding from its own local catchment area. Stormwater drainage investigations are recommended to see whether any stormwater augmentation measures are required, particularly for the low-lying area surrounding Lachlan Street.

6. RECOMMENDATION

It is recommended that further consideration be given to implementing the measures outlined in Option 3. These measures are summarised in Table 5. The total cost of the recommendations is estimated at $4,900,000.

TABLE 5
Recommended Flood Mitigation Measures

Measure	Description	Estimated Cost	Priority
Orange Grove Road Culvert amplification	Add 1 x 3.0m x 2.4m RCBC to existing 3 x 3.0m x 2.4m RCBC	$350,000	High
Creek rehabilitation downstream of Orange Grove Road	Remove 4x1.2m diameter low flow pipes, lower creek invert, and restore channel to more 'natural' state	$1,900,000	Medium
Channel improvement works from Orange Grove Road to Elizabeth Drive	Amplify and realign Brickmakers Creek between Orange Grove Road and Elizabeth Drive	$2,000,000	High
Floodwall	Construct low level flood wall, approximately 200m long, between Brickmakers Creek and the Hume Highway	$100,000	Medium
Elizabeth Drive Culvert amplification	Add 2 x 3.3m x 2.7m RCBC to existing 2 x 3.3m x 2.7m RCBC	$570,000	High

FIGURES

PRELIMINARY COST ESTIMATES

Orange Grove Road Culvert Amplification
Supply additional 1 x 3.0m x 2.4m RCBC to existing 3 x 3.0m x 2.4m RCBC

Item	Description	Quantity	Rate	Amount
	Investigation & design			$30,000
1a	Site Establishment/Removal			$5,000
1b	Traffic management			$5,000
1c	Liaison with Service Authorities (assumes no relocation works required)			$2,000
1d	Erosion control measures			$2,000
1e	Provision for trench shoring system			$5,000
1f	Demolition of existing roadworks	100 m^2	$25	$2,500
1g	Trench excavation	350 m^3	$45	$15,750
1h	Construct cast-in-situ culvert base slab	20 m^3	$350	$7,000
1i	Supply and lay box culvert units (2.44m length)	10 units	$6,000	$60,000
1j	Trench backfill to road subgrade level	60 m^3	$35	$2,100
1k	Road restoration – base course	100 m^2	$50	$5,000
1l	Road restoration – surface course	100 m^2	$25	$2,500
1m	Road structures	20 m	$75	$1,500
1n	Allowance for nightwork			$120,000
	Sub Total			$265,350
	Contingency (30%)			$79,605
	Total			$350,000

Elizabeth Drive Culvert Upgrade
Supply additional 2 x 3.3m x 2.7m RCBC to existing 2 x 3.3m x 2.7m RCBC

Item	Description	Quantity	Rate	Amount
	Investigation & design			$30,000
2a	Site Establishment/Removal			$5,000
2b	Traffic management			$8,000
2c	Liaison with Service Authorities (assumes no relocation works required)			$3,000
2d	Erosion control measures			$2,000
2e	Provision for trench shoring system			$8,000
2f	Demolition of existing roadworks	210 m^2	$25	$5,250
2g	Trench excavation	840 m^3	$45	$37,800
2h	Construct cast-in-situ culvert base slab	45 m^3	$350	$15,750
2i	Supply and lay box culvert units (2.44m length)	25 units	$7,200	$180,000
2j	Trench backfill to road subgrade level	125 m^3	$35	$4,375
2k	Road restoration – base course	210 m^2	$60	$12,600
2l	Road restoration – surface course	210 m^2	$25	$5,500
2m	Road structures	40 m	$75	$3,000
2n	Allowance for nightwork			$120,000
	Sub Total			$440,275
	Contingency (30%)			$132,082
	Total			$570,000

Construct 200m long block floodwall approx 1.0m high

Item	Description	Quantity	Rate	Amount
3a	Site Establishment/Removal			$2,500
3b	Traffic management			$500
3c	Liaison with Service Authorities (assumes no relocation works required)			$500
3d	Erosion control measures			$1,000
3e	Excavation for retaining wall footings	50 m^3	$45	$2,250
3f	Concrete footings	50 m^3	$250	$12,500
3g	Blockwork	200 m^2	$300	$60,000
	Sub Total			$79,250
	Contingency (30%)			$23,775
	Total			$100,000

Realignment and widening existing channel between Orange Grove Road and Elizabeth Drive (approx 530m length)

Item	Description	Quantity	Rate	Amount
	General			
	Investigation & design			$60,000
4a	Site establishment/removal			$10,000
4b	Temporary construction fencing	1200 m	$10	$12,000
4c	Traffic management			$5,000
4d	Liaison with Service Authorities (assume no conflicts)			$1,000
4e	Erosion control measures			$10,000
4f	Protect existing trees and vegetation			$2,000
	SubTotal			$100,000
	Earthworks			
4g	Remove grass and vegetation from site	26,500 m^2	$0.60	$15,900
4h	Strip topsoil and stockpile for respreading	2,650 m^3	$4.50	$11,925
4i	Remove large trees (provisional)	10	$150	$1,500
4j	Excavate material from channel to disposal off site	30,000 m^3	$30	$900,000
4k	Respread topsoil, trim and compact	26,500 m^2	$1.00	$26,500
	SubTotal			$955,825
	Landscaping			
4l	Native grassing/tube stock planting	26,500 m^2	$10	$265,000
4m	Large trees & shrubs (provisional)			$20,000
4n	Rock scour protection (includes geotextile)	2,500 m^3	$70	$175,000
	SubTotal			$460,000
	TOTAL			$1,515,825
	Contingency (30%)			$454,747
	TOTAL			$2,000,000

Creek rehabilitation between Orange Grove Road and Homepride Avenue, including removal of 4 x 1200mm diameter low flow pipes (approx 400m length)

Item	Description	Quantity	Rate	Amount
	General			
5a	Site establishment/removal			$8,000
5b	Temporary construction fencing	900 m	$10	$9,000
5c	Traffic management			$4,000
5d	Liaison with Service Authorities (assume no conflicts)			$1,000
5e	Erosion control measures			$8,000
5f	Protect existing trees and vegetation			$500
	SubTotal			$30,500
	Removal of Low Flow Pipes			
5g	Remove and transport to Council depot (re PB proposal)	1480m	$500	$740,000
	Earthworks			
5h	Remove grass and vegetation from site	16,000 m^2	$0.60	$9,600
5i	Strip topsoil and stockpile for respreading	1,600 m^3	$4.50	$7,200
5j	Remove large trees (provisional)	5	$150	$750
5k	Excavate material from channel to disposal off site	14,000 m^3	$25	$350,000
5l	Respread topsoil, trim and compact	16,000 m^2	$1.00	$16,000
	SubTotal			$383,550
	Landscaping			
5m	Native grassing/tube stock planting	16,000 m^2	$10	$160,000
5n	Large trees & shrubs (provisional)			$15,000
5o	Rock scour protection (includes geotextile)	1,500 m^3	$70	$105,000
	SubTotal			$280,000
	TOTAL			$1,434,050
	Contingency (30%)			$430,215
	TOTAL			$1,900,000

APPENDIX D

Fairfield Council – List of Houses and Commercial Buildings Potentially affected by the 100 Year Flood in Cabramatta Creek

APPENDIX E

Summary of Submissions Received from Public Exhibition of the Draft Report

SUMMARY OF SUBMISSIONS RECEIVED FROM PUBLIC EXHIBITION OF DRAFT REPORT

No.	Issues Raised	Response
1	Concerned that floods rarer than the 100 year flood are being considered. Also concerned over notations on Section 149 Certificates, availability of flood insurance and impact on property values.	The main purpose of the Plan is to try and reduce the risk from future floods. This considers all flood risks, up to what is termed the "probable maximum flood". As the likelihood of floods greater than 100 years is quite rare, this area has been classified as having a "low flood risk". There is no evidence that such a classification will devalue property values. In NSW, insurance against flooding is generally unavailable, regardless of flood affectation. These issues are also covered in the 'frequently asked questions' included in Appendix A of the report.
2	Submission from the NSW Department of Primary Industries, Fisheries Division, concerning the value of creeks for aquatic biodiversity, water quality issues within the creek, and proposals to construct detention basins as part of the Plan. The Fisheries Division recommends offline detention basins to avoid interference with fish passage. Further detail and evaluation of these basins were recommended. It was also noted that Council would require a permit for dredging and reclamation for certain works.	Basin details provided in the report are conceptual only, and will require further evaluation and detailed design prior to implementation. Wherever possible, opportunities for off-line basins will be pursued. Further clarification of this issue has been included in Section 10.1.8.8 of the report.
3	General letter from resident advising Council of contact details for any further advice.	Not required
4	Feedback form returned, supporting the floodplain management study and plan, but suggesting there are other measures that could also be considered. No details provided	Not required
5	Feedback form returned, supporting the floodplain management study and plan. Suggested other measures should be included and recommended that the creek be cleaned out to improve flow.	Further consideration of creek maintenance is recommended in the plan.
6	Feedback form returned, supporting the floodplain management study and plan. Also suggested that rails could be put around the creek, and that the creek could be lined with stone to improve its appearance.	Not required
7	Letter thanking Council for support in trying to alleviate flood problems for people within the catchment. Suggested that the exhibition period be extended to allow a public meeting for residents to participate in the determination of options to solve the problem.	The project has already had an extensive community consultation phase, including newsletters, questionnaires and two public meetings. There was also a relatively long exhibition period of over 8 weeks.
8	Letter questioning how the PMF can be about 1m higher than the 100 year flood. Requested further consultation and noted that Basin 18 has recently been constructed, but not taken into account for this study.	Basin 18 has been provided in the report as compensation for the WSO highway and also to mitigate the impacts of future development within the catchment. Whilst there may be some improvement of flood

No.	Issues Raised	Response
		behaviour now, this will diminish over time as the highway and further development is completed.
9	Submission from State Emergency Service, Liverpool Unit, endorsing the plan as an excellent document that addresses flooding issues in the Cabramatta Creek floodplain. Expressed some concern that the original plan for a large basin in the centre of the catchment (Basin 22) had been replaced with a smaller basin. Problems with Hoxton Park Road being inundated by floodwater and access difficulties for evacuation centers were also raised.	The original concept for Basin 22 (in the 1999 draft report) was for a large, multi-purpose basin. This has not been possible due to high land acquisition costs and other technical difficulties, including a high saline water table that limits the permissible excavation depths. Recent improvements to Hoxton Park Road may slightly improve its susceptibility to flooding; however flooding problems here are still anticipated. Further consultation between Council's committee and the SES is recommended to further evaluate evacuation issues within the catchment.
10	Council's efforts in managing the flood risk within the catchment was acknowledged, A public meeting was suggested so that owners could participate in the determination of measures to alleviate flooding. It was also suggested that the exhibition period be extended so that any errors in the report could be corrected.	The project has already had an extensive community consultation phase, including newsletters, questionnaires and two public meetings. There was also a relatively long exhibition period of over 8 weeks.
11	Questioned the flood risk classification provided on a particular property. Was concerned that floods greater than the 100 year flood were being considered, and that such advice would be included on Section 149 Certificates. Concerned that this might impact on insurance, financial institutions and property values. Suggested that the exhibition period be extended.	The main purpose of the Plan is to try and reduce the risk from future floods. This considers all flood risks, up to what is termed the "probable maximum flood". As the likelihood of floods greater than 100 years is quite rare, this area has been classified as having a "low flood risk". There is no evidence that such a classification will devalue property values. In NSW, insurance against flooding is generally unavailable, regardless of flood affectation. These issues are also covered in the 'frequently asked questions' included in Appendix A of the report
12	Similar submission to LCC12 above	See comments above
13	Similar submission to LCC12 above	See comments above
14	Concerned that floods greater than the 100 year flood are now being considered. Concerned that this will impact on home insurance and property values. Also felt that little work had been undertaken within the catchment since 1981, despite new development that had occurred, and the creek no longer had sufficient capacity. Recommended flood mitigation works rather than flood risk assessment.	Whilst all floods are being considered, land between the 100 year flood and the PMF has been categorized as having a 'low' flood risk, and the flood related development controls are relatively minor. In NSW, insurance against flooding is generally unavailable, regardless of flood affectation. Appendix A provides further details. The recommended plan includes a mix of flood mitigation works and flood risk management measures.
15	Advice from Council officer that Basin 18 has recently been constructed on Maxwells Creek.	The Cabramatta Creek catchment is subject to rapid change with the construction of the WSO highway and other development. Flood levels in Maxwells Creek may now be reduced as a result of the construction of this basin. However, as the WSO highway and other development progresses, this impact will be diminished. The basin principally acts as compensation for both the WSO highway

No.	Issues Raised	Response
		and development between1989 to 2026.
16	Advice from Council officer of some rain gauges recently installed in the upper catchment, as per study recommendations.	Not required.
17	Strongly disputes flood notation on a particular property, as there is now an effective retaining wall between this property and the creek (presumably due to the WSO highway).	This may require a site specific assessment which is beyond the scope of the current floodplain management study.
18	Endorses that recognition of floods greater than the 100 year flood provides an opportunity to identify and mitigate these risks on a proactive manner. However, concerned that notations of flood risk for property affected by the PMF will impact on property values, insurance premiums and development potential. Also notes that some measures recommended for Brickmakers Creek (in Appendix C) have not been included in the main study and plan.	Land between the 100 year flood and the PMF has been categorized as having a 'low' flood risk, and the flood related development controls are relatively minor. In NSW, insurance against flooding is generally unavailable, regardless of flood affectation. Appendix A provides further details. Measures for Brickmakers Creek recommended in Appendix C are included in the recommended Plan (Table 10.1). Further reference to these works will be included in the report Summary.
19	Concerned that property has been identified as being within the PMF when historically such flooding has not been experienced. Supports measures to alleviate flooding. Stresses the need to ensure that creeks and drains are kept clear from rubbish and that potential for culvert blockage is minimized.	The PMF is a flood much rarer than the 100 year flood. Whilst many places in NSW have experienced floods larger than the 100 year flood, there are no records of similarly rare floods having occurred in the Cabramatta Creek catchment. This is not to say that such flooding is not possible in Cabramatta Creek. The Plan also endorses a program to keep the creek clear of debris.
20	Concerned over the reduced capacity of Brickmakers Creek, in the vicinity of the Cumberland Highway, due to weed growth and pollution. The culvert under the Hume Highway was also considered to be inadequate.	These comments are endorsed by the current study. Appropriate recommendations are included in the Plan for culvert amplification and other channel improvement measures.
21	Resident concerned that property purchased in 1999 had no flood classification, but is now shown to be within the PMF flood. Questions what the current Section 149 Certificate will show.	It is not Council's intention to sterilize land that is above the 100 year flood from development. Land between the 100 year flood and PMF is identified as having a 'low flood risk' and there are relatively minor flood-related development controls proposed as part of the plan.
22	Submission from the Bureau of Meteorology concerning flood warning matters	The Bureau provided further details concerning range of meteorologically-based warning services provided by the bureau, including Flood Watches, Severe Thunderstorm Warnings, and Severe Weather Warnings. Given the short time between rainfall and flooding within the Cabramatta Creek catchment, the Bureau recommended that any flood warning system strategically incorporates these meteorologically based warning services. Section 10.3.1.1 of the report has been amended to include these recommendations.
23	Submission concerned over consideration of the PMF flood and 'Low Flood Risk' precinct, and that inclusion of this on Section 149 Certificates would be detrimental due to	Many of the issues relating to the impact of the 'low flood risk' precinct (ie insurance, property values, finance) are discussed in the frequently asked questions in Appendix

No.	Issues Raised	Response
	insurance, property values, finance and anguish. Also questioned whether areas that had recently been filled been taken into consideration with the mapping, and why the previously proposed basin on Maxwells Creek (between Kurrajong Road and Jedda Road) was not shown in the Plan.	A. Whilst the mapping included in the report is as up-to-date as possible, frequent review of the Plan and mapping is recommended, as new information or other changes become apparent. The basin originally proposed on Maxwells Creek has been relocated further upstream and incorporated with a dual-purpose RTA-Council basin.
24	Submission made by the Sydney Landscape Unit of the Department of Infrastructure Planning & Natural Resources concerning the Department's preference for the construction of off-line detention basins rather than on-line basins.	Basin details provided in the report are conceptual only, and will require further evaluation and detailed design prior to implementation. Wherever possible, opportunities for off-line basins will be pursued. Further clarification of this issue has been included in Section 10.1.8.8 of the report.
25	Submission made by the Flood Group of the Department of Infrastructure, Planning & Natural Resources concerning clarification on a number of issues. Included comments/clarification of basin design, cost estimates, damage calculations, accuracy of mapping, source of funding and other implementation measures.	These issues have been discussed with the Department, and several minor changes made to the draft report to provide further information/clarification, where required.
26	Feedback form supporting the floodplain management study and plan, but also concerned that property may be affected due to Section 149 notification. Requested further discussion on the implications of the study.	Many of the issues associated with Section 149 notifications and property values are examined in the 'frequently asked questions', included in Appendix A of the report.
27	Question related to a particular property. Surrounding residents have reportedly been allowed to fill their properties above the 100 year flood. The respondent believes that he should be allowed to do the same.	This is a site specific issue beyond the scope of the floodplain management study. It is an issue for Council to consider should a formal request be submitted.
28	Feedback form not supporting the floodplain management study and plan. The owners have lived at a particular property since 1969 and have never experienced flooding. It appears they are now concerned that this property has been identified in one of the flood risk precincts.	The absence of floods over the last 30-40 years is not necessarily an indicator that a large or extreme flood may not occur some time in the future.
29	Letter received stating that property has not flooded since 1961. Some concern was expressed for other property affected by flooding. It was suggested that building a dam or reservoir was the only answer to the problem	Construction of a large, central dam (known as Basin 22) has been examined, but discounted due to financial and other technical issues. The construction of a number of smaller detention basins throughout the catchment does form a major component of the recommended floodplain management plan.
30	Phone call and meeting with resident who questioned whether there was any requirement for property owners to advise their insurance company concerning flood advice that may appear on a Section 149 Certificate.	Insurance for flooding is normally not provided by Insurance companies, regardless of the notation that may be included on a Section 149 Certificate.
31	Phone call from resident suggesting that rainwater tanks should be considered to stop flooding.	Rainwater tanks are a good measure to help conserve our water supplies. In the Cabramatta Creek Catchment, it has been

No.	Issues Raised	Response
		considered that the construction of much larger detention basins, strategically located throughout the catchment, is likely to be more effective in reducing flood flows.
32	Phone call from resident believing that it was Council's fault that his property was now shown to have a flood risk.	The study has attempted to identify the various flood risks throughout the catchment, and to develop strategies to reduce/manage this flood risk.
33	Comment from Council staff that further evaluation/consultation in relation to measures proposed in the Tresalam Street area should be undertaken as part of future investigations.	The measures included in the Plan for Tresalam Street are now noted as being subject to further evaluation.