UPPER PARRAMATTA RIVER CATCHMENT
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

VOLUME 1 — MAIN REPORT

The Upper Parramatta River Catchment (Source: UPRCT Report Card, 1999)

Report for Public Exhibition

April 2003

Bewsher Consulting Pty Ltd

OUTCOMES GROUP
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UPPER PARRAMATTA RIVER CATCHMENT TRUST

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FLOODPLAIN RISK MANAGEMENT

STUDY AND PLAN

REPORT FOR PUBLIC EXHIBITION

APRIL 2003

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FOREWORD

In New South Wales, the prime responsibility for local planning and the management of flood liable land rests with local government. To assist local government with floodplain management, the NSW Government has adopted a Flood Prone Land Policy in conjunction with the *2001 Floodplain Management Manual*.

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood risk and does not create additional flood problems.

The Policy sets out four sequential stages in the development of a floodplain management system:

1. Flood Study — Assessment to define the nature and extent of flooding.
2. Floodplain Risk Management Study — Comprehensive evaluation of management options with respect to existing and proposed development.
3. Floodplain Risk Management Plan — Formal adoption by Council of a management plan for floodplain risks.
4. Implementation of the Plan — Measures undertaken to reduce the impact of flooding on existing development, and implementing controls to ensure that new development is compatible with the flood risk.

This *Floodplain Risk Management Study* and draft *Floodplain Risk Management Plan* constitutes the second and third stage of the management process for the Upper Parramatta River catchment and has been prepared for the Upper Parramatta River Catchment Trust (which covers parts of the Baulkham Hills, Blacktown, Holroyd and Parramatta Local Government Areas) by Bewsher Consulting Pty Ltd in association with Don Fox Planning Pty Ltd.

In broad terms, this *Floodplain Risk Management Study* has investigated what can be done to minimise the effects of flooding in the Upper Parramatta River catchment and has recommended a strategy in the form of a draft *Floodplain Risk Management Plan*.

The next stage of the floodplain risk management process will be for each of the four constituent Councils of the Upper Parramatta River Catchment Trust area to formally adopt and implement the draft *Floodplain Risk Management Plan*.

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EXECUTIVE SUMMARY

FLOODPLAIN RISK MANAGEMENT IN NEW SOUTH WALES

The prime responsibility for planning and management of flood prone lands in New South Wales (NSW) rests with local government. The NSW Government's Flood Prone Land Policy and the *2001 Floodplain Management Manual* form the basis of floodplain management in NSW.

The NSW Government provides assistance on statewide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain risk management studies, and for the implementation of works identified in these studies.

The Flood Prone Land Policy also provides some legal protection for Councils, other public authorities and their staff against claims for damages resulting from the issuing of advice or granting approvals on floodplains, providing they have acted substantially in accordance with the principles contained in the *2001 Floodplain Management Manual*.

STUDY AREA

The Upper Parramatta River Catchment Trust commissioned Bewsher Consulting Pty Ltd, in association with Don Fox Planning Pty Ltd, to undertake a *Floodplain Risk Management Study and Plan* for the Upper Parramatta River catchment in Sydney's western suburbs.

The Upper Parramatta River catchment covers an area of 110 square kilometres and includes parts of the Cities of Blacktown, Holroyd and Parramatta and part of the Shire of Baulkham Hills. Most of the catchment is urbanised and has a population of more than 230,000.

THE FLOOD PROBLEM

The potential for serious flooding in the Upper Parramatta River catchment was recognised in the early 1970s with a major flood mitigation strategy being carried out. However, progress on flood mitigation works was slow over the next 10 years, at the same time as extensive urban development was occurring in the catchment.

From the middle of 1986 to 1988, the catchment experienced a period of above average rainfall. The major storm of August 1986 was estimated at the time to be about a 20 year flood. Another major storm in April 1988 was even larger, now estimated to be about a 30 year flood. Lesser, yet still significant storms also occurred in November 1987 and July 1988. Many properties that had never been flooded before were inundated on several occasions.

By 1990, it was estimated than more than 2,300 residential properties in the Upper Parramatta River catchment at 63 different locations would experience over-ground flooding in a 100 year flood. Of those, about 630 dwelling would be flooded above floor level. More than 350 business properties, including about one-third of the Parramatta CBD would also be flooded. The total flood damage that could be expected, on average, every year was estimated at that time to be nearly $8 million dollars in today's terms.

IMPROVEMENTS TO FLOOD RISK SINCE 1990

The establishment of the Upper Parramatta River Catchment Trust in 1989 provided a coordinated approach to a flood mitigation strategy for the catchment. Since 1989, the Trust and the four local councils have made good progress in addressing the existing flood threats in the catchment. The number of flood-affected houses flooded above floor level in a 100 year flood has been reduced by one-third, while the number of flood-affected businesses has been reduced by two-thirds. There are no longer any properties that would be flooded by minor to moderately sized floods. The Parramatta CBD is now protected from flooding in a 100 year flood.

This has been achieved with a number of flood mitigation measures including the construction of thirteen large flood retarding basins, the reconstruction of more than six large sections of creek to provide increased capacity and the purchase of more than ten of the most severely flood-affected homes in the catchment.

STUDY OBJECTIVES

Despite the expenditure of more than $35 million on flood mitigation works since 1989, none of the four councils within the area of the Trust have adopted a formal Floodplain Risk Management Plan as required by the NSW Government's Flood Prone Land Policy.

Therefore, the primary objective of the current *Upper Parramatta River Floodplain Risk Management Study and Plan* is to bring together, and place in appropriate context, all past, current and proposed future activities related to the reduction of flood risk in the catchment.

In broad terms, the current study has investigated what can be done to minimise the effects of flooding in the Upper Parramatta River catchment and recommended a strategy in the form of a draft *Floodplain Risk Management Plan*.

This study and plan constitute key components of the NSW Government's Floodplain Risk Management Process as outlined in the *2001 Floodplain Management Manual*.

Key objectives of the study include:

- briefly outlining hydrological and hydraulic modelling undertaken in the catchment to date;
- briefly reviewing past, current and future flood-related activities of the Trust and the four constituent Councils;
- reviewing, in detail, issues relating to planning and development controls within the catchment's floodplains;
- identifying additional floodplain risk management measures that particularly relate to community awareness about flooding, the release of flood-related information to the community, flood warning and emergency management;
- developing a mutually agreeable draft *Floodplain Risk Management Plan* that outlines the best measures to reduce flood damage, based on environmental, social, economic, financial and engineering considerations.

DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

The draft *Upper Parramatta River Catchment Floodplain Risk Management Plan* involves a combination of capital and non-capital measures of the following key elements:

- ***capital measures*** — flood mitigation works and investigations identified in the *1991 Catchment Management Priorities Study* by Webb, McKeown & Associates, and identified and updated by the Trust and the four constituent Councils since that time;
- ***non-capital measures*** —
  - adoption of consistent planning controls and policies across the four constituent Councils, consistent with the requirements of the *Floodplain Management Manual*;
  - implementation of a comprehensive community flood awareness strategy;
  - instigation of emergency management measures, in conjunction with the SES, in recognition of the growing role of emergency services in floodplain risk management and planning.

Flood Mitigation Measures

As part of the *1991 Catchment Management Priorities Study* a total of 83 mitigation measures were identified to address 62 separate flood problems in the Upper Parramatta River catchment.

A comprehensive method for assessing and prioritising this large number measures was developed as part of the 1991 study. This methodology was reviewed in a study in 2000. The procedure has proved to be useful and successful in the past and hence there is no justification to change it as part of this study.

This ranking procedure has been retained in this current study and therefore, it is recommended that the prioritised list currently used by the Trust and the four constituent Councils be adopted, as is, in the draft *Floodplain Risk Management Plan*.

The recommended works involve a combination of:

- flood retarding basins (or detention basins);
- enlargement of creek channels and the construction of floodways;
- erosion and scour protection works for existing creek channels;
- modifications to urban areas to provide overland flow paths;
- enlargement of culverts and bridge structures at creek crossings;
- augmentation of piped drainage systems;
- improvements to existing levee systems;
- voluntary purchase of several severely flood-affected homes;
- raising or flood-proofing of several flood-affected homes.

These measures represent about $36 million of outstanding works in the catchment in (2001 dollar values). Costs for each of the four constituent Councils are:

- Baulkham Hills Shire Council — $6.6 million;
- Parramatta City Council — $16.2 million;
- Holroyd City Council — $9.4 million;
- Blacktown City Council — $3.9 million.

Timing of the proposed works will depend on the Trust's and the Councils' overall budgetary commitments, and the availability of funds from other sources.

It should be noted that many of the proposed works identified in the 1991 study were only based on a very preliminary assessment. The Trust is currently funding a program of staged investigations of all areas that remain unprotected from major floods, in conjunction with the four local councils. The investigations will determine if there is a feasible and cost justifiable solution for each area, costs and likely benefits and how the works ranks against other identified flood projects in the catchment. When this program of investigations is completed in late 2003 the scale and cost of all outstanding flood works in the catchment will be known with considerable confidence.

Planning Controls and Policies

Land use planning, development controls and specific flood-related policies are key components of the recommended draft *Floodplain Risk Management Plan*.

It will be important, however, that each Council ensures that the planning outcomes derived from this study are integrated with all other existing and future floodplain risk management studies currently under preparation in their LGA, to provide a consistent platform for dealing with the issue of flooding with future development.

Need to Consider Probable Maximum Flood

Up until quite recently, the '100 year flood' generally defined the boundary between 'flood-prone land' and land considered to be 'flood-free'. There was little acknowledgment that larger floods could occur. There is now an increased emphasis on assessing all flood risks up to the largest flood that could possibly occur. This largest flood is referred to as the 'probable maximum flood' (PMF). As a result, 'flood-prone land' or the 'floodplain' now covers all land that would be inundated by all floods up to a probable maximum flood.

Flood Risk Precincts

The Planning Matrix Approach to floodplain risk management considers the range of land uses, and their potential risk to flooding, within the floodplain up to the level of the probable maximum flood. The approach is fully consistent with the *2001 Floodplain Management Manual*. This study recognises that different development controls should apply to different flood risk areas.

A key component of the Planning Matrix Approach is to divide the floodplain into different areas of similar risk, known as Flood Risk Precincts. The Planning Matrix is the tool that will be used by the Councils, in their DCPs and Flood Policies, to detail all the flood-related building controls for all land uses in each of the Flood Risk Precincts.

The three Flood Risk Precincts recommended for the Upper Parramatta River catchment as follows:

- ***High Flood Risk Precinct*** — This has been defined as generally the area of land below the 100 year flood level subject to a high hydraulic hazard (in accordance with the provisional criteria outlined in the *Floodplain Management Manual*). The High Flood Risk Precinct is where high flood damages, potential risk to life, or evacuation problems would be anticipated. Most development should be restricted in this precinct.

- ***Medium Flood Risk Precinct*** — This has been defined as generally land below the 100 year flood level subject to low hydraulic hazard in a 100 year flood. In this precinct there would still be a significant risk of flood damage or risk to life, but these could be minimised with the application of appropriate development controls.

- ***Low Flood Risk Precinct*** — This has been defined as all other land within the floodplain, namely above the 100 year flood level and below the level of the PMF. The Low Flood Risk Precinct would be where risk of damages would be low for most land uses. One of the major purposes of this precinct is to identify and recognise the potential flood risk for all persons and properties affected by the PMF, regardless of whether any specific development controls are to be applied. This provides a basis for flood awareness programs, evacuation and emergency planning and to maximise the preparedness of the community.

Some Proposed Development Controls

Some of the recommended development controls in the draft Planning Matrix are as follows:

- ***High Flood Risk Precinct*** — most land uses would not be permitted and limited alterations and additions to existing residential development would be permitted subject to stringent conditions;

- ***Low Flood Risk Precinct*** — generally all land uses would be permitted, except sensitive uses and facilities, which would include hospitals, nursing homes and others that may provide an important contribution to emergency management in times of flood. Floor levels for most residential and business development in this precinct would have to be above the 100 year flood plus 0.5m freeboard.

- ***Medium Flood Risk Precinct*** — generally most land uses would be permitted, except

sensitive uses and facilities, critical utilities and the importation of fill material. All permitted development would be subject to most of the flood-related building controls. Floor levels for most residential and business development in this precinct would have to be above the 100 year flood plus 0.5m freeboard.

- ***extensions to existing homes, and construction of garages and garden sheds*** — these types of development are referred to as "concessional development" and would be generally permitted in all areas of the floodplain but would be subject to range of flood-related building controls relating to floor levels, building components, structural soundness, flood impact on others, access during a flood and storage of goods.

- ***rebuilding of existing homes*** — if a house is to be rebuilt to substantially reduce its risk of flooding (for example by building it at a higher level, this would also be classified as "concessional development", meaning that it would be permitted in all areas of the floodplain. Again, the development would be subject to range of flood-related building controls listed above;

- ***new detached dwelling on a vacant block of land*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, the development would be subject to range of flood-related building controls relating to floor levels, building components, structural soundness, flood impact on others, access during a flood and storage of goods. Importation of fill material would not be permitted in a Medium Flood Risk Precinct;

- ***commercial and industrial development*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, the development would be subject to range of flood-related building controls floor levels, building design and evacuation issues;

- ***subdivision of land*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, an engineer's report would be required to certify that the development would not increase flood affectation elsewhere and it would have to be demonstrated that the development complies with the relevant DCP or Flood Policy;

- ***filling of land*** — generally, the importation of fill material would not be permitted in a High or Medium Flood Risk Precinct. However, some 'filling' may be acceptable to Council, including 'filling' that would change the Flood Risk Precinct of a particular site, provided the certain strict conditions were met. In a Low Risk Precinct, an engineer's report would be required to certify that the development would not increase flood affectation elsewhere

Development Control Plans (DCPs)

The most appropriate way to implement the proposed flood policy is its adoption by Council as a DCP (in the case of Holroyd, Blacktown and Baulkham Hills) or associated Flood Policy document (in the case of Parramatta).

A separate DCP or Flood Policy has been prepared for each of the four constituent Councils. Each of the documents are very similar, involving a preamble of provisions to establish a framework to allow for the outcomes of any number of floodplain risk management plans to be incorporated into the document. The *Upper Parramatta River Catchment Floodplain Risk Management Plan* would be one of these plans.

Other Planning and Policy Recommendations)

Other recommended planning measures and policy changes include:

- ***Sydney REP No.28 — Parramatta*** — should be amended to provide a consistent framework for flood planning controls (existing or proposed) for each of Council's LEPs;

- ***Changes to Council Local Environmental Plans (LEPs)*** — to provide a consistent framework for more detail controls to be provided in a DCP;

- ***Discouragement of Building in High Flood Risk Precinct*** —by utilising foreshore building line provisions embodied within LEPs or the like.

Community Consultation and Awareness

Flood awareness is critical to reducing the flood risk to the floodplain community and flood awareness is essential for flood readiness.

A comprehensive community flood awareness strategy is recommended as part of the draft *Floodplain Risk Management Plan.* Most of the components of this strategy relate to the release of flood information to the community and comply with the requirements of the *2001 Floodplain Management Manual* and Section 149 of the *Environmental Planning & Assessment Act, 1979.*

Flood Risk Precinct Maps

Flood Risk Precinct maps would show all known areas of the floodplain up the probable maximum flood. They would show the limits of the three Flood Risk Precincts (low, medium and high). Flood levels, flood depths or flood extents of floods of varying probabilities would not necessarily be shown — only areas of similar flood risk. The Flood Risk Precinct Maps would consider flooding from creeks, rivers and stormwater overland flows.

The Trust is currently preparing Flood Risk Precinct Maps for the Upper Parramatta River catchment for all areas covered by its MIKE-11 hydraulic modelling.

It is recommended that the Flood Risk Precinct maps be readily available to the public. This would preferably be via the Trust's web site, with links to and from each of the Council web sites. The maps should be at least be available at Councils' inquiry counters and on their respective GIS data base systems. It should be noted that Councils have a duty of care to make information about flood risks known to the public.

Brochure on Flood-related Building Controls

To help the community understand how the Flood Risk Precinct Maps and the associated planning controls would affect the way they may want to improve their property, a brochure outlining a simplified explanation of what type of development would be permitted and the flood-related building controls for residential development, is proposed. This information would be taken directly from the Planning Matrix. A draft brochure is currently with the Trust for their review.

Flood Information Packs

Flood notification to all residents in the floodplain (that is up to the level of the probable maximum flood) is recommended as a key means of raising flood awareness in the catchment. It is important with such notifications that the recipients of the information understand that the supplied information actually applies to them and is not a part of a general mail out to everyone in the catchment.

The Flood Information Packs that would be sent to all residents (owners and occupiers) in the floodplain would include the following information:

- ***flood notification letter*** — this would explain that the particular property was located in a floodplain, how flooding may affect the property, generally what development controls would apply and how more information could be obtained.
- ***flood information brochure*** — this A4-size folded brochure, entitled "Facts about Flooding in the Upper Parramatta River Catchment", would broadly describe flooding and the flood problems of the catchment, the Flood Risk Precincts, the Flood Risk Precinct Maps and some key flood-related development constraints and opportunities. A draft version of this brochure is currently with the Trust for its review;
- ***frequently asked questions*** — a four-page handout on 'Frequently Asked Questions' providing a simplified explanation of flood-related matters is also proposed for inclusion in the Flood Information Packs, as well as being available at Council's inquiry counters. A draft version of this handout is currently with the Trust for its review.
- ***SES FloodSafe Brochures and associated information*** — the NSW State Emergency Service's (SES) FloodSafe program has produced area-specific brochures that describe what to do in a flood, how the SES can help and broadly describe the flood problem of the area. These brochures also include a broad scale map showing the approximate extent of the floodplain up to the probable maximum flood. A FloodSafe brochure is currently being prepared for the Upper Parramatta River catchment, in conjunction with the SES

Flood Certificates

In addition to the use of Flood Notification Letters, Flood Certificates are recommended for use in more 'formal' situations such as when a Development Application is submitted or a Section 149 Certificate is issued.

Section 149 Certificates

A Section 149 Certificate is a zoning certificate issued under *Environmental Planning & Assessment Act, 1979*, which can be obtained to confirm controls relevant to individual properties, and must be attached to a contract prepared for the sale of property.

It is important that all properties in the floodplain (that is, up to the probable maximum flood) be notified on a Section 149 Certificate. Using the wording presented in the *2001 Floodplain Management Manual* as a guide together with some legal advice, consistent wording for S149 (2) certificates across the catchment has been recommended.

Quality Assurance of Flood Data Released to the Public

The flood-related information provided on Flood Certificates, Section 149 Certificates and released to the public during the development approval process would normally be provided by the Trust to the Council and then formally adopted by the Council before being issued.

Given that potentially different 'versions' of the Trust's data may exist, it is recommended that a more formal strategy for the release and adoption of new sets of flood data (particularly some quality assurance procedures) be developed by the Trust in conjunction with the four constituent Councils. This would ensure that a consistent and up-to-date set of flood levels is always being used across the catchment.

Flood Warning

Unfortunately, there is limited scope to improve the flood warning in the Upper Parramatta River catchment. This catchment responds very quickly to heavy rainfall, that is, the catchment experiences 'flash flooding'. As such, the Commonwealth Bureau of Meteorology would be unable to provide a specific flood warning service to this catchment. Therefore, provision of a 'formal' flood warning system for the Upper Parramatta River catchment has not been considered further.

However, an informal local formal warning system for the Parramatta central business district, using the Trust's upstream stream level gauges, appears feasible, although it may operate too infrequently to be maintained. It is recommended that this option be considered during preparation of a Local Flood Plan for the catchment.

Emergency Management

The following emergency management recommendations have been made as part of this draft *Floodplain Risk Management Plan*:

- briefly outlining hydrological and hydraulic modelling undertaken in the catchment to date;
- support for the continued development of the Local Flood Plan is considered to be an important outcome of this *Floodplain Risk Management Study*. The Trust and the Floodplain Risk Management Committee have important roles in assisting the SES in the future development of the Local Flood Plan(s) for the catchment. This may involve a separate flood plan for each local government area or an integrated flood plan for the whole catchment as part of the SES Sydney Western Division Flood Plan. Discussions are recommended between the Trust, the Committee, the SES's Deputy Director General and the SES's State Planning Coordinator on this matter;
- flood intelligence data readily available from the Trust, be included in the SES Local Flood Plan;
- that the planning controls developed for the catchment reflect the current thinking that it is safer for people to actually stay in their homes in flash-flood areas (in lower flood risk areas), where there is essentially no warning time, and that there be a 'safe-haven' above the level of the probable maximum flood, generally in the form of a upper-storey;

THE NEXT STEPS

The next steps to progress the floodplain risk management process are as follows:

- the Trust and the four constituent Councils resolve to place this study report and draft Plan on public exhibition;
- each of the Councils presents this study and the draft Plan to a meeting of Council to endorse formal public exhibition for about six weeks. It is envisaged that the Flood Risk Precinct maps will not be placed on exhibition, however, the Flood Information Brochure and FloodSafe Brochure will be available for the public exhibition;
- the Committee reviews the comments and submissions received on the study and plan during the period of public exhibition;
- any necessary amendments are made to the report and plan, and a final report is prepared and submitted to the Trust and the four constituent Councils for adoption;
- as funds become available, implementation of the plan proceeds in accordance with established priorities;
- Each Council carries out the 'in-house' components of the Plan such as the reviews of LEPs and zonings, together with the adoption of DCPs of Flood Policy.

1. INTRODUCTION

The Upper Parramatta River Catchment Trust commissioned Bewsher Consulting Pty Ltd, in association Don Fox Planning Pty Ltd, to undertake a *Floodplain Risk Management Study and Plan* for the Upper Parramatta River catchment in Sydney's western suburbs.

The Upper Parramatta River catchment (**Section 1.1**) covers an area of 110 square kilometres and includes parts of the Cities of Blacktown, Holroyd and Parramatta and part of the Shire of Baulkham Hills. Most of the catchment is urbanised and has a population of more than 230,000.

The potential for serious flooding in the Upper Parramatta River catchment was recognised in the early 1970s with a major flood mitigation strategy being carried out. However, progress on flood mitigation works was slow over the next 10 years, at the same time as extensive urban developed was occurring in the catchment. In the late 1980s, particularly in 1986 and 1988, the catchment experienced a series of storms and major floods, and many properties that had never been flooded before were inundated above floor level on more than one occasion.

Following representations from the four local councils after the devastation of those floods, the NSW State Government established the Upper Parramatta River Catchment Trust (UPRCT or 'the Trust') in 1989 **(Section 1.2)**. At the time of the establishment of the Trust, more than 600 residential properties and more than 350 industrial properties would have been flooded above floor level in a 100 year average recurrence interval (ARI) flood.

The Trust and the four local councils have made good progress in addressing the existing flood threats since 1989. The number of flood-affected houses flooded above floor level in a 100 year ARI flood has been reduced by one-third, while the number of flood-affected businesses has been reduced by two-thirds. This has been achieved with a number of flood mitigation measures including the construction of thirteen large flood retarding basins, the reconstruction of more than six large sections of creek to provide increased capacity and the purchase of several of the most severely flood-affected homes in the catchment.

Despite the expenditure of more than $35 million on this flood mitigation strategy since 1989, none of the four councils within the area of the Trust have adopted a formal Floodplain Risk Management Plan as required by the New South Wales (NSW) Government's Flood Prone Land Policy.

Therefore, the primary objective of the current *Upper Parramatta River Floodplain Risk Management Study and Plan* is to bring together, and place in appropriate context, all past, current and proposed future activities related to the reduction of flood risk in the catchment (**Section 1.3**). This study and plan constitute key components of the NSW Government's floodplain risk management process as outlined in the *Floodplain*

Management Manual (NSW Government, 2001) (**Section 1.4**). A number of funding sources are available for the implementation of floodplain risk management measures and these are described in **Section 1.5**.

The structure of this report is as follows:

- **Chapter 2** summarises the flood problems, together with the behaviour and impacts of flooding in the Upper Parramatta River catchment. **Chapter 2** also discusses the modelling of flood flows and flood levels in the catchment;

- **Chapter 3** provides an overview of the previous flood-related studies and investigations that have been undertaken in the catchment, together with an outline of the available mapping and survey that has been carried out;

- **Chapter 4** presents an overview of floodplain risk management measures available for dealing with flood problems generally and the methodology used to assess these management measures in the current study. The large number of floodplain risk management measures that have already examined and implemented in the catchment are also listed in this chapter;

- **Chapter 5** discusses possible future floodplain risk management options for the Upper Parramatta River catchment, particularly flood-related planning and development controls, community awareness about flooding, the release of flood-related information to the community, flood warning and emergency management;

- **Chapter 6** presents the draft *Upper Parramatta River Catchment Floodplain Risk Management Plan*. For each recommended element of the plan, costs and priorities for each Council are presented;

- **Chapter 7** lists all the documents referenced in this study;

- **Chapter 8** provides a bibliography of all studies and investigations that have been undertaken in the catchment since the early 1970s;

- **Chapter 9** provides a glossary of terms used in this study.

Don Fox Planning Pty Ltd has prepared a stand-alone document entitled *Planning Issues and Outcomes* as part of this study (Don Fox Planning, 2003). Because planning and development controls are such an integral component of the draft *Floodplain Risk Management Plan*, the report has been included in its entirety as **Volume 2** of the current report. Draft Development Control Plans (DCPs) for Holroyd, Blacktown and Baulkham Hills local government areas and a draft Flood Policy for the Parramatta local government area are included as Appendices in **Volume 2**. Key components of the **Volume 2** report have been summarised in appropriate locations throughout the main body of this report.

1.1 THE STUDY AREA

The Upper Parramatta River catchment covers an area of 110 square kilometres and covers all land that drains to the Parramatta River upstream of its tidal limit at the Charles Street Weir, between the Barry Wilde Bridge (Wilde Avenue) and the Gasworks Bridge (Macarthur Street). Most of the catchment is urbanised and has a population of more than 230,000. However, there are significant areas of urban bushland, generally located along the major watercourses.

A map of the study area is presented as **Figure 1.1**. The Upper Parramatta River has a number of tributaries that flow into it within the study area. The two largest tributaries are Toongabbie Creek and Darling Mills Creek. Other tributaries include the following:

- Brickfield Creek;
- Domain Creek;
- Finlaysons Creek;
- Coopers Creek;
- Pendle Creek (also known as Pendle Hill Creek);
- Greystanes Creek (also known as Girraween Creek);
- Grantham Creek;
- Blacktown Creek;
- Lalor Creek;
- Quarry Creek;
- The Quarry Branch (also known as Northmead Gully);
- Excelsior Creek;
- Blue Gum Creek;
- Rifle Range Creek;
- Hunts Creek.

The Upper Parramatta River catchment includes parts of the following four local government areas (LGAs):

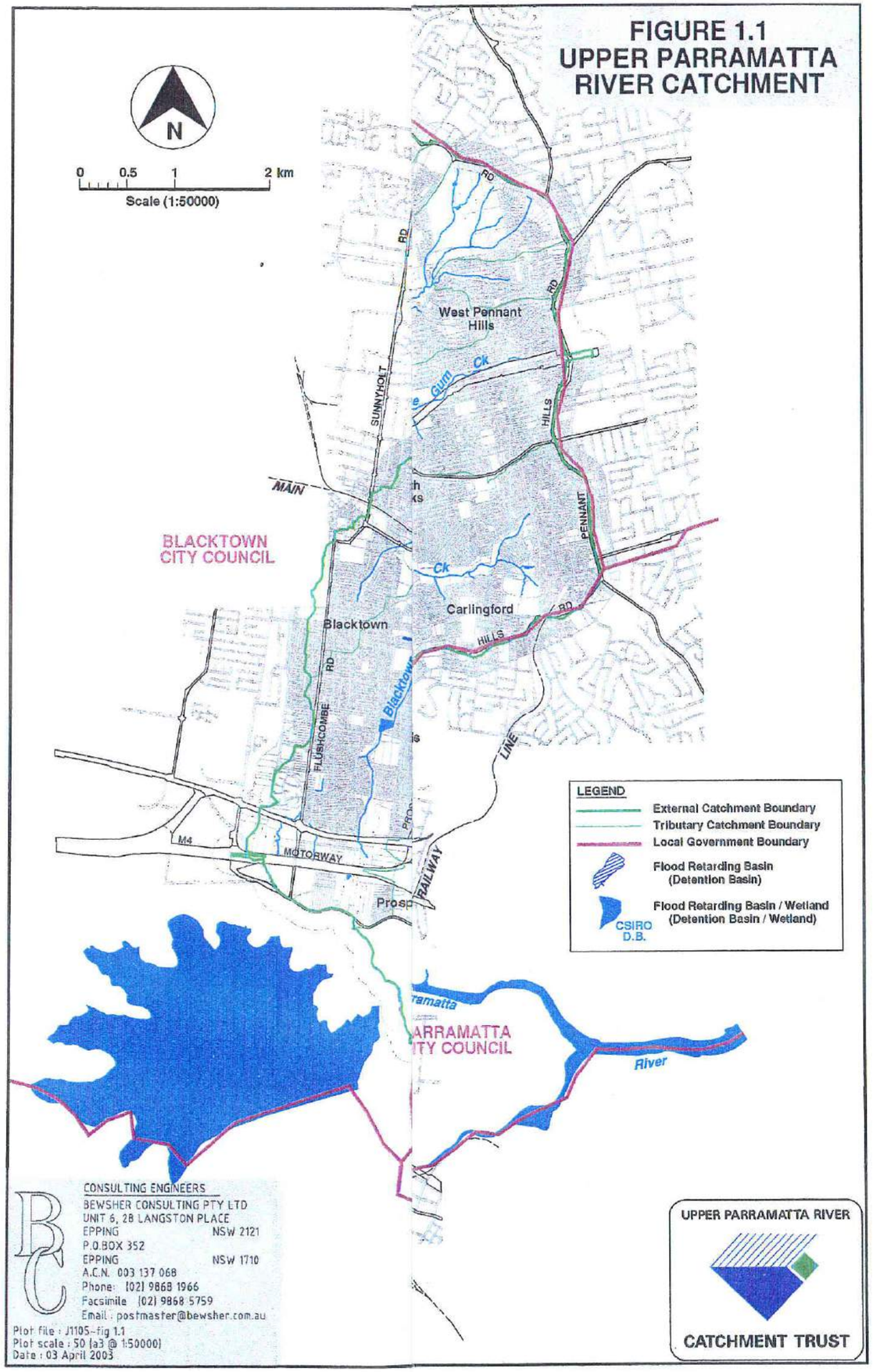
- Shire of Baulkham Hills — including the suburbs of Oatlands, Carlingford, North Rocks, Northmead, North Parramatta, West Pennant Hills, Castle Hill and Baulkham Hills;

- City of Blacktown — including the suburbs of Toongabbie, Seven Hills, Prospect, Blacktown, Lalor Park and Kings Langley;

- City of Holroyd — including the suburbs of Westmead, Wentworthville, South Wentworthville, Greystanes, Pendle Hill, Girraween, Prospect, Toongabbie and Merrylands West;

- City of Parramatta — including the suburbs of Parramatta, North Parramatta, Westmead, Northmead, Wentworthville, Toongabbie, Old Toongabbie and Winston Hills.

FIGURE 1.1
UPPER PARRAMATTA RIVER CATCHMENT



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Plot file : J1105-fig 1.1
Plot scale : 50 (a3 @ 1:50000)
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UPPER PARRAMATTA RIVER CATCHMENT TRUST

An understanding of the existing land use together with the population characteristics are important considerations in floodplain risk management studies. The population, characteristics and development trends of the study area provide an understanding of the values that the community has in regard to the utilisation of the floodplain, as opposed to merely sterilising its use to minimise the risks of flooding.

To ensure that all potential floodplain risk management measures are assessed, with the aim to improve (or least maintain) the diversity and well being of the riverine ecosystem, consideration of vegetation issues is also an important component of these types of studies.

A general overview of the characteristics of the Upper Parramatta River catchment, including vegetation, existing land use, heritage and changing population characteristics are presented in Chapter 2 of **Volume 2** of this report.

1.2 THE UPPER PARRAMATTA RIVER CATCHMENT TRUST

The NSW Government established the Upper Parramatta River Catchment Trust (the Trust) in 1989, under the *Water Supply Authorities Act, 1987*, in response to representations from the four catchment councils following the series of major floods in the catchment in the late 1980s.

The Trust's main function is to generally improve the social, economic and environmental well being of the catchment community by

- mitigating the impacts of flooding and trunk drainage surcharge;
- improving water quality in the catchment's creeks and streams;
- improving environmental and recreational values of streams and stream banks;
- instituting appropriate planning controls.

Although the Trust's charter includes water quality, native vegetation and other catchment issues, flooding remains the principal focus of the Trust and the four constituent Councils. The Trust helps to speed up the implementation of flood mitigation projects by providing a coordination role, providing technical advice and funding half the cost of approved projects.

The Trust's principal source of income is a river management service charge levied on all rateable properties in the catchment. Sydney Water, on behalf of the Trust, collects the charge each quarter. In 2002/03 the quarterly charge for a residential property with a single dwelling was $7.40.

1.3 OBJECTIVES OF THIS STUDY

The primary objective of the current *Upper Parramatta River Floodplain Risk Management Study and Plan* is to bring together, and place in appropriate context, all past, current and proposed future activities related to the reduction of flood risk in the catchment. In broad terms, the current study has investigated what can be done to

minimise the effects of flooding in the Upper Parramatta River catchment and recommended a strategy in the form of a draft *Floodplain Risk Management Plan*.

As mentioned above, despite the expenditure of more than $35 million on flood mitigation works and measures since 1989, none of the four councils within the area of the Trust have adopted a formal Floodplain Risk Management Plan as required by the New South Wales (NSW) Government's Flood Prone Land Policy. This study and plan constitute key components of the NSW Government's floodplain risk management process as outlined in the *Floodplain Management Manual* (NSW Government, 2001) (see **Section 1.4**).

Some of the objectives of the study include:

- briefly outlining the hydrological and hydraulic modelling activities that have been undertaken for the catchment to date;
- briefly reviewing the past, current and future flood-related activities of the Trust and the four constituent Councils;
- reviewing, in detail, issues relating to planning and development controls within the catchment's floodplains;
- identifying additional floodplain risk management measures that particularly relate to community awareness about flooding, the release of flood-related information to the community, flood warning and emergency management;
- developing a mutually agreeable draft *Floodplain Risk Management Plan* for the Upper Parramatta River catchment that outlines the best measures to reduce flood damage, based on environmental, social, economic, financial and engineering considerations.

1.4 THE NSW GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance on statewide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain management studies, and for the implementation of works identified in these studies.

The NSW Government's Flood Prone Land Policy and the new *Floodplain Management Manual* (NSW Government, 2001) form the basis of floodplain management in New South Wales. The new *Floodplain Management Manual* now supersedes the *Floodplain Development Manual* (NSW Government, 1986).

The Flood Prone Land Policy is provided in Appendix A of the *Floodplain Management Manual*, its primary objective being to:

- "reduce the impacts of flooding and flood liability on individual owners and occupiers of flood-prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible."

One of the primary aims of the 2001 *Floodplain Management Manual* is to foster the following floodplain risk management principles:

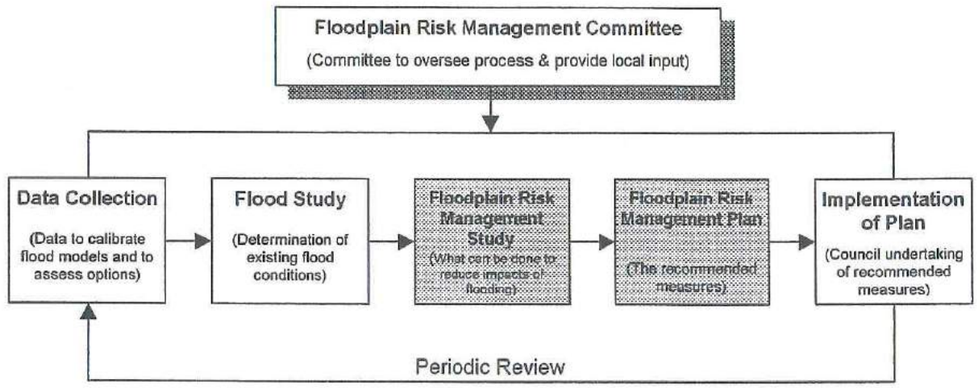
- "to reduce the social and financial costs that result from the risks of occupying the floodplain;
- to increase the sustainable social, economic, and ecological benefits of using the floodplain;
- to improve or maintain the diversity and well-being of native riverine and floodplain ecosystems."

In order to follow these principles, the *Floodplain Management Manual* encourages a risk management approach and provides the following hierarchy of floodplain risk management measures that should be considered:

- avoidance of the flood risk;
- minimisation of the flood risk using appropriate planning controls;
- mitigation of the flood risk — this is considered to be the least preferred option in the new Manual, as it is often costly and is most likely to adversely affect the natural environment.

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

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



▒ Steps undertaken as part of the current study

Source: *Floodplain Management Manual* (NSW Government, 2001)

FIGURE 1.2: NSW GOVERNMENT FLOODPLAIN RISK MANAGEMENT PROCESS

1.5 FUNDING OF FLOODPLAIN RISK MANAGEMENT PLAN

In NSW, the primary source of funding for the various elements of the floodplain risk management plan is generally via State Government funding through the Department of Land and Water Conservation (DLWC). The Commonwealth Government also provides funding for flood mitigation projects in outer metropolitan areas such as the Upper Parramatta River catchment, generally matching the State's contribution on a 'one-to-one' basis.

Although much of the current *Floodplain Risk Management Plan* may be eligible for Government assistance (be it State or Commonwealth), funding cannot be guaranteed. Government funds are allocated on a prioritised basis to competing projects throughout the State. Funding of investigation and design activities is also normally available. Maintenance costs, however, are the responsibility of Council.

Also, funding of flood risk management measures is only available to implement measures that contribute to reducing existing flood problems — they are not available to avoid future flood risks created by new development.

As discussed in **Section 1.2**, the Trust's principal source of income is a quarterly river management service charge levied on all rateable properties in the Upper Parramatta River catchment. Using these charges, the Trust can provide the local councils with half the funds to complete floodplain risk management activities within the Upper Parramatta River catchment areas in their local government area.

A key target for the Trust each year is to obtain external Government funding for flood mitigation projects to supplement the income from the service charge. After several years of not receiving any Government assistance in the late 1990s, the Trust received more than $1 million in Government grants to undertake works in the catchment in 2001–2002 (UPRCT, 2002b).

1.6 ROLES AND RESPONSIBILITIES OF ORGANISATIONS

Many government and non-government organisations have various responsibilities in the management of flood risks in NSW. **Table 1.1** summarises the key responsibilities of these organisations before, during and after a flood.

TABLE 1.1 ROLES AND RESPONSIBILITIES IN FLOOD RISK MANAGEMENT

ORGANISATION	ROLES AND RESPONSIBILITIES
Upper Parramatta River Catchment Trust (the Trust)	▸ strategic and coordinating role of all flood-related matters within the catchment; ▸ collection of river management service charge for use in funding elements of the Floodplain Risk Management Plan; ▸ coordination of flood mitigation works; ▸ calculation of flood levels and determination of flood behaviour of all major streams; ▸ collection of rainfall, streamflow and water level data; ▸ collection of flood levels after a flood.
Local Councils in Upper Parramatta River catchment	▸ adoption of flood levels (and other flood-related information) provided by the Trust); ▸ determination of flood behaviour from local drainage problems and in areas other than major streams; ▸ provision of flood levels (and other flood-related information) to the public; ▸ preparation and adoption of flood-related planning instruments; ▸ closing of local roads during a flood (in association with NSW Police Service and State Emergency Service).
NSW State Government NSW Department of Land and Water Conservation (DLWC)	▸ NSW Government Department responsible for development and administration of Flood Prone Land Policy; ▸ provides an oversight and coordination role for all flood related matters across NSW; ▸ administers state government funding of elements of the Floodplain Risk Management Plan.
State Emergency Service of NSW (SES)	▸ formal responsibility for emergency management operations in response to flooding; ▸ establishes the 'flood planning process' through and involving the Local Emergency Management Committee; ▸ responsible for preparation of Local Flood Plans; ▸ coordinates evacuation (if required) during a flood including notification of who should evacuate.
NSW Roads and Traffic Authority	▸ responsible for road closures for major roads during a flood (in association with the NSW Police Service and the SES).
NSW Department of Community Services (DOCS) (DOCS, 2003)	▸ through it Disaster Recovery Service, provides support to help the community recover from the disaster of a flood. This can include practical assistance such as beds, food, accommodation, through to personal support and counselling; ▸ manage Evacuation Centres (short-term assistance) during and immediately after a flood, providing food, accommodation, first aid, clothing, blankets, registration of victims and information; ▸ manage Recovery Centres for longer term assistance to deal with advice on insurance, counselling, financial assistance, etc.; ▸ works with non-government agencies including the Red Cross, Salvation Army, St Vincent de Paul Society, the Seventh Day Adventist Church and Anglicare.
Commonwealth Government Commonwealth Bureau of Meteorology	▸ responsible for issuing flood warnings in catchments where formal warning systems exist; ▸ issues 'thunderstorm warnings' in catchments where 'flash flooding' occurs
Commonwealth Department of Transport and Regional Services (DOTARS) (DOTARS, 2003)	▸ through the Regional Flood Mitigation Programme, DOTARS provides funding for flood mitigation projects in outer metropolitan areas such as Upper Parramatta River catchment; ▸ administers Natural Disaster Relief Arrangements.

2. IMPACTS AND BEHAVIOUR OF FLOODS

Floods and the damages caused by floods have been reported in the Upper Parramatta River catchment since the earliest days of European settlement. However, the potential for serious flooding in the catchment was not officially recognised until the early 1970s with a major flood mitigation strategy being carried out. In the 1970s and 1980s, extensive urban developed was occurring in the catchment. In the late 1980s, particularly in 1986 and 1988, the catchment experienced a series of storms and major floods, and many properties that had never been flooded before were inundated above floor level on more than one occasion. The impacts of flooding before the establishment of the Upper Parramatta River Catchment Trust (the Trust) are discussed in **Section 2.1**.

Since 1989, the Trust and its four constituent Councils have made good progress in addressing these flood threats. The number of flood-affected houses flooded above floor level in a 100 year ARI flood has been reduced by one-third, while the number of flood-affected businesses has been reduced by two-thirds. The current flood problems in the catchment are outlined in **Section 2.2**.

The current flood problems in the catchment are determined and quantified by the use of hydrologic and hydraulic computer models. These models were originally developed and maintained by the then Department of Water Resources (DWR) in the early 1980s. These models have been maintained and refined by the Trust since 1989. A brief overview of this modelling is provided in **Section 2.3**.

It should be noted that, in this report, the size of the flood (or its probability) is described in terms of average recurrence interval or ARI, for example '100 year ARI flood'. A '100 year ARI flood' has a 1% chance or a chance of 1 in 100 of occurring in any one year. The size of a flood can also be described in terms of its probability of occurring in any one year, for example, a 100 year ARI flood can also be called a '1% annual exceedance probability (AEP)' flood. For improved clarity, a '100 year ARI flood' will be simply referred to as a 100 year flood in this document (refer to the Glossary in **Chapter 9** for more information).

2.1 FLOOD PROBLEMS IN THE CATCHMENT PRIOR TO 1990

2.1.1 Prior to the August 1986 flood

The largest flood in the Upper Parramatta River catchment last century, prior to those of the late 1980s, occurred in 1914 (about a 40 year flood). Following the end of World War 2 in 1945, the catchment began to experience rapid urban growth. However, the only floods to occur in this period were a large flood in 1956 (about a 30 year flood) and two 10–20 year floods in the 1960s. (DWR, 1989).

Following a fatality when a car was washed off a flooded bridge in Toongabbie during a relatively minor flood in 1974, the potential for serious flooding in the catchment was officially recognised and a major flood mitigation study was carried out.

The resulting report, completed in 1976, recommended a flood mitigation strategy involving the construction of twenty-two flood retarding basins and a number of creek enlargement works. The report also warned of the likely growth in flooding arising from continuing development in the catchment. A further study, completed in 1980, refined these proposals.

However, in the absence of any significant flood events in the 1970s and early 1980s, progress on the construction of the recommended flood mitigation scheme was slow, with only three flood retarding basins built by 1986. At the same time extensive urban development was continuing in the catchment.

2.1.2 The late 1980s

From the middle of 1986 to 1988, the Upper Parramatta River catchment experienced a period of above average rainfall. The major storm of August 1986 was estimated at the time to be about a 20 year flood. Another major storm in April 1988 was even larger, estimated at the time to be about a 60 year flood (DWR, 1989). The April 1988 flood is now estimated to be only about a 30 year flood (UPRCT, 2002c). Lesser, yet still significant storms also occurred in November 1987 and July 1988. Many properties that had never been flooded before were inundated on several occasions.

In the 1986 flood, nearly 600 residential properties in the catchment experienced overground flooding, while nearly 140 dwellings were inundated above floor level. Nearly 40 business properties were also flooded above floor level. A study of damages suffered by the catchment community estimated the total damage bill to be more than $15 million dollars in today's terms, acknowledging that this amount was probably an underestimate. More than 60% of this damage was sustained by the business sector, even though the August 1986 flood did not affect the Parramatta Central Business District (CBD).

2.1.3 The 1990 Situation

By 1990, it was estimated than more than 2,300 residential properties in the Upper Parramatta River catchment at 63 different locations would experience over-ground flooding in a 100 year flood. Of those 2,300 properties, about 630 dwelling would be flooded above floor level. More than 350 business properties, including about one-third of the Parramatta CBD would also be flooded (UPRCT, 1999). The total flood damage that could be expected, on average, every year (known as the 'average annual damage') was estimated, at the time, to be nearly $8 million dollars in today's terms.

Figure 2.1 shows the locations of the key problem areas in the catchment in 1990. **Table 2.1** lists the number of residential and business properties that were determined to be flooded above floor level in a 100 year flood in 1990.

FIGURE 2.1: FLOOD PROBLEMS IN THE CATCHMENT IN 1990

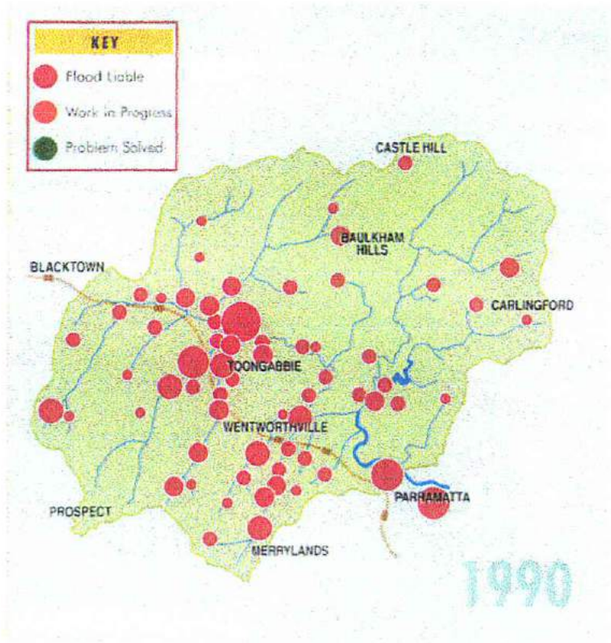
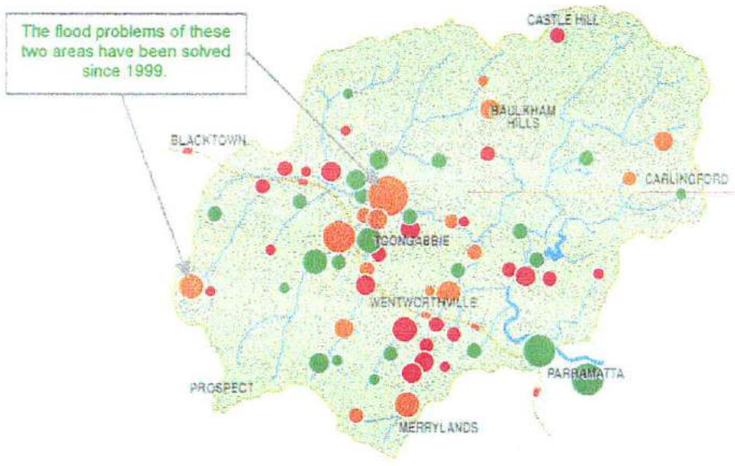


FIGURE 2.2: FLOOD PROBLEMS IN THE CATCHMENT IN 2003



Source: adapted from UPRCT (1999)

TABLE 2.1: KEY FLOOD-AFFECTED AREAS IN 1990

AREA	NO. PROPERTIES ESTIMATED IN 1990 TO BE FLOODED ABOVE FLOOR LEVEL IN A 100 YEAR FLOOD	
	RESIDENTIAL	BUSINESS
Parramatta Central Business District	—	200
Darling Mills Creek	—	10
Toongabbie Creek — Briens Road to Old Windsor Road	19	—
Toongabbie Creek — Hammers Road to Oakes Road	32	—
Toongabbie Creek — Old Windsor Road (Johnsons Bridge) to McCoy Park Flood Retarding Basin	333	1
Toongabbie Creek — McCoy Park Flood Retarding Basin to Old Windsor Road (Pyes Crossing)	—	79
Finlaysons Creek	90	—
Coopers Creek	16	1
Pendle Hill Creek	50	15
Greystanes Creek	47	21
Lalor Creek	6	4
Blacktown Creek	40	23
TOTALS	**633**	**354**

Source: DWR (1989)

2.2 FLOOD PROBLEMS IN 2002

2.2.1 Improvements to Flood Risk

The establishment of the Upper Parramatta River Catchment Trust in 1989, provided a coordinated approach to a flood mitigation strategy for the catchment. Since 1989, the Trust and the four local councils have made good progress in addressing the existing flood threats in the catchment. The number of flood-affected houses flooded above floor level in a 100 year ARI flood has been reduced by one-third, while the number of flood-affected businesses has been reduced by two-thirds. There are no longer any properties that would be flooded by minor to moderately sized floods. The Parramatta Central Business District (CBD) is now protected from flooding from the Parramatta River in a 100 year flood (UPRCT, 1999). Parts of the CBD are, however, still subject to flooding from local runoff and smaller tributaries.

This has been achieved with a number of flood mitigation measures including the construction of thirteen large flood retarding basins, the reconstruction of more than six large sections of creek to provide increased capacity and the purchase of about eight of the most severely flood-affected homes in the catchment (about five of which were modified and resold after purchase). These measures are discussed in more detail in **Section 4.3**.

Figure 2.2 provides a pictorial view of the progress made in reducing the flood threat in the catchment as at 1999, comparing the situation to that in 1990. **Figure 2.3** shows how the number of flood affected properties has reduced since 1990. The current estimate of the extent of the 100 year flood is shown on **Figure 2.4**.

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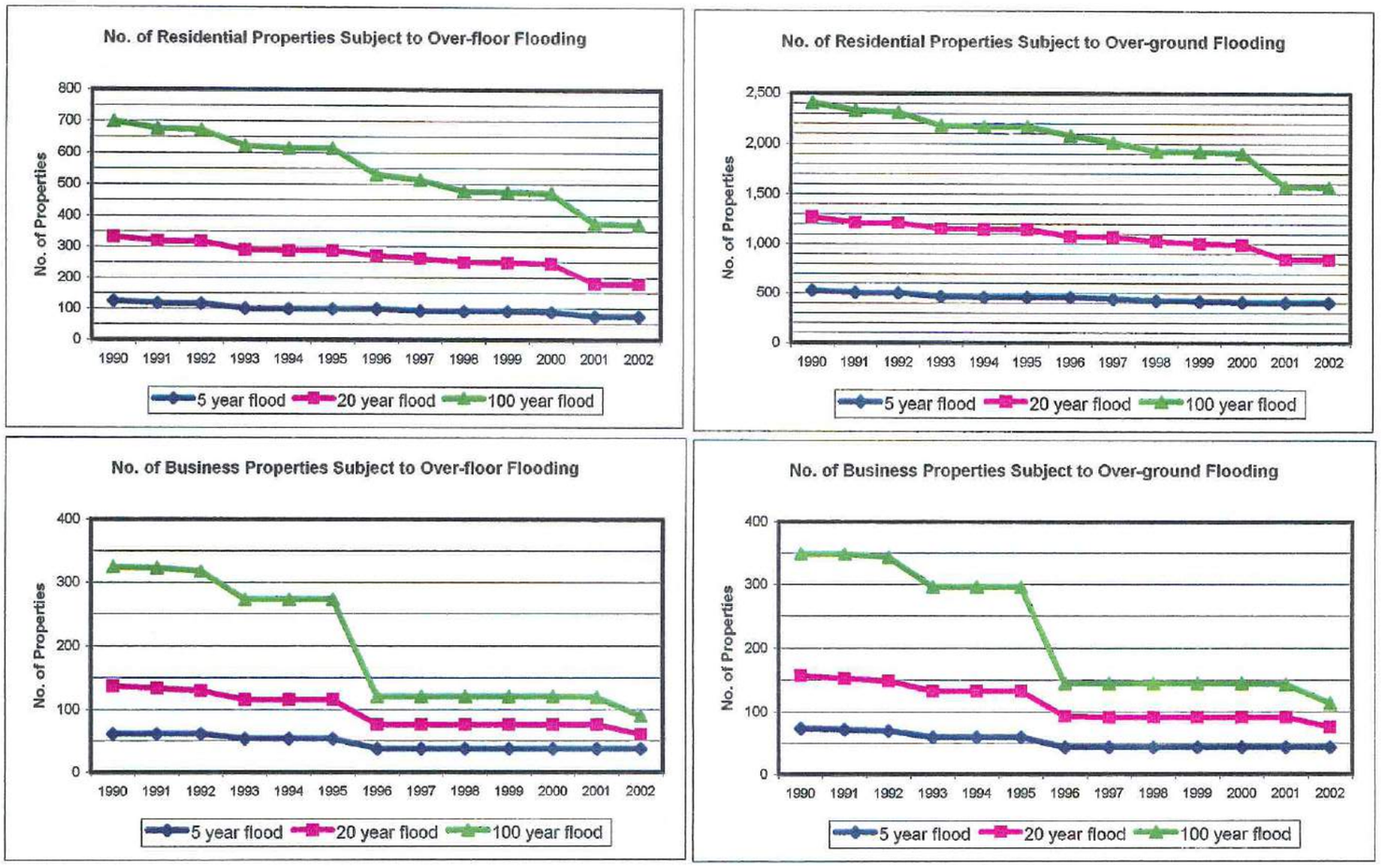
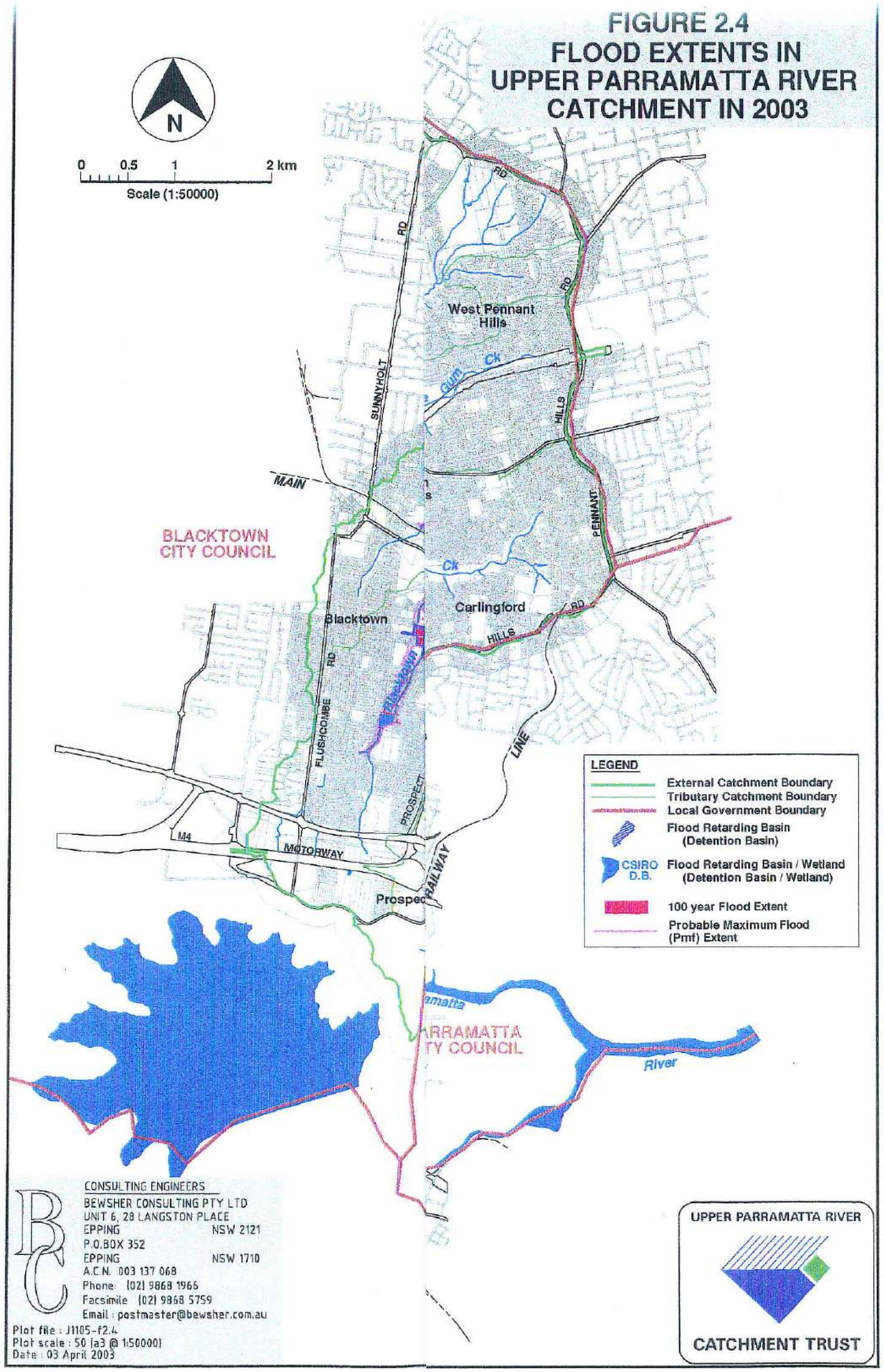


Source: UPRCT (2003)

FIGURE 2.3: PROPERTIES SUSCEPTIBLE TO FLOODING 1990–2002

FIGURE 2.4
FLOOD EXTENTS IN UPPER PARRAMATTA RIVER CATCHMENT IN 2003



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Plot scale : 50 (a3 @ 1:50000)
Date : 03 April 2003

UPPER PARRAMATTA RIVER CATCHMENT TRUST

2.2.2 The Need to Consider the Probable Maximum Flood

Up until quite recently, the largest flood that was generally considered in assessment of flood mitigation options in the Upper Parramatta River catchment (in fact, in most of NSW), was the 100 year flood. Generally, the '100 year flood' defined the boundary between 'flood-prone land' and land that was considered to 'flood-free'. There was little acknowledgment that larger floods could occur.

With the release of the Floodplain Management Manual in 2001 (NSW Government, 2001), there is now an increased emphasis on assessing all flood risks up to the largest flood that could possibly occur. This largest flood is referred to as the 'probable maximum flood' (PMF). Consequently, 'flood-prone land' (or the 'floodplain') now covers all land that would be inundated by all floods up to a probable maximum flood.

A PMF study was undertaken for the catchment in 2001 by Sinclair Knight Merz (SKM) (SKM, 2001). The flows in a PMF were found to vary from 1.5 to 5 times that of a 100 year flood in this catchment. Flows of this magnitude would result in flood levels up to 5m higher than the 100 year flood in the lower areas of the catchment and about 1–2m higher in the upper reaches of the tributary creeks. It has been estimated that in the order of 9,000 properties in the catchment would be flooded above ground level in a PMF. There may be some isolated hazardous locations in the catchment during a PMF.

Figure 2.4 shows the estimated extent of the PMF in the catchment.

The principal concern during an extreme flood event, such as the PMF, is the risk to human life, rather than the risk to property. Therefore, it is important that the potential risks of such a flood are recognised. It is unlikely that flood mitigation works would be recommended to try to solve the flood problems of a PMF. Rather, the potential impacts of the PMF can be addressed through planning and building controls, emergency management and community awareness that recognise such a flood is at least possible, albeit extremely unlikely. These types of floodplain risk management measures can minimise the risks of a PMF to acceptable levels.

One potentially hazardous situation that can happen in floods larger than the 100 year flood, occurs when development is constructed just above the level of the 100 year flood without forethought as to what would happen if a larger flood occurred. Traditionally, there would have been no escape route envisaged for that property. However, the escape route away from the property in a flood larger than the 100 year flood may well lead the occupant through deeper water before 'dry land' is reached. These areas of 'evacuation islands' are potentially dangerous in very large floods because if the flood is larger than predicted, these islands can become inundated, leaving the occupant with nowhere to go.

The impacts of the probable maximum flood, particularly from an 'emergency management' perspective, should therefore be carefully considered for all development in the floodplain. This has been recognised in this study through the recommended planning and development controls described in **Section 5.2** and the community awareness strategy described in **Section 5.3**.

2.3 FLOODPLAIN MODELLING

2.3.1 RAFTS-XP and MIKE-11 Models

To understand the flooding characteristics of the Upper Parramatta River catchment, the then Department of Water Resources first established detailed computer models of the catchment in the early 1980s. Since 1989, these models have been maintained, enhanced and updated as flood mitigation works are completed, by the Trust. Hydrologic models calculate the flood flows that can be expected in historical or design (statistical) storms. Hydraulic models are used to compute the flood levels for a particular flood flow.

The Trust currently uses a RAFTS-XP hydrologic model of the catchment to calculate runoff hydrographs for all subcatchments. The MIKE-11 hydraulic model is then used to route the aggregated hydrographs along the creeks and floodplains to determine design flood flow estimates and design flood levels. These computer models take into account all land use types, developments and flood mitigation works. Since the early 1990s the models have been substantially altered to reflect the significant changes that have occurred in the catchment.

All of the four constituent Councils use the results of these computer models to assess the flood liability of properties, set appropriate floor levels and development conditions for new development, provide flood advice on Section 149 Certificates and the likely flooding impacts of proposed development. The Trust and the Councils also use the models to design flood mitigation and trunk drainage works (UPRCT, 2001a) (UPRCT, 2002c).

2.3.2 Independent Review of Models in 2001

Overview

Because the Trust's and the constituent Council's flood-related activities rely so heavily on the Trust's flood computer modelling, and because of the lack of any recent large floods with which to calibrate the continuously updated model, a review of the Trust's modelling was undertaken in 2001. The report, entitled '*Review of UPRCT Catchment Flood Modelling*' (Cardno Willing Pty Ltd, 2001), confirmed the reasonableness of the Trust's modelling.

The study concluded the 100 year flood flows were consistent with those determined elsewhere in the Sydney region and that all model parameters were within acceptable ranges. The study recommended specific sets of model parameters and model versions that should be use to provide the most reasonable results — particularly that the 1997 RAFTS parameters should be adopted until changes were justified by further studies.

A number of other recommendations were made as part of the Cardno Willing Study. These have been addressed and acted upon by the Trust as appropriate.

Consideration of Culvert Blockage in Hydraulic Modelling

One of the recommendations made by the study was that the Trust considers the possible blockage of culverts by debris in its flood modelling.

During the August 1998 flood in the Wollongong area (about a 100 year flood) culverts up to 6 metres across (diagonally) were completely blocked by debris, causing flood levels to be considerably higher than ever anticipated. The culverts were mainly blocked rocks and vegetation, including large trees. As a result, Wollongong City Council has decided to assume that culverts up to 6 metres across are either completely blocked, or completely unblocked, during major storms, and adopt the highest flood levels that would occur at each location (Wollongong City Council, 2001).

Wollongong Council's Conduit Blockage Policy highlights the fact that a blocked culvert would raise upstream flood levels, but decrease downstream flood levels. Also, in some instances a blocked culvert can force floodwaters to take a different flow path, inundating areas that would not otherwise be affected. Hydraulic modelling of culvert blockage therefore often requires modelling of a large number of combinations of particular culverts being assumed to blocked and unblocked.

The Wollongong area is particularly prone to culvert blockage because of its intense rainfalls, very steep escarpment, highly erodible streams and dense forest immediately upstream of urban areas. These conditions do not occur in the Upper Parramatta River catchment.

During the large floods of the late 1980s in this catchment cars were washed into the creeks at one or two locations, but did not totally obstruct flow. It is acknowledged that cars, and other large items, could obstruct culverts during future major floods in the Upper Parramatta River catchment. However, it is impossible to predict where this might happen and the degree of blockage and as such, the probability of a particular culvert being totally blocked during a 100 year flood is considered to be much less than 1% in any one year. Therefore, if flood levels were calculated assuming a 100 year storm and total blockage of all culverts, this would reflect a flood with a probability much rarer than 1% or '1 in 100'.

For these reasons, the Trust considers that it is not appropriate to assume blockage of culverts in its flood modelling (UPRCT, 2002d).

2.3.3 Data Collection Network

To support its flood modelling activities, the Trust maintains an extensive data collection network that includes:

- fourteen telemetry-accessible pluviometers (continuous rainfall recorders);
- 78 maximum flood height indicators;

- four streamflow stations plus access to one gauging station operated by the Department of Land and Water Conservation (DLWC);

- one flow and water quality monitoring station on the Parramatta River at Cumberland Hospital.

The Trust also has an hydrographic team on call to undertake flow gaugings during future floods. There are also about 875 historical flood levels that have been archived and plotted on the Trust's Geographical Information System (GIS) (see **Section 3.4**).

2.3.4 Accuracy of Computer Models

The accuracy of the computer models used to predict the flood behaviour is dependent on the accuracy of the survey ground levels and on other factors (see **Section 3.3**). Models in themselves are only approximations of real behaviour and, in the case of the MIKE-11 model used by the Trust, produces flood level results only at discreet cross-section locations. Information about flood behaviour at intermediate locations is generally obtained by linear interpolation. Again this introduces some errors.

Ongoing physical changes in the catchment mean that the Trust's hydrologic RAFTS model and the hydraulic MIKE-11 model must be continually updated to reflect these changes. Data collected during the large floods of the late 1980s can therefore no longer be used for model calibration.

If large floods had recently occurred in the catchment, the data collected could have been used to calibrate the models, and to assess how well the models reproduce the observed flood flows and flood levels. From this, the accuracy of the computed 100 year flood levels could be inferred. However, in the absence of such flood data the accuracy of the flood levels cannot be determined.

To ensure that its flood levels are as accurate as possible, the Trust takes the following measures (UPRCT, 2002d):

- use of the most up-to-date modelling and GIS software;
- regular updates of its models to include physical changes in the catchment;
- discretisation of the catchment and its waterways to a high degree,
- use of current best engineering practice in its modelling work; and
- review of the modelling by independent external experts.

To provide greater confidence in the accuracy of the Trust's flood models, it is recommended that, as part of the draft *Floodplain Risk Management Plan*, that a formal quality assurance procedure for the preparation, release and adoption of design flood levels be developed and adopted by the Trust and the four constituent councils.

2.4 DESIGN FLOOD LEVELS, FLOW VELOCITIES AND FLOW RATES

2.4.1 Release of Information to Constituent Councils

As discussed in **Section 2.3**, the Trust's flood computer models are being continuingly enhanced and updated to reflect significant changes as they occur in the catchment. The Trust has adopted a practice of issuing an updated set of flood levels to the constituent councils once each year. These reflect a range of changes such as completed flood mitigation works, new land developments, more accurate data on land use and ground survey or improvements in computer modelling technology. Flow velocities and peak flow estimates are only provided to councils on request.

The new design flow rates, velocities and flood levels are presented in tabular form. The resulting flood extents are also made available in the Trust's GIS data base (see **Section 3.4**). The latest set of flood levels, flow velocities and peak flow estimates have not been reproduced as part of this study, but are available on request from the each of the four constituent councils.

Once new flood levels have been released to the councils, it becomes the responsibility of each council to adopt those flood levels for use within that council's part of the catchment. During the course of this study, informal discussions were held with the Trust and the councils about:

- the frequency at which new sets of flood levels should be released;
- the importance of using consistent and most up-to-date flood levels across the catchment.

If the frequency at which new sets of flood levels are released is too frequent, then this may affect the council's confidence in the results, with councils often being reluctant to adopt, and hence change, the flood levels to be used in the catchment. This has the potential problem of councils using flood levels that are 'out-of-date'. Another problem is that adjacent councils could be using different flood levels for nearby, or even the same, locations in the floodplain.

If the frequency at which new sets of flood levels are released is not frequent enough then the benefits of important changes to the creek system, such as flood mitigation works, may not realised in a particular design or development.

It is recommended as part of the draft *Floodplain Risk Management Plan* that a more formal strategy for the release and adoption of new sets of flood levels (particularly some quality assurance procedures) be developed by the Trust in conjunction with the four constituent Councils. This would ensure that a consistent and up-to-date set of flood levels is always being used across the catchment.

2.4.2 Upper Parramatta River Catchment Flood Study Report

It should be noted that there is no definitive Flood Study Report document for the Upper Parramatta River catchment. The original flood study completed by the then Department of Water Resources in 1989 entitled *Toongabbie Creek Flood Study* (DWR,1989) describes the original modelling of the catchment. The most recent Flood Study Report is known as *Upper Parramatta River Catchment Flood Study — Draft 5* and was prepared in 1997 (UPRCT, 1997). However, this document has not been finalised and hence has not been released as a public document (Lynch, S. UPRCT, pers. comm., April 2002).

It is recommended as part of the draft *Floodplain Risk Management Plan* that documentation relating to the calculation of flood levels is undertaken. This could be a component of the quality assurance procedures developed for the release of flood level data, as described above in **Section 2.4.1**.

3. BACKGROUND INFORMATION

This chapter presents an overview of the available background information relevant to for this study.

There have been more than 100 studies, investigation, designs and other documents prepared about flood-related issues within the Upper Parramatta River catchment in the past twenty-five years. It is beyond the scope of this report to discuss all these documents. However, they have been listed as a Bibliography in **Table 8.1** of this report. The numbering system presented in the bibliography was originally developed in the early 1990s and was added to up until the late 1990s. The bibliography has not been updated as part of this study.

Précis of several of the key documents relevant to the preparation of this *Floodplain Risk Management Study* are presented in this document.

Studies relating to floodplain modelling have been outlined in **Chapter 2**, including:

- *Review of UPRCT Catchment Flood Modelling* (Cardno Willing Pty Ltd, 2001);
- the *Upper Parramatta River Catchment Flood Study Draft 5* (UPRCT, 1997);
- *Probable Maximum Flood Study — Upper Parramatta River Catchment* (Sinclair Knight Merz, 2001)

Two important studies undertaken that have determined the priorities for flood mitigation works and other floodplain risk management measures in the Upper Parramatta River catchment, are summarised in this chapter. These two studies are:

- *Catchment Management Priorities Study* (Webb, McKeown & Associates, 1991a) (**Section 3.1**);
- *A Review of the Trust and Councils' Flood Mitigation and Trunk Drainage Program* (DVA Consulting, 2000) (**Section 3.2**).

The base mapping and ground survey that has been undertaken by the Trust in the catchment is outlined in **Section 3.3**. **Section 3.4** presents an overview of the Trust's Geographical Information System, together with how that information can be accessed.

3.1 CATCHMENT MANAGEMENT PRIORITIES STUDY (1991)

The *Catchment Management Priorities Study* was undertaken by Webb, McKeown & Associates in 1991, for the then newly established Upper Parramatta River Catchment Trust, to provide a rational basis for addressing the large number of flood problems in the catchment in a systematic way. As part of the study, a total of eighty-three mitigation measures were identified to address sixty-two separate flood problems in the Upper Parramatta River catchment. This information was presented in a Compendium of Data (Webb, McKeown &Associates, 1991b) as part of the study.

As part of the 1991 study, Webb McKeown & Associates developed a comprehensive method for assessing and prioritising the large number of floodplain risk management measures. This ranking procedure is outlined in **Section 4.2**. The Trust and the four constituent councils use this prioritisation method as the basis for selecting projects to be jointly funded by the Trust and the respective councils.

The list of measures and their rankings are periodically refined and updated as measures are constructed and other problem areas identified and investigated.

3.2 REVIEW OF TRUST'S AND COUNCILS' FLOOD MITIGATION AND TRUNK DRAINAGE PROGRAM (2000)

Ten years after the establishment of the Trust, a review was undertaken by DVA Consulting of the Trust's flood mitigation program and priority rankings, to determine whether there was a 'cut off point' beyond which the outstanding identified measures would not be practical or cost effective. This report was entitled *A Review of the Trust and Councils' Flood Mitigation and Trunk Drainage Program* and was completed in 2000.

The study concluded that the outstanding works that were cost justifiable should proceed. The study also concluded that all other flood problems should be investigated to determine whether they should remain on the priority list or be excluded.

The Trust is currently funding a program of staged investigations of all areas that remain unprotected from major floods, in conjunction with the four local councils. The investigations will determine if there is a feasible and cost justifiable solution for each area, its cost and likely benefits and how it ranks against other identified flood projects in the catchment. When this program of investigations is completed in late 2003 the scale and cost of all outstanding flood works in the catchment will be known with considerable confidence

3.3 BASE MAPPING AND GROUND SURVEY

The Upper Parramatta River Catchment Trust is the custodian of large amounts of land data applicable to the floodplains and other areas of the catchment. This includes, but may not be limited to, the following (UPRCT, 2002c):

- ***historical aerial photography*** — historical air photo mosaics of the catchment taken in 1951, 1965, 1977 and 1990;
- ***recent aerial photography*** — aerial photography in digital form from 1997 and late 2001;
- ***ground survey*** — detailed surveyed ground levels are available along the 2000 cross-sections that are used in the MIKE-11 computer model as well as in certain flood-liable areas;

- ***floor levels*** — surveyed floor levels are currently only available in certain flood-liable areas, however, the Trust plans to survey the ground and floor levels of all flood-affected properties in the catchment up to at least the level of the 100 year flood (and possibly up to the level of the PMF) by late 2003;

- ***laser survey data*** — the Trust has recently obtained laser survey data for the whole of the catchment. This consists of about 22 million spot levels at about 2m spacings with a vertical accuracy of ±0.15m. This is sufficient to provide ground contours at 0.5m intervals across the catchment.

3.4 TRUST'S GEOGRAPHICAL INFORMATION SYSTEM

To assist in catchment flood modelling and other activities, the Trust has developed and manages a comprehensive computer 'geographical information system' (GIS) database. In a GIS, different types of information are stored on 'layers'. The Trust's GIS has a large number of different layers, containing information including, but not necessarily limited to, the following (UPRCT, 2001a and UPRCT, 2002c):

- the 2001 aerial photography of the catchment;
- the laser survey data described above including the 0.5m contours;
- cadastral information including boundaries of properties, creeks, roads etc.;
- locations of creeks and their catchment boundaries;
- locations of flood retarding basins;
- soils and vegetation community types, including weeds;
- subcatchment boundaries used in the RAFTS-XP hydrological model;
- locations and extents of MIKE-11 cross-sections used in the hydraulic modelling;
- flood extents for a range of flood events up to the probable maximum flood;
- approximately 875 historical flood levels;
- areas of low and high hazard (see **Section 5.2.3**);

The Trust's GIS system will be an invaluable tool in the production of the Flood Risk Precinct Maps, recommended as part of the draft *Floodplain Risk Management Plan*.

The Trust's GIS data base can be accessed via its website at www.uprct.nsw.gov.au/gis/gis.htm. However, not all the data listed above can be directly accessed.

4. OVERVIEW OF FLOODPLAIN RISK MANAGEMENT MEASURES

One of the primary aims of the *Floodplain Management Manual* (NSW Government, 2001) (the Manual) is to foster the following floodplain risk management principles:

- "to reduce the social and financial costs that result from the risks of occupying the floodplain;
- to increase the sustainable social, economic, and ecological benefits of using the floodplain;
- to improve or maintain the diversity and well-being of native riverine and floodplain ecosystems."

To follow these principles, the Manual provides the following broad hierarchy of floodplain risk management measures that should be considered:

- avoidance of the flood risk;
- minimisation of the flood risk using appropriate planning controls;
- mitigation of the flood risk — this is considered to be the least preferred option in the Manual, as it is often costly and is most likely to adversely affect the natural environment.

Using this hierarchy of measures, the *Floodplain Management Manual* divides ways to manage the flood risk into three groups (**Section 4.1**):

- those that modify property in order to minimise flood damage (**Section 4.1.1**);
- those that modify people's response to flooding (**Section 4.1.2**);
- those that modify flood behaviour (**Section 4.1.3**).

As described in **Section 3.1**, a comprehensive method for assessing and prioritising the large number of floodplain risk management measures identified in the catchment was developed in the *Catchment Management Priorities Study* (Webb, McKeown & Associates, 1991a). This ranking procedure is outlined in **Section 4.2**.

As part of the 1991 *Catchment Management Priorities Study*, a total of 83 mitigation measures were identified to address 62 separate flood problems in the Upper Parramatta River catchment. Since 1991, this list of measures has been refined and updated as measures have been constructed and other problem areas identified and investigated. These measures were separated into the following two types of measures:

- 'works' measures — these measures had progressed to a stage where plans and costs were reasonably well-developed;

- 'investigation' measures — these measures were less advanced and an investigation was required to fully assess the problem and proposed solution.

Table 4.1 provides a summary of all the floodplain risk management measures that have been identified by the Trust. **Figure 4.1** shows the location of each of these measures.
The following information is provided in **Table 4.1**:

- ***ID No***. — for ease of identification, an 'ID No.' has been given to each measure as part of the current study. The 'ID No.' lists the measures in approximately the same order as the *Catchment Management Priorities Study*. Measures that were completed or close to completion when the Trust was established in 1989, have been assigned the highest 'ID No.';

- ***Trust Problem and Measure Codes*** — as part of the *Catchment Management Priorities Study*, an alphanumeric code was assigned to each flood problem area and each mitigation measure examined. These codes are still used by the Trust and have been used in the current study;

- ***status*** — this lists whether a project has been completed (and when) or whether it is a 'future project'. Based on the ranking procedure outlined in **Section 4.2**, the priority for each of the future projects is provided in terms of 'works' measures and 'investigation' measures for each of the four constituent Councils. The 'Certainty Factor' (see **Section 4.2**) is also provided;

- ***approximate cost*** — the approximate factored cost (see **Section 4.2**) for all future works from current Trust estimates is provided;

- ***recommended for further consideration as part of this study*** — the floodplain risk management measures already identified and prioritised by the Trust (as listed in **Table 4.1**) have not been reassessed as part of the current study. Therefore all those projects that have not already been completed or listed as no longer viable or deferred indefinitely, have been 'recommended for further consideration as part of this study'.

An overview of the floodplain risk management measures already implemented in the Upper Parramatta River catchment is provided in **Section 4.3**. The majority of these works are 'flood modification works' (**Section 4.3.1**) with some voluntary house purchase and house raising (**Section 4.3.2**).

Land use planning, development controls and specific flood-related policies are key mechanisms that can and have been used to manage flood-affected areas. An outline of the existing planning and development controls that apply to the Upper Parramatta River catchment is provided in **Section 4.3.3**.

The Trust places great importance on making sure that the catchment community is aware of Trust's activities and local environmental issues. Community consultation and awareness in flood-related issues are discussed in **Section 4.3.4**. Other site-specific flood-related investigations that have been carried out within the Upper Parramatta River catchment are discussed in **Section 4.3.5**.

TABLE 4.1: FLOODPLAIN RISK MANAGEMENT MEASURES — MEASURES PREVIOUSLY IDENTIFIED BY THE TRUST

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority(2) (Certainty)		
1	Gollan Avenue catchment — Pipe augmentation and property adjustments in area bounded by Ellis Street, James Ruse Drive, Pennant Hills Road and Bettington Road, Oatlands	Brickfield Creek	Baulkham Hills	BHP2BR	BHM2BR1	2001		—	no
2	Bray Court, Yalding Avenue, Paragon Drive and McDonald Street, North Rocks — modification of buildings and improvements to provide overland flow path	tributary of Hunts Creek	Baulkham Hills	BHP1H	BHM1H1		No.1 Priority 'works' for BHSC (3)	$0.32	yes
3	Landscape Street, Meryll Avenue, Coronation Road Mulgray Avenue, Jasper Road Baulkham Hills — establishment of overland flow path by acquiring (and reselling) and/or modifying five properties	tributary of Quarry Creek	Baulkham Hills	BHP1QC	BHM1QC1	1993–1997		—	—
4	Excelsior Avenue to Reiby Drive, Castle Hill — modification of buildings and improvements to provide overland flow path, plus possible flood retarding basin.	Quarry Creek	Baulkham Hills	BHP2QC	BHM2QC1		No.2 Priority 'works' for BHSC (3)	$1.02	yes
5	Lindsay Street, Coronation Road and Mulgray Avenue, Baulkham Hills — establishment of overland flow path including acquisition of two houses	tributary of Quarry Creek	Baulkham Hills	BHP3QC	BHM3QC1 BHM4QC1	Current design	No.3 and 5 Priority 'works' for BHSC (3)	$0.41 $1.35	yes
6	Upper Gooden Catchment — Luculia Avenue to Leatherwood Circuit, Baulkham Hills — floodway and drainage improvements	tributary of Toongabbie Creek	Baulkham Hills	BHP1T	BHM1T2	Study completed 2002		—	—
7	Watkins Road, Baulkham Hills — investigation into pipe augmentation	tributary of Toongabbie Creek	Baulkham Hills	BHP2T	BHM2T1	Current design	No.2 priority investigation for BHSC (1)	$0.44	yes
8	Oakes Road Trunk Drainage — Carmen Drive, Watton Road, Mahers Road West, Oakes Road, Sylvia Avenue and Morton Avenue, Carlingford — pipe enlargement and construction of five small flood retarding basins	tributary of Blue Gum (Darling Mills) Creek	Baulkham Hills	BHP2DM	BHM2DM1		No.4 priority 'works' for BHSC (4)	$2.04	yes

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority(2) (Certainty)		
9	Loyalty Road (North Rocks) Flood Retarding Basin — largest flood basin in NSW (30m high, 100m long) — reduced major flooding in North Rocks, Northmead, parts of North Parramatta, Parramatta CBD and Rosehill	Darling Mill Creek	Baulkham Hills Parramatta	BHP3DM	BHM3DM1	mid 1996		—	—
10	Orange Grove Pipe Augmentation — Orange Grove and Francis Street — investigation into pipe upgrading	tributary of Darling Mills Creek	Baulkham Hills	BHP4DM	BHM4DM1		No.1 priority investigation for BHSC (1)	$1.00	yes
11	Anderson Avenue, Northmead — voluntary purchase of one house	tributary of Darling Mills Creek	Baulkham Hills	BHP5DM1	BHM5DM1		—	—	no (local drainage problem only)
12	Upper Toongabbie Creek Flood Mitigation Strategy — high level floodway next to Toongabbie Creek at Sue Savage Reserve, Toongabbie, enlargement of Sierra Place flood retarding basin — significantly reduced major flooding in confluence area of Greystanes, Pendle Hill and Toongabbie Creeks	Greystanes Creek Pendle Hill Creek Toongabbie Creek	Parramatta	PP1GE	PM1GE1	2001		—	—
13	Greystanes Creek Restoration at Toongabbie Bowling Club — badly eroded and overgrown channel reconstructed to have a capacity to carry about a 20 year flood	Greystanes Creek	Parramatta (Holroyd) (Blacktown)	PP2GE	PM2GE1	2001		—	—
14	Hart Drive (Cumberland Highway), Wentworthville Culvert Upgrade and associated regrading works in vicinity of Craig Avon Way	Toongabbie Creek	Parramatta	PP1T	PM1T1	1994		—	—
15	Fitzwilliam Road, Nulang Road and Preston Street, Toongabbie — pipe upgrade and augmentation	tributary of Toongabbie Creek	Parramatta	PP2T	PM2T1	Current study	No.5 priority investigation for PCC (2)	$0.82	—
16	Oakes Road, Old Toongabbie House Raising (6 homes) and Flood Proofing (4 homes)	Toongabbie Creek	Parramatta	PP3T	PM3T1		No.2 priority 'works' for PCC (4)	$0.32	yes

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority(2) (Certainty)		
17	Edison Parade and Einstein Street, Winston Hills — Diversion of drainage around existing levee	Toongabbie Creek	Parramatta	PP4T	PM4T1		No.5 priority 'works' for PCC (4)	$0.65	yes
18	Hood Street, Old Toongabbie, voluntary purchase (one house) and Sherwood Street, Old Toongabbie levee	Toongabbie Creek	Parramatta	PP5T	PM5T1	1993 (voluntary purchase)	No.6 priority investigation for PCC (1)	$1.60	yes
19	Lister Street, Winston Hills levee extension and pump out — these works would be additional to the major diversion drain constructed in 1990 to prevent flooding from behind the existing levee	Toongabbie Creek	Parramatta	PP6T	PM6T1	1990 (diversion drain) 1980s (levee)	No.7 priority investigation for PCC (1)	$0.60	yes
20	Campbell's Cash and Carry at Kleins Road and Boundary Road, Northmead — investigation into pipe augmentation or trunk drainage diversion works	Darling Mills Creek	Parramatta	PP7T	PM7T1		No.4 priority investigation for PCC (1)	$0.30	yes
21	Fletcher Close, Old Toongabbie — Flood Wall	Toongabbie Creek	Parramatta	PP8T	PM8T1		No.2 priority investigation for PCC (1)	$0.06	yes
22	O'Connell, Ferris, Iron, Barney and Church Streets, North Parramatta — pipe upgrade and augmentation	Darling Mills Creek	Parramatta	PP1DM	PM1DM		No.7 priority 'works' for PCC (4)	$0.65	yes
23	Bellotti Avenue, Churchill Drive, Jerome Avenue, Defoe Place and Twain Street, Winston Hills— pipe upgrade and augmentation including modification of pits	tributary of Quarry Branch Creek	Parramatta	PP1QB	PM1QB1	some works complete	No.8 priority 'works' for PCC (4)	$0.42	yes
24	Wentworth Avenue to Burrabogee Road, Pendle Hill channel formalisation, culvert upgrade and construction of drop structure	Pendle Hill Creek	Parramatta	PP1PH	PM1PH1	Current concept design	No.3 priority 'works' for PCC (3)	$1.80	yes
25	Burrabogee Road to Barangaroo Road, Pendle Hill — Pendle Hill Creek Floodway	Pendle Hill Creek	Parramatta	PP2PH	PM2PH1	1992 1994 1999	No.4 priority 'works' for PCC (4)	$3.32	yes

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority[2] (Certainty)		
26	Barangaroo Road to Fitzwilliam Road, Pendle Hill — channel improvements and additional cell in Fitzwilliam Road culverts	Pendle Hill Creek	Parramatta	PP3PH	PM3PH1		No.6 priority 'works' for PCC (3)	$1.35	yes
27	Scott Street, Andrews Avenue and Lamonerie Street, Pendle Hill— pipe augmentation and channel works	Pendle Hill Creek	Parramatta	PP4PH	PM4PH1		No.5 priority investigation for PCC (1)	$0.90	yes
28	Belmore Street transition chamber and Belmore Park, North Parramatta flood retarding basin	Brickfield Creek (Belmore Park Branch)	Parramatta	PP1BR	PM1BR3	late 1990s (flood retarding basin)	No.9 priority 'works' for PCC (3)	$0.67	yes
29	James Ruse Drive, Oatlands — Flood retarding basin	Brickfield Creek	Parramatta Baulkham Hills	PP2BR	PM2BR1		project deferred indefinitely	—	no
30	Old Saleyards Flood Retarding Basin upstream of Gladstone Street near Macarthur Street, North Parramatta	Brickfield Creek	Parramatta Baulkham Hills	PP2BR	PM2BR2		No.3 priority investigation for PCC (1)	$0.73	yes
31	Doyle Ground and Dan Mahony Reserve, North Parramatta — construction of two flood retarding basins	Brickfield Creek	Parramatta	PP2BR	PM2BR3		No.1 priority investigation for PCC (1)	$0.60	yes
32 A	North Wentworthville Floodplain Risk Management Study and Plan — study concentrated on confluence area of Coopers, Finlaysons and Toongabbie Creeks	Coopers, Finlaysons and Toongabbie Creeks	Parramatta	PP1C	PM1C1	2001		—	—
32 B	North Wentworthville Floodplain Risk Management Study and Plan — Upgrading of Briens Road culvert, 3 voluntary acquisitions	Toongabbie Creek	Parramatta	PP1C	PM1C1	Culvert design 2002, acquisitions late 2002	No.1 priority 'works' for PCC (3)	$2.25	yes
33	Greystanes Creek Restoration Project — straightening and widening of about 1,200m of Greystanes Creek between Fox Hills Golf Course and Octavia Street, Toongabbie	Greystanes Creek	Holroyd Blacktown	HP1GE	HM1GE1	1993		—	—

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority[2] (Certainty)		
34	Cornelia Road to Railway Line, Toongabbie — channel enlargement and clearing	Greystanes Creek	Holroyd Blacktown	HP2GE	HM2GE1		project deferred indefinitely	—	no
35	Portia Road, Toongabbie Road and Oramzi Road, Toongabbie — voluntary purchase of properties to create overland flow path	Greystanes Creek	Holroyd	HP3GE	HM3GE1		No.6 priority investigation for HCC (1)	$0.40	yes
36	Toongabbie Road pipe augmentation works between Gilba and Portia Roads, Toongabbie	Greystanes Creek	Holroyd	HP4GE	HM4GE1		No.3 priority investigation for HCC (1)	$0.40	yes
37	Octavia Street Toongabbie — enlargement of culvert crossing of Greystanes Creek	Greystanes Creek	Holroyd Blacktown	HP5GE	HM5GE1		project deferred indefinitely	—	no
38	Cumberland Golf Course Flood Retarding Basins, Greystanes — two wet basins (water storage and flood storage) and one dry flood retarding basin constructed in north-west corner of golf course	Pendle Hill Creek	Holroyd	HP1PH	HM1PH1	1993		—	—
39	Main Western Railway Culvert in the vicinity of Civic Park, west of Pendle Hill Shopping Centre — upgrading of railway culverts and channel upgrading to Wentworth Avenue culvert	Pendle Hill Creek	Holroyd	HP2PH	HM2PH1		No.1 priority 'works' for HCC (3)	$0.75	yes
40	M4, Great Western Highway, Magowar Road to Gilba Road, Pendle Hill— gabion lining of creek	Pendle Hill Creek	Holroyd	HP5PH	HM5PH1		No.11 priority investigation for HCC (2)	$2.16	yes
41	Runyon Avenue to Old Prospect Road, Greystanes — pipe augmentation works	Coopers Creek	Holroyd	HP2C	HM2C1	1994		—	—
42	Great Western Highway, and Emert Street/ Fream Street (Cumberland Highway), Wentworthville — investigation into channel improvements	Coopers Creek	Holroyd	HP3C	HM3C1		No.5 priority investigation for HCC (1)	$2.00	yes
43	Holroyd High School, Greystanes — investigation into construction of flood retarding basin	Finlaysons	Holroyd	HP1F	HM1F1		No.1 priority investigation for HCC (2)	$0.31	yes

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority(2) (Certainty)		
44	Centenary Road, South Wentworthville — pipe augmentation and culvert enlargement	Finlaysons	Holroyd	HP2F	HM2F1		No.2 priority investigation for HCC (2)	$0.54	yes
45	Pitt Park, South Wentworthville — flood retarding basin to alleviate flooding in Pearson Street, South Wentworthville	Finlaysons	Holroyd	HP3F	HM3F1		No.9 priority investigation for HCC (2)	$0.29	yes
46 A	Finlaysons Creek Flood Retarding Basins and Pipe augmentation works — investigation into possible flood retarding basins at Central Gardens, John Knowles Park, Beechwood Avenue Park, plus pipe amplification from Eddy Avenue to Brian Street	Finlaysons	Holroyd	HP4F	HM4F1	Current study		—	—
46 B	Finlaysons Creek Flood Retarding Basins and Pipe augmentation works — pipe amplification from Tucknotts Street to Paton Street and to Eddy Avenue, Merrylands West	Finlaysons	Holroyd	HP4F	HM4F1	1994		—	—
47	Veron Street, Wentworthville to Railway Line — upgrade of culvert	Finlaysons	Holroyd	HP5F	HM5F1		No.10 priority investigation for HCC (1)	$0.60	yes
48	Great Western Highway to Old Prospect Road, South Wentworthville — upgrade of culvert	Finlaysons	Holroyd	HP6F	HM6F1		No.8 priority investigation for HCC (1)	$1.00	yes
49	Fullagar Road, Wentworthville — upgrade of culvert under road	Finlaysons	Holroyd	HP7F	HM7F1		No.7 priority investigation for HCC (1)	$0.60	yes
50	Austral Avenue to Alexander Avenue, Westmead — Investigation into M.J. Bennett Reserve flood retarding basin and channel improvement works	tributary of Toongabbie Creek / Finlaysons Creek	Holroyd	HP1T	HM1T		No.4 priority investigation for HCC (2)	$0.36	yes

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority(2) (Certainty)		
51	Amos Street to Good Street, Westmead — pipe augmentation and Sydney Smith Park, Westmead — flood retarding basin	Domain Creek	Holroyd	HP1D	HM1D	1994 (pipe works) 1999 (basin)		—	—
52	Ollier Crescent to Myrtle Street Drainage Amplification, Prospect — flood retarding basin next to Woolworths and construction of extensive pipework scheme	Blacktown Creek	Blacktown	BLP1BL	BLM1BL1	2001		—	—
53 A	Kisdon Crescent, Prospect — voluntary purchase of one house	Blacktown Creek	Blacktown	BLP2BL	BLM2BL1		No.2 priority 'works' for BCC (3)	$0.39	yes
53 B	Kisdon Crescent, Prospect — construction of flood retarding basin near Hampton Crescent, Prospect	Blacktown Creek	Blacktown	BLP2BL	BLM2BL2	mid 1990s		—	—
54	Station Road, Seven Hills — construction of new road bridge and channel formalisation	Blacktown Creek	Blacktown	BLP3BL	BLM3BL2	detailed design essentially complete	No.1 priority 'works' for BCC (4)	$1.68	yes
55	International Peace Park, Seven Hills channelisation works and other improvements — to alleviate flooding up to the 20 year flood in Jean Street, Jeanette Street and Hartley Road, Seven Hills	Blacktown Creek	Blacktown	BLP4BL	BLM4BL1	Current study		—	—
56	Seven Hills Road to Terminus Road channel improvements — to alleviate flooding up to the 20 year flood in Hartley Road and bus depot	Blacktown Creek	Blacktown	BLP5BL	BLM5BL1	Current study		—	—
57 A	Wall Park Avenue to Cornell Street, Blacktown — raising of 10 houses to above 100 year flood level	Blacktown Creek	Blacktown	BLP6BL	BLM6BL1	Current study		—	—
57 B	Blacktown Road to Wall Park Avenue to Cornell Street, Blacktown — raising of 6 houses to above 20 year flood level (4) and 100 year flood level (2)	Blacktown Creek	Blacktown	BLP6BL	BLM6BL1	Current study		—	—
58	Bedivere Street to Merlin Street, Blacktown — pipe augmentation	Blacktown Creek	Blacktown	BLP7BL	BLM7BL1	2001		—	—

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority[2] (Certainty)		
59	Ashley Brown Reserve Flood Retarding Basin — to alleviate flooding in the Northcott Road, Seven Hills Road and Powers Road,	Lalor Creek	Blacktown	BLP1L	BLM1L1		project no longer feasible	—	no
60	Mercury Place, Kings Langley — improvements to pipe drainage system	Lalor Creek	Blacktown	BLP2L	BLM2L1	1995		—	—
61	Thomas Street, Seven Hills — investigation into amplification of pipe drainage system	Lalor Creek	Blacktown	BLP3L	BLM3L1		No.3 priority investigation for BCC (1)	$0.30	yes
62	Jura Place, Seven Hills — investigation into amplification of pipe drainage system	Grantham Creek	Blacktown	BLP1GA	BLM1GA1		No.2 priority investigation for BCC (1)	$1.00	yes
63	"Grantham" Poultry Research Station Flood Retarding Basin and bank protection works — investigation into need for basin to alleviate flood problems between the research station to Best Road to the railway line to Santiago Place and Chile Place	Grantham Creek	Blacktown	BLP2GA	BLM2GA1		No.1 priority investigation for BCC (2)	$0.56	yes
64 A	Metella Road Branch Flood Retarding Basins — construction of three flood retarding basins upstream of Fox Hills Golf Course at Aldgate Street, Rowood Road and Metella Reserve	Greystanes Creek (Metella Rd Branch)	Blacktown	BL1GE	BLM1GE1		project deferred indefinitely	—	no
64 B	Metella Road Branch — channel enlargement and stabilisation downstream of Blacktown Road	Greystanes Creek (Metella Rd Branch)	Blacktown	BL1GE	BLM1GE2	1995		—	—
65	Metella Road Floodway Floodplain Risk Management Plan — assessment of appropriate development controls between Octavia Street and Cornelia Road, Toongabbie	Greystanes Creek	Blacktown (Holroyd)	BL2GE	BLM2GE1	completed to draft October 2002		—	—
66	Muirfield Golf Course, North Rocks Flood Retarding Basins — two small basins constructed to alleviate flooding in Perry Street and Randal Crescent, North Rocks	Rifle Range Creek	Baulkham Hills	BHP1DM	BHM1DM1	1993		—	—

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority (2) (Certainty)		
67	Foundry Road Bridge, Seven Hills — culvert replaced by bridge to prevent flooding of nearby factories	Toongabbie Creek	Blacktown	BLP1T	BLM1T1	1993		—	—
68	Hopkins Street, North Wentworthville — raising of 7 residences above 100 year flood level	Coopers Creek	Parramatta	—	—	1990		—	—
69	Transfield's Industrial Site, Powers Road, Seven Hills — enlargement of creek to 20 year flood capacity	Blacktown Creek	Blacktown	—	—	1991		—	—
70	Duncan Reserve Flood Retarding Basin — basin constructed in reserve to reduce flooding in nearby homes and Seven Hills Industrial area	Grantham Creek	Blacktown	—	—	1992		—	—
71	Darcy Road, Wentworthville — voluntary purchase of one house	Coopers Creek	Parramatta	—	—	1991–1993		—	—
72	Bogan Street, Greystanes — voluntary purchase of one house	Pendle Hill Creek	Holroyd	—	—	1991–1993		—	—
73	Powers Road, Seven Hills to McCoy Park Flood Retarding Basin — reconstruction and formalising of creek channel to have capacity to carry 100 year flood	Toongabbie Creek	Parramatta	BLP2T	BLM2T1	1993		—	—
74	Sierra Place Flood Retarding Basin, West Baulkham Hills — original basin was built in 1990 but was amplified in 2001 (see No.12B) to prevent the basin overtopping in a 100 year flood; protects 309 properties and 44 dwellings	Toongabbie Creek	Baulkham Hills	—	—	1990		—	—
75	Gooden Reserve Flood Retarding Basin, Baulkham Hills — constructed as part of M2 Motorway plus also protects 10 homes and 28 properties from flooding	tributary of Toongabbie Creek	Baulkham Hills	—	—	late 1990s		—	—
76	Lancelot Street, Blacktown Flood Retarding Basin — under construction when Trust formed in 1989	Blacktown Creek	Blacktown	—	—	1990–1992		—	—
77	St. Martins Flood Retarding Basin — constructed upstream of St. Martins Crescent, Blacktown	Blacktown Creek	Blacktown	—	—	early 1990s		—	—

ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL(S)	TRUST CODES		STATUS		APPROX COST (3) ($mil)	Recommended for further consideration as part of this study
				Problem	Measure	Project Complete	Future Project Priority[2] (Certainty)		
78	McCoy Park Flood Retarding Basin, Toongabbie — constructed by Parramatta Council to reduce flood levels immediately downstream in Toongabbie and Old Toongabbie; some reductions in flood levels down to Lennox Bridge in Parramatta, 7.5km downstream	Toongabbie and Blacktown Creeks	Parramatta	—	—	1984		—	—
79	Fox Hills Golf Course Flood Retarding Basin, Toongabbie — large basin under construction when Trust formed in 1989	Greystanes Creek	Blacktown	—	—	1990		—	—
80	Department of Planning Flood Retarding Basin, Prospect — large basin under construction when Trust formed in 1989. Enlarged in 2002 to handle extra runoff from upstream developments.	Greystanes Creek	Blacktown	—	—	1990		—	—
81	CSIRO Flood Retarding Basin, Prospect — large basin under construction when Trust formed in 1989	Greystanes Creek	Blacktown	—	—	1990		—	—
82	Gollan Reserve Flood Retarding Basin — pipe augmentation form Gowan Brae Avenue and basin in Gollan Reserve, Oatlands	Brickfield Creek	Baulkham Hills	—	—	2000		—	—
83	Darling Street Flood Retarding Basin — basin built in Darling Park, Greystanes, upstream of the M4 Motorway; under construction when Trust formed in 1989	Pendle Hill Creek	Holroyd	—	—	1990		—	—
84	Seven Hills Industrial Area Floodplain Management Study — study to address remaining flood issues at the former Transfield and Prospect Electricity Sites in Powers Road, Seven Hills as site to be redeveloped as high-technology business park.	Blacktown Creek	Blacktown	—	—	Current study		—	—

Abbreviations *BHSC = Baulkham Hills Shire Council; PCC = Parramatta City Council; HCC = Holroyd City Council; BCC = Blacktown City Council.*

Notes: *(1)* *See **Figure 4.1** for locations of floodplain risk management measures.*
(2) *Priorities and certainty factors taken directly from UPRCT (2001b). For definition of certainty factors 1 to 5 see Table 4.2.*
(3) *Factored cost = estimated cost x cost multiplier based on certainty factor from UPRCT (2001b) (see Table 4.2 for definitions of cost multipliers. Only costs for future works have been provided.*

Source: *UPRCT (1999), UPRCT (2001a), UPRCT (2001b), UPRCT (2002a) and Webb, McKeown & Associates (1991a).*

FIGURE 4.1
FLOODPLAIN RISK MANAGEMENT MEASURES PREVIOUSLY IDENTIFIED FOR THE CATCHMENT

N

0 0.5 1 2 km
Scale (1:50000)

BAULKHAM HILLS SHIRE COUNCIL
BLACKTOWN CITY COUNCIL
HOLROYD CITY COUNCIL
PARRAMATTA CITY COUNCIL

Baulkham Hills
Castle Hill
West Pennant Hills
Lalor Park
Seven Hills
Blacktown
Toongabbie
Winston Hills
North Rocks
Carlingford
Northmead
Old Toongabbie
Oatlands
Girraween
Pendle Hill
Wentworthville
Westmead
North Parramatta
Prospect
Greystanes
South Wentworthville
Parramatta
Merrylands West

Quarry Ck
Lalor Ck
Excelsior Ck
Bellbird Ck
Darling Mills Ck
Blue Gum Ck
Rifle Range Ck
Hunts Ck
The Quarry Branch
Toongabbie Ck
Greystanes Ck
Grantham Ck
Blacktown Ck
Pendle Hill Ck
Coopers Ck
Finlaysons Ck
Domain Ck
Parramatta River

Sierra Pl D.B.
McCoy Park D.B.
Duncan Reserve D.B.
Fox Hills D.B.
Dept of Planning D.B.
CSIRO D.B.
Darling Street D.B's.
Loyalty Road D.B.
Charles St Weir

LEGEND
- External Catchment Boundary
- Tributary Catchment Boundary
- Local Government Boundary
- Flood Retarding Basin (Detention Basin)
- CSIRO D.B. Flood Retarding Basin / Wetland (Detention Basin / Wetland)
- 82 Completed or Current Project
- 30 Proposed future project recommended for further consideration as part of this study
- 29 Project deferred indefinitely and not recommended for further consideration as part of this study

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UPPER PARRAMATTA RIVER CATCHMENT TRUST

4.1 RANGE OF AVAILABLE FLOODPLAIN RISK MANAGEMENT MEASURES

The *Floodplain Management Manual* divides ways to manage the flood risk into three groups in the following order of importance:

- ***property modification measures*** — these measures were included as 'non-structural' measures in the *Floodplain Development Manual* (NSW Government, 1986). Property modification measures refer to either/or:

  - modifications to existing development such as voluntary purchase or house raising of most severely flood-affected properties, or flood proofing;

  - controls on future development of property and community infrastructure through planning and development controls. Planning and development controls can generally be implemented for minimal cost and would ensure that the potential for flood damage does not increase in the future.

- ***response modification measures*** — these measures were also included as 'non-structural' measures in the *Floodplain Development Manual*. Measures that modify people's response to flooding usually includes measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management measures during floods.

- ***flood modification measures*** — these measures were formerly referred to as structural measures in the *Floodplain Development Manual*.

  Measures that modify flood behaviour usually include structural or engineering works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. Examples include, flood retarding (or detention) basins, levee banks and modifications to the watercourse to improve its ability to convey floodwaters. Most of the floodplain risk management measures already implemented by the Trust in the study area are flood modification measures.

4.2 CRITERIA FOR THE ASSESSMENT OF FLOODPLAIN RISK MANAGEMENT MEASURES

4.2.1 Ranking Procedure Used in this Study

A comprehensive method for assessing and prioritising the large number of floodplain risk management measures identified in the catchment was developed in the *Catchment Management Priorities Study* (Webb, McKeown & Associates, 1991a). DVA Consulting reviewed this methodology in 2000 in *A Review of the Trust and Councils' Flood Mitigation and Trunk Drainage Program* (see **Chapter 3**).

Both methodologies highlighted the fact that flooding is a physical phenomenon that creates social and environmental problems and hence the prioritisation of measures could not be made on economic criteria alone. The tangible implications to consider include social impacts, environmental impacts, public inconvenience, traffic interruptions and emergency management. There are also many intangible considerations to take into account such as the trauma and anxiety suffered by people whose houses or workplaces are flooded, especially when personal items are lost, and the severe disruption caused to everyday living (DVA Consulting, 2000).

A combination of both these ranking procedures is currently used by the Trust to prioritise works across the catchment and within each Council area. This ranking procedure has been retained in this current study for the flood modification measures already identified by the Trust (as listed in **Table 4.1**). However, the procedure may be difficult to use for prioritising catchment-wide type measures such as planning and development controls, community awareness programs and the like.

4.2.2 Factors and Criteria Used

As part of the 1991 *Catchment Management Priorities Study*, a total of 83 possible mitigation measures were identified to address 62 separate flood problems in the Upper Parramatta River catchment. These measures were separated into the following two types of measures:

- 'works' measures — these measures had progressed to a stage where plans and costs were reasonably well-developed;
- 'investigation' measures — these measures were less advanced and an investigation was required to fully assess the problem and proposed solution.

The factors and criteria that have been used in determining the ranking of the floodplain risk management measures include the following (Webb, McKeown & Associates, 1991a):

- higher weighting was given to measures that protected residential properties rather than business properties;
- the relative magnitude of flood problem was based on the frequency, number and type of flood-affected properties;
- the benefits of a particular measure were generally quantified from the expected recovery in property values;
- environmental factors, such as whether the measure included bank erosion controls, improvements to degraded stream vegetation or stormwater management devices;

- a certainty factor was used to determine whether a project was near to the construction phase and hence quite reliable data would be available, or whether the project was yet to be investigated and hence there was only very preliminary data available (see **Table 4.2**). This factor allowed for this variability of the status of the projects to be taken into account. The certainty factor was also used to modify the cost estimate, with higher multipliers used for less advanced projects.

TABLE 4.2: CERTAINTY FACTORS USED IN RANKING PROCEDURE

CERTAINTY FACTOR	COMMENTS
1	▪ 'investigation' measure ▪ problem only known about and the type and extent of works unknown ▪ cost estimates derived from experience in apparently similar situations ▪ factored cost = estimated cost x 2.0
2	▪ 'investigation' measure ▪ likely type of works required known but extent of works unknown ▪ cost estimates derived from cost of similar works ▪ factored cost = estimated cost x 1.8
3	▪ 'works' measure ▪ concept design undertaken with some indication of size and extent ▪ cost estimates derived from 'catchment average costs' and approximate quantities ▪ factored cost = estimated cost x 1.5
4	▪ 'works' measure ▪ works have been sized but not designed in detail ▪ cost estimates may be available or 'catchment average costs' used ▪ factored cost = estimated cost x 1.2
5	▪ 'works' measure ▪ works designed and pre-construction drawings available ▪ cost estimates available ▪ factored cost = estimated cost x 1.1

Source: adapted from Webb, McKeown & Associates (1991a)

4.3 FLOODPLAIN RISK MANAGEMENT MEASURES ALREADY IMPLEMENTED IN THE CATCHMENT

As mentioned above, as part of the 1991 *Catchment Management Priorities Study*, a total of 83 mitigation measures were identified to address 62 separate flood problems in the Upper Parramatta River catchment. The majority of these works are 'flood modification works' (**Section 4.3.1**) with some voluntary house purchase and house raising (**Section 4.3.2**).

More information about these works can be found in the following references:

- Upper Parramatta River Catchment's Trust Report Card (UPRCT, 1999);
- The Trust's Annual Reports, in particular 2000–2001 (UPRCT, 2001a) and 2001–2002 (UPRCT, 2002b);
- The Trust's website www.uprct.nsw.gov.au (UPRCT, 2002a).

4.3.1 Flood Modification Measures

The flood modification measures already implemented in the Upper Parramatta River catchment include flood retarding basins, enlargement of creek channels and the construction of floodways and overland flow paths, the enlargement of bridges, culverts and other pipe works and the construction of levees. These are briefly outlined below.

Flood Retarding Basins

Flood retarding basins are also called detention basins or upstream flood mitigation storages. They act as empty dams that only fill up during times of flood. These storages allow floodwaters to be stored temporarily, with the primary aim to reduce downstream flood flows and hence reduce flood levels. Flood retarding basins are generally most effective when they are located just upstream of the targeted flood-prone area.

Problems associated with flood retarding basins include the need for large areas of land, (which generally needs to be held in public ownership), the consequences of the embankment overtopping or failing and the consequences of temporarily storing water on the environment behind the basin wall.

The construction of flood retarding basins in the study area has been a key component of the long-term flood mitigation strategy for the catchment. The following basins have been constructed and/or enlarged over the past 20 years (see **Figure 4.1** for locations and **Table 4.1** for more information):

- Loyalty Road Flood Retarding Basin, North Rocks (ID No.9);
- Sierra Place Flood Retarding Basin, West Baulkham Hills (ID No.12 and ID No.74);
- Belmore Park, North Parramatta (ID No.28);
- Cumberland Golf Course Flood Retarding Basins, Greystanes (ID No.38);
- Sydney Smith Park Flood Retarding Basin, Westmead (ID No.51);
- Flood Retarding Basin between Ollier Crescent and Myrtle Street, Prospect (ID No.52);
- Muirfield Golf Course Flood Retarding Basins, North Rocks (ID No.66);
- Duncan Reserve Flood Retarding Basin (ID No.70);
- Gooden Drive Reserve Flood Retarding Basin (ID No.75);
- Lancelot Street Flood Retarding Basin, Blacktown (ID No.76);
- St. Martins Flood Retarding Basin, Blacktown (ID No.77);
- McCoy Park Flood Retarding Basin, Toongabbie (ID No.78);
- Fox Hills Golf Course Flood Retarding Basin, Toongabbie (ID No.79);
- Department of Planning Flood Retarding Basin, Prospect (ID No.80);
- CSIRO Flood Retarding Basin, Prospect (ID No.81);
- Gollan Reserve Flood Retarding Basin, Oatlands (ID No.82);
- Darling Street Reserve Flood Retarding Basins, Greystanes (ID No.83).

Enlargement of Creek Channels, Construction of Floodways and Overland Flow Paths

The enlargement, straightening and lining of creek channels together with the construction of floodways and overland flow paths have also been widely used as flood mitigation measures in the Upper Parramatta River catchment.

These types of works were popular throughout NSW up until the late 1990s but their significant construction costs and environmental impacts now often preclude them as a viable flood mitigation option. The widening of the watercourses generally leads to disturbance of the existing riverbed and banks. This may initiate increased erosion, water turbidity, downstream siltation, and loss of aquatic habitat. These environmental impacts now need to be mitigated with ecologically sensitive treatments.

Current Department of Land and Water Conservation (DLWC) policy now requires that when any channel works are proposed, the works should ideally be designed to restore a more natural creek system and provide increased ecological values. Design assistance is available from the DLWC on these matters. For all works within 40m of the top of the bank of a creek, the DLWC requires that a Part 3A permit is obtained under the *Rivers & Foreshores Improvement Act, 1948*.

It should also be noted that for any proposal that involves earthworks along a creekline, a permit is required from NSW Fisheries under the *Fisheries Management Act, 1994*.

The following channel works have been undertaken within the study area over the past 20 years (see **Figure 4.1** for locations and **Table 4.1** for more information):

- high level floodway at Sue Savage Reserve, Toongabbie (ID No.12);
- reconstruction of Greystanes Creek at Toongabbie Bowling Club (ID No.13);
- Pendle Creek Floodway, Burrabogee Road–Barangaroo Road, Pendle Hill (ID No.25);
- reconstruction of Greystanes Creek, Toongabbie (ID No.33);
- channel enlargement and stabilisation of Metella Road Branch (ID No.64B);
- enlargement of Blacktown Creek through Transfield Industrial Site, Toongabbie (ID No.69);
- reconstruction of Toongabbie Creek between Powers Road and McCoy Park Flood Retarding Basin (ID No.73).

Enlargement of Bridges, Culverts and Other Pipe Works

Bridges, culverts and piped drainage systems are often designed to carry flows much less than in a 100 year flood. Consequently they often act a restriction to flood flows in major storms, leading to an increase in upstream flood levels. Enlarging such structures, to allow more water to flow through them, has been a popular flood mitigation measure in the study area. Whenever such works are undertaken, the

impacts of allowing more water downstream are always carefully assessed to ensure flood levels are not increased in downstream properties.

The following bridge, culvert and pipe augmentation works have been undertaken within the study area (see **Figure 4.1** for locations and **Table 4.1** for more information):

- enlargement of culvert under Hart Drive (Cumberland Highway), Wentworthville (ID No.14);
- pipe augmentation works between Runyon Avenue and Old Prospect Road, Greystanes (ID No.41);
- pipe augmentation works in the vicinity of Paton Street, Merrylands West (ID No.46);
- pipe augmentation works between Amos Street and Good Street, Westmead (ID No.51);
- extensive pipe amplification works between Ollier Crescent and Myrtle Street, Prospect (ID No.52);
- pipe augmentation works between Bedivere Street and Merlin Street, Blacktown (ID No.58);
- improvements to pipe drainage system in Mercury Place, Kings Langley (ID No.60);
- construction of new road bridge at Foundry Road, Seven Hills (ID No.67);

Levees

Permanent levee banks are often considered as a measure to provide protection to existing development on the floodplain.

The issues that have to be considered when considering levees include the following:

- ***hydraulics and loss of floodplain area*** — construction of a levee would generally cause floodwaters to be diverted away from a particular area and cause floodwaters to be constricted to a much narrower width. This often results in an increase in flood levels in areas not protected by the levee, which is not acceptable;
- ***drainage behind the levee*** — for all levees it must be ensured that all rain that falls on the local catchment behind the levee can drain to the stream and ponding does not occur behind the levee. Another problem is the surcharging of the local drainage system behind the levee;
- ***perceived safety*** — if a levee is overtopped (as occurred in Nyngan in 1990), inundation of properties could occur within the perceived protected area. There is often a community perception that once a levee is constructed, it provides a

'flood-free' area behind the levee. This often leads to a false sense of security. Unless the levee is constructed to the level of the probable maximum flood, floods larger than the flood the levee was designed for, can occur;

- ***aesthetics*** — levees can be designed and landscaped so that they are not visually intrusive, particularly earthen levees. Levees constructed as concrete walls are often not visually acceptable. Many communities do not like levees because the levees block their views of the waterway;

- ***erosion and undermining of foundations*** — this is a potential problem with levees and often occurs without careful design, particularly in creeks with fast flood velocities.

The following levees and associated works have been undertaken within the study area (see **Figure 4.1** for locations and **Table 4.1** for more information):

- levee along Toongabbie Creek next to Edison Parade, Winston Hills (mid 1980s);

- levee along Toongabbie Creek at Peter Parade, Old Toongabbie (built mid 1980s, rebuilt 1993);

- broad levee between Toongabbie Creek and Chanel Street, Toongabbie (Sue Savage Reserve and Reynolds Park) (built mid 1980s);

- levee extension, pump out and diversion drain in Lister Street, Winston Hills (ID No.19).

4.3.1 Voluntary Purchase and House Raising

Voluntary Purchase

Under a voluntary purchase scheme, Council, in association with the Trust would offer to purchase flood liable properties if and when they became available for purchase. Voluntary purchase is not compulsory acquisition and affected property owners can expect to receive market values for their properties. The valuation made for a property is not prejudiced by the fact that there is a voluntary purchase scheme is in place or that there may be development constraints that apply to that land due to its flood-prone nature.

The cost of this measure is high and, therefore, only the most severely affected properties are usually considered for inclusion in voluntary purchase schemes.

Three severely flood-affected properties have been purchased within the study area (ID Nos 18, 71 and 72) (see **Figure 4.1** for locations and **Table 4.1** for more information). The voluntary purchase of three severely flood liable residences is planned as part of the North Wentworthville Floodplain Management Plan (Perrens Consultants Pty Ltd, 2002).

House Raising

The raising of timber and fibro houses has proved to be an effective floodplain management measure for various locations throughout NSW. Fairfield City Council has been implementing a house-raising program in Prospect Creek for many years now, with over 120 houses being successfully raised.

There are various forms of house raising schemes that can be considered. The easiest form of house raising is where houses are of either timber or fibro construction. Experience by Fairfield Council in Prospect Creek has shown that such houses can be raised by 1m–2m for an average cost of about $40,000.

Where houses are built with a brick veneer, or full brick construction, the physical raising of these houses has been found to be more costly, and in many cases impractical. Under these circumstances, variations to the traditional house-raising concept may need to be considered. One solution would be 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.

There are a number of 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 flood damage potential;
- there may be aesthetic and town planning constraints associated with raising some houses. For example, isolated raising of individual properties in a street may be less desirable than schemes that include a group of properties within that location.

Seven houses in Hopkins Street, North Wentworthville were successfully raised in the early 1990s (ID No.68) (see **Figure 4.1** for location and **Table 4.1** for more information).

Reconstruction and Redevelopment

An alternative to house raising or voluntary purchase is to completely rebuild the house at higher level or at a different location on the block of land. This may or may not be accompanied by a change in home ownership.

An important overland flow path was established in the Meryll Street/Landscape Street area of Baulkham Hills by purchasing, modifying and reselling about five different properties (ID No.3) (see **Figure 4.1** for location and **Table 4.1** for more information).

4.3.2 Planning Controls and Policies

Land use planning, development controls and specific flood-related policies are key mechanisms that can and have been used to manage flood-affected areas. 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.

Review of Planning and Development Controls

An overview of the existing planning and development controls that apply to the Upper Parramatta River catchment is provided in Section 2.3 of **Volume 2** of the current study, namely *Planning Issues and Outcomes* (Don Fox Planning, 2003). A brief summary of the key issues presented in **Volume 2** is provided in this section.

The proposed approach to floodplain planning and the recommended planning measures and policy changes, in particular the use of 'The Planning Matrix Approach' in the various Development Control Plans and Policies developed for each constituent Councils, is discussed in **Section 5.2** of this report.

The following existing planning and development controls are discussed in Section 2.3 of **Volume 2** of this report:

- ***State Environmental Planning Policies (SEPPs)***;
- ***Regional Environmental Plans (REPs)***, namely:
  - Sydney Regional Environmental Plan No.22 — Parramatta River 1998;
  - Sydney Regional Environmental Plan No.28 — Parramatta 1999;
- ***Advisory Circulars*** from the NSW Department of Urban Affairs and Planning (DUAP) (now PlanningNSW);
- ***ministerial directions*** pursuant to Section 117(2) of the *Environmental Planning and Assessment (EPA) Act, 1979*;
- ***Local Environmental Plans (LEPs)*** — a LEP is a plan, prepared in accordance with the *EPA Act, 1979,* that 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 study area is affected by the following separate local environmental plans for each of the four Local Government Areas (LGAs) within the catchment:
  - Parramatta Local Environmental Plan, 2001;
  - Holroyd Local Environmental Plan,1991;
  - Blacktown Local Environmental Plan,1988;
  - Baulkham Hills Local Environmental Plan,1991;

- ***Development Control Plans (DCPs)*** — a DCP is a plan prepared in accordance with Section 72 of the *EPA Act, 1979* that provides detailed guidelines for the assessment of development applications. Relevant DCPs for each of the four constituent Councils include:

  - ***Parramatta City Council*** — *Parramatta Development Control Plan 2001* and *Parramatta City Centre DCP*. These are comprehensive DCPs and it is likely that only minimal changes will occur as a result of this study. This is discussed further in **Section 5.2**;

  - ***Holroyd City Council*** — Holroyd Council presently has no floodplain management plans, flood policy or any DCP or provisions within a DCP dealing with floodplain risk management. However, Council has recently exhibited draft *Holroyd Development Control Plan No. 4(A) – Guidelines for Detached Dwelling Houses Including Alterations and Additions*, which includes specific provisions in regard to flood risk management. However, this DCP does not cover the full range of matters that would be appropriate to be considered in the assessment of flood risk issues across the range of potential land uses within the LGA. This is discussed further in **Section 5.2**;

  - ***Blacktown City Council*** — *Blacktown Development Control Plan 1992*. This is a comprehensive Development Control Plan with Section 8 of Part A providing provisions that relate specifically to flood risk management. Previous projects undertaken by Don Fox Planning have involved the review of this section of the DCP to provide a framework for flood risk management in accordance with current best practice. **Section 5.2** outlines the recommended amendments to this DCP 1992, in accordance with these previous recommendations;

  - ***Baulkham Hills Shire Council*** — Baulkham Hills Council does not have any specific flood policy or flood-related development control plans. Reliance is placed on State Government studies including the "*Chain of Ponds Creek – Floodplain Management Study*" carried out by the then Department of Water Resources in 1986. Council has historically simply adopted the 100 year flood as the standard flood.

- ***Development Application (DA) assessment*** — this particularly relates to the relevant 'Matters for Consideration' contained in Section 79C of the *EPA Act, 1979*.

- ***Section 149 Certificates*** — A Section 149 Certificate is a zoning certificate issued under the provisions of the *EPA Act, 1979*, which can be obtained to confirm zoning controls pertaining to individual properties, and must be attached to a contract prepared for the sale of property. The current standard wording used often causes inconsistencies to arise between local councils in regard to the extent of information they provide on flooding.

  A detailed review of appropriate 149 Certificate notations has been undertaken as part of this study and is outlined in Section 2.3.11 and 4.6 of **Volume 2** of this report. A summary is provided in this document in **Section 5.3.5**. The various

options for notations take into consideration flooding from both riverine and overland flow situations. These notations have been the subject of separate legal advice obtained by the Trust, to ensure that the interests of the councils are appropriately covered.

- ***Section 94 Contributions Plans*** — Section 94 Contributions Plans are prepared under the *EPA Act, 1979* and can provide a basis for the levying of development contributions to construct drainage and flood mitigation works required as a result of future development. Section 94 contributions can only be applied to fund works associated with the new development and cannot be applied for the purposes of rectifying past inadequacies. It is understood that the only existing Section 94 Contributions Plans of this nature in the catchment relates to the North Wentworthville Floodplain Risk Management Plan in the Parramatta local government area.

Trust's On-site Stormwater Detention (OSD) Policy

In 1991, the Trust and the four constituent councils adopted a common on-site stormwater detention policy to control the growth of flooding, particularly from infill development and redevelopment of sites with multi-unit housing. The principal requirement of this policy is that the stormwater discharge from all future development must be limited to 80 litres per second per hectare. This ensures that downstream flood flows and hence flood levels do not increase in all storm events up to the size of a 100 year flood.

The Trust supports the OSD policy by maintaining a technical manual (UPRCT, 2001c), operating an OSD database, inspecting OSD systems, conducting training, providing technical advice on specific projects, auditing and providing policy advice. There are currently more than 1,500 OSD systems in the catchment (UPRCT, 2001a).

4.3.3 Community Consultation and Awareness

The success of any floodplain risk management plan hinges on its acceptance by the floodplain community, residents within the study area and other stakeholders. Community awareness about flooding is also critical to reducing the flood risk to the floodplain community.

Current Community Awareness Activities Undertaken by the Trust

The Trust has always placed great importance on making sure the catchment community is aware of the Trust's activities and local environmental issues.

The Trust produces a regular newsletter (usually 2–3 times per year) entitled "Streamline", which is distributed to each household in the catchment, that provides updates on the Trust's activities.

The Trust's web site (www.uprct.nsw.gov.au) (UPRCT, 2002a) is a comprehensive source of information on Trust projects, publications and catchment facts. An important component of the Trust's web site is its geographical information system (GIS), which allows ready access to a variety of maps relating to the catchment.

Other community awareness activities of the Trust include attending community meetings, preparing displays at community fairs and supporting programs such as Streamwatch and the regional environment awards.

Recent Community Surveys

In August 2000, a catchment community survey was undertaken to determine the level of awareness of the Trust, its activities and other environmental issues. More than two-thirds of the respondents were strongly in favour of the continuation of the flood mitigation program (UPRCT, 2001a).

In 2001, the Trust undertook a telephone survey of 300 catchment residents to determine the current community attitudes towards flooding and floodplain management (Owl Research and Marketing, 2001). Only 3% of the respondents said that flooding was one of the two most important issues to be addressed in the catchment. This is a significantly different situation than in the late 1980s when the issue of flooding was at the forefront of most residents' minds in the catchment. The reasons for this change are a combination of:

- it is more than 13 years since the last major flood in the catchment in 1988;
- the large population turnover in the catchment where nearly half the residents have lived in the catchment for less than 10 years;
- a complacency that the presence and activities of the Trust has 'fixed all the problems'.

The Need for a Community Awareness Strategy

The results of the 2001 community survey highlight the sense of urgency for making sure that there is an acceptable level of awareness about flooding in the Upper Parramatta River catchment. Even though many of the flood problems in the catchment have been essentially solved, flood awareness, particularly to the possibility of floods larger than the 100 year flood, is essential to reducing flood risks to life and property.

A comprehensive community consultation and awareness strategy is recommended as a high priority component of the draft *Floodplain Risk Management Plan* for the catchment. This is discussed in **Section 5.3**.

Floodplain Risk Management Committee

A key element of the community consultation process for the current study has been regular meetings with, presentations to and feedback from the Upper Parramatta River Catchment Floodplain Risk Management Committee (The Committee). The Committee has provided the vital link between the consultant, the Trust, the four constituent Council, the Department of Land and Water Conservation (DLWC) and the local catchment community.

Members of the Upper Parramatta River Catchment Floodplain Risk Management Committee include:

- the Trust's Chairman, as ex-officio chair;
- the Trust's Executive Officer;
- a technical representative from each of the four constituent Councils;
- a representative from the DLWC;
- a representative from PlanningNSW;
- a representative from the State Emergency Service (SES);
- five community representatives selected following a newspaper advertisement that appeared in local newspapers in early 2002.

4.3.4 Site Specific Investigations

Three local floodplain risk management studies have been recently carried out to address site specific flood problems in more detail than that provided by the *Catchment Management Priorities Study* of 1991. These are described below.

North Wentworthville Floodplain Management Study

This study, completed in 2001, covered the confluence area of Toongabbie, Finlaysons and Coopers Creek where more than 180 homes are currently affected by flooding and the natural creeks are badly degraded and polluted (ID No.32A). The key works recommendations of the study were as follows (Allen Jack & Cottier , 2001):

- a flood culvert under Briens Road to lower upstream flood levels;
- voluntary acquisition of three houses in the high hazard flood zone;
- investigate widening Cooper Creek channel downstream of Fulton Avenue.

Metella Road, Toongabbie Floodplain Risk Management Study

A draft report for this study was presented to Council's Floodplain Risk Management Committee in October 2002. The study addresses floodplain risk management issues of a low hazard floodway area of Greystanes Creek close to Toongabbie railway station currently under development pressures for multi-unit housing (ID No.65). The Land and Environment Court approved one large development in December 2000 and there were concerns that if more similar developments were approved, there would be increases in flood levels in upstream areas.

This study looks at the cumulative impacts of the maximum possible development allowed under current Council zoning and recommends a number of 'compensatory works' that would permit development without adversely affecting neighbouring properties. It is proposed that prospective developers would fund these compensatory works under a Section 94 Contributions Plan (Bewsher Consulting Pty Ltd, 2002).

Seven Hills Industrial Area Floodplain Management Study

This study is currently being carried out with Blacktown Council and Trust funding. It addresses the remaining flood issues of former Transfield and Prospect Electricity Industrial Sites in Powers Road, Seven Hills (ID No.84). These sites are to be redeveloped as a high-technology business park and hence there was an opportunity to address the feasibility of a range of flood mitigation options to address flood problems in this section of Blacktown Creek (Patterson Britton & Associates, 2002).

However, because of a long delay in completing the study, the opportunity to influence the design of the redevelopment may have been lost.

The only possible flood mitigation works identified by the study was the enlargement of the Powers Road culvert under Lalor Creek. However, hydraulic modelling of these works show that flood levels would be increased in downstream areas and hence this option would not be acceptable.

- unnecessary restrictions on some land uses below the flood planning level, while allowing other inappropriate land uses to occur immediately above the flood planning level. For example, whilst it may be appropriate for some land uses, such as a hospital, to be located above a probable maximum flood (PMF), it could be argued that residential, industrial or recreational land uses do not require such restrictive control.

- polarisation of the floodplain into perceived 'flood prone' and 'flood free' areas;

- lack of recognition of the significant flood risk that may exist above the flood planning level (and as a result, there may be few measures in place to manage the consequences of flooding above the flood planning level);

- creation of a political climate where the redefinition of the flood planning level (due to the availability of more accurate flood behaviour data, or for other reasons) is fiercely opposed by some parts of the community. There are often concerns about the significant impacts on land values (despite the fact that such effects are likely to only short term), particularly on land, which was previously perceived to be 'flood free', that would be recognised as 'flood prone'.

To overcome the shortcomings of a singular FPL, a 'graded' set of planning and development controls that consider the variation of damage risk, with flood frequency and land use, have been proposed for the Upper Parramatta River catchment. This approach is known as the Planning Matrix Approach.

5.2.2 The Planning Matrix Approach

The Planning Matrix Approach to floodplain risk management considers the range of land uses, and their potential risk to flooding, within the floodplain up to the level of the probable maximum flood. 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.

The Planning Matrix Approach was first introduced with the Eastern Creek and Tributaries Floodplain Management Plan (Blacktown City Council) in the late 1990s and has now been adopted and recommended for many other areas. These areas include the management of floodplains that are jointly administered by more than one local council (eg. Cabramatta Creek FPMS where its management is jointly the responsibility of Fairfield and Liverpool City Councils), or where Councils have a number of floodplains within their local government area.

The Planning Matrix Approach is fully consistent with the Floodplain Management Manual (NSW, Government, 2001).

5.2.3 Flood Risk Precincts

A key component of the Planning Matrix Approach is to divide the floodplain into different areas of similar risk, known as Flood Risk Precincts. Different parts of the floodplain are subject to different degrees of flood hazard and different degrees of flood

risk. This study recognises that different development controls should apply to different flood risk areas, or precincts.

Flood Risk Precincts have previously been identified for those parts of the Eastern Creek and Tributaries Floodplain located north and south of the Castlereagh Freeway Reservation in the Blacktown LGA and for the North Wentworthville in the Parramatta LGA. These were originally referred to as 'hazard bands'. Three Flood Risk Precincts have been adopted for these areas — low risk, medium risk and high risk. In the case of Eastern Creek, four Flood Risk Precincts have been adopted.

It should be noted that 'flood hazard' and 'flood risk' are not interchangeable terms. Once the 'flood hazard' has been determined for a particular location, and considered together with the consequences of that flooding, the 'flood risk' can then be determined.

Flood Hazard

Flood hazard is a term used in the *Floodplain Management Manual* (NSW Government, 2001). Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use. It takes into account such factors as:

- danger to human life;
- difficulty and danger of evacuating people and their possessions;
- potential for damage to the structure and contents of houses;
- social disruption, including isolation of houses;
- loss of production, particularly in industrial areas;
- damage to infrastructure, such as roads, services and open space areas.

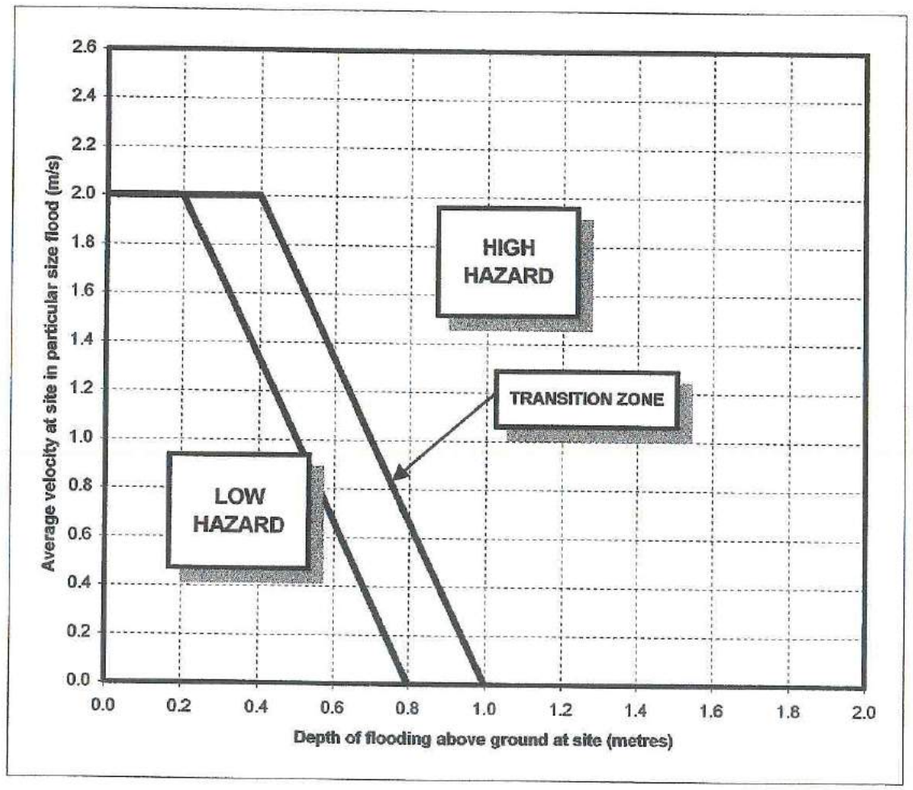
Appendix G of the *2001 Floodplain Management Manual* describes how the floodplain can be divided up to reflect the risk to personal safety and property damage. The two flood hazard categories defined in the *Floodplain Management Manual* are:

- ***high hazard*** — where there is 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;

- ***low hazard*** — where able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flood hazard is firstly evaluated by considering the hydraulic behaviour of the flood — by taking into account the depth and velocity of floodwaters in relation to ground levels for a range of flood sizes. **Figure 5.1** shows how high and low hazard are determined using only the depth and velocity of floodwaters.

The flood hazard is then refined in light of other factors affecting the safety of individuals. By then combining the flood hazard and the consequences of the flood, the 'flood risk' is determined.



Source: Adapted from Figure G.2 of Floodplain Management Manual (DLWC, 2001)

Notes: (1) This is a provisional flood hazard diagram only.

(2) In the Transition Zone, the degree of hazard is dependent on site conditions and the nature of the development.

FIGURE 5.1
MEASURING PROVISIONAL FLOOD HAZARD

Flood Risk Precincts for the Upper Parramatta River Catchment

Using the definitions of flood hazard from the Floodplain Management Manual and **Figure 5.1**, three Flood Risk Precincts have been recommended for the Upper Parramatta River catchment, namely 'high risk', 'medium risk' and 'low' risk. The Medium and High Risk Precincts generally refer to low and high hazard land, respectively, below the level of the 100 year flood. The Low Risk Precinct refers to land above the level of the 100 year flood but below the level of the probable maximum flood (PMF).

The Flood Risk Precincts have been defined to provide a basis for strategic planning and development controls and take into account the specific characteristics of the Upper Parramatta River catchment floodplain.

It is acknowledged that generally only 'hydraulic' considerations have been used to define the Flood Risk Precincts at this stage. In locations where a Medium Flood Risk Precinct is an 'island' surrounded by a High Flood Risk Precinct, then the Medium Risk land has been defined as High Risk. When evacuation and other emergency management risks are more thoroughly assessed in the future, this may also alter some of the precinct boundaries. An example may include areas that become islands in a 100 year flood but would be inundated in a PMF. In such a case, the flood risk may also be increased to a higher risk.

The definitions of the three Flood Risk Precincts for the Upper Parramatta River catchment are as follows:

- ***High Flood Risk Precinct*** — This has been defined as generally the area of land below the 100 year flood level subject to a high hydraulic hazard (in accordance with the provisional criteria outlined in the *Floodplain Management Manual*). The High Flood Risk Precinct is where high flood damages, potential risk to life, or evacuation problems would be anticipated. Most development should be restricted in this precinct. In this precinct, it would be difficult to achieve a substantial reduction in flood damages or to ensure safe evacuation with reasonable flood-related building and planning controls.

- ***Medium Flood Risk Precinct***— This has been defined as generally land below the 100 year flood level subject to low hydraulic hazard in a 100 year flood In this precinct there would still be a significant risk of flood damage or risk to life, but these could be minimised with the application of appropriate development controls.

- ***Low Flood Risk Precinct*** — This has been defined as all other land within the floodplain, namely above the 100 year flood level and below the level of the PMF. The Low Flood Risk Precinct would be where risk of damages would be low for most land uses and so it the application of compulsory flood-related development controls are not likely to be cost effective.

  Most land uses would be permitted within this precinct. However, this area would be still subject to some flood-related risk and those uses that may be

considered critical, or should be afforded maximum protection against risk from flooding, would be identified as undesirable land uses in this precinct.

The other major purpose of the Low Flood Risk Precinct is to identify and recognise the potential flood risk for all persons and properties affected by the PMF, regardless of whether any specific development controls are to be applied. This provides a basis for flood awareness programs, evacuation and emergency planning and to maximise the preparedness of the community.

5.2.4 Planning Matrix for the Upper Parramatta River Catchment

The first stage in developing a matrix of flood planning controls is to identify each of the floodplains to which the overall policy document is to be applied. Although this current study relates only to the Upper Parramatta River catchment floodplains, it is suggested that each council would benefit considerably by having a singular policy document that applies to all floodplains within its LGA. This is consistent with the approach being currently pursued by some of the four constituent councils.

To satisfy this objective, separate Development Control Plans (DCPs) for Holroyd, Blacktown and Baulkham Hills, and a Flood Policy for Parramatta, have been prepared. This DCP/Flood Policy has a common preamble, objectives and general policies, while specific controls for each floodplain are reflected within a planning matrix prepared for each individual floodplain and annexed to the principal document. Parramatta City Council are currently extracting the relevant information out of the Flood Policy and incorporating it into their existing comprehensive DCP.

During November 2002, workshops were held with the individual Councils to discuss the details of the Planning Matrix for the catchment. Following these workshops, a meeting was held with representations from all four councils (the Flood Policy Task Group) and a mutually agreeable matrix across the whole catchment was achieved. The only variation between the four Councils is that slightly more filling would be permitted in the Medium and High Risk Precincts in the Blacktown LGA, than in the other three councils. This variation has been incorporated because this development control has always been applicable in Blacktown, as the LGA has a number of large rural holdings located within the floodplains of its western areas, outside the Upper Parramatta River catchment.

The resultant Planning Matrix proposed for use across the Upper Parramatta River Catchment (in Holroyd, Baulkham Hills and Parramatta) is presented as **Table 5.1**. The slightly different Planning Matrix for use in Blacktown is presented in Appendix E of **Volume 2** of this report.

Components of the Planning Matrix

The development of the Planning Matrix involves three major components:

- ***categorisation of the floodplain*** — as discussed in **Section 5.2.3**, the Upper Parramatta River catchment floodplain has been divided into three Flood Risk Precincts, namely High Risk, Medium Risk and Low Risk;

Upper Parramatta River Floodplain

(Also applies to Other Floodplains not separately scheduled in interim – subject to review)

Planning Consideration	Flood Risk Precincts (FRP's)																							
	Low Flood Risk									**Medium Flood Risk**									**High Flood Risk**									
	Sensitive Uses & Facilities	Critical Utilities & Uses	Subdivision	Filling	Residential **	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Utilities & Uses	Subdivision	Filling	Residential **	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Utilities & Uses	Subdivision	Filling	Residential **	Commercial & Industrial	Tourist Related Development	Recreation & Non-Urban	Concessional Development
Floor Level		3			2,5	2	2							2,5	2	2	1	4								1	4
Building Components		2												1	1	1	1	1								1	1
Structural Soundness		3												2	2	2	2	2								1	1
Flood Affectation		2	2	1	2	2	2					1		2	2	2	2	2								1	1
Evacuation		2,4	*		3,4	4	4					*		3,5	3,4	3,4	1	3								1	3,5
Management & Design		2,3,4	1									1		2, 3	2,3,4	2,3,4	2,3,4	2,3								2,3,4	2,3

Not Relevant

Unsuitable Land Use

* Refer to 'Management & Design' planning consideration for subdivision

** For rebuilding of existing dwelling refer also to "Concessional Development" provisions

Freeboard equals an additional height of 500mm

Notes: 1. Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.

2. Filling is exclusive of importation of earth material onto a site which results in the increase in ground levels by up to 100mm across 50% of the site or the raising of ground levels across part of the site as a result of compensatory works. Such works are to form part of a proposed use which is otherwise permitted and be assessed as part of that proposal.

3. Filling associated with compensatory earthworks involves the relocation of earth material within a site so as to result in an insignificant change in the flood storage characteristics of the floodplain.

4. 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 local government area.

Floor Level

1. All Floor Levels to be equal to or greater than the 5 year *ARI flood* level plus *freeboard* unless justified by site specific assessment
2. *Habitable floor* levels to be equal to or greater than the 100 year *ARI flood* plus *freeboard*
3. All Floor Levels to be equal to or greater than the *PMF flood* plus *freeboard*
4. Floor levels to be as close to the *design floor level* (the level nominated above that would apply if not "concessional development") as practical & no lower than the existing floor level when undertaking alterations or additions
5. Floor levels of open car parking areas to be equal to or greater than the 20 year *ARI flood* plus *freeboard*. This may be achieved with an suspended floor which allows the continued passage of flood waters or filling if justified by a site specific assessment, as required with reference to "Flood Affectation" and other controls below. Enclosed car parking (eg. garages or basement car parking) must be protected from the 100 year *ARI flood*.

Building Components & Method

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

Structural Soundness

1. Engineers report to certify that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a 100 year *flood* plus *freeboard*
2. Applicant to demonstrate that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a 100 year *flood* plus *freeboard*
3. Applicant to demonstrate that any structure can withstand the forces of floodwater, debris & buoyancy up to & including a *PMF flood*

Flood Affectation

1. Engineers report required to certify that the development will not increase *flood* affectation elsewhere
2. The impact of the development on flooding elsewhere to be considered

Note: When assessing flood affectation the following must be considered:
1. Changes in *flood* levels & velocities caused by alteration of conveyance of *flood* waters.
2. Loss of storage area in the *floodplain*.
3. Cumulative impacts of the development.

Evacuation

1. *Reliable access* for pedestrians required during a 5 year *ARI flood*
2. *Reliable access* for pedestrians and vehicles required during a *PMF flood*
3. *Reliable access* for pedestrians or vehicles is required from the dwelling, commencing at a minimum *flood* level equal to the lowest *habitable floor* level to an area of refuge above the *PMF* level, either on-site or off-site.
4. Applicant to demonstrate that the development is to be consistent with any relevant *flood evacuation strategy* or similar plan
5. The development is to be consistent with any relevant *flood evacuation strategy* or similar plan

Management and Design

1. Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this Plan
2. *Site Emergency Response Flood plan* required (except for single dwelling-houses) where floor levels are below the *design floor level*
3. Applicant to demonstrate that area is available to store goods above the 100 year *flood* plus 0.5m (*freeboard*)
4. No external storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any *flood*

- ***prioritisation of land uses within the floodplain*** — different land uses are categorised into similar levels of sensitivity to the flood hazard. As shown in **Table 5.1**, the following categories have been adopted for the Upper Parramatta River catchment:

  - sensitive uses and facilities;
  - critical utilities and uses;
  - subdivision;
  - residential;
  - commercial and industrial;
  - tourist related development;
  - recreation and non-urban;
  - concessional development.

  The definitions of each of these different land types are only slightly different for each of the four constituent councils and are provided in the relevant Appendices C to F in **Volume 2** of this report (Don Fox Planning, 2003);

- ***controls to modify building form and community response*** — different planning controls are assigned, which modify building form and the ability of the community to respond in times of flooding, depending upon the type of land use and the location of that land use within the floodplain.

  The types of controls can be categorised under six main headings, namely:

  - floor levels;
  - building components and method;
  - structural soundness;
  - flood affectation;
  - evacuation;
  - management and design.

  A discussion of the types of development controls applicable to each of these issues is provided in Section 4.5.3 of **Volume 2** of this report.

Selection of Controls

The selection of the controls and the various flood conditions at which these controls should apply, has been based on the following issues and criteria:

- the procedures and philosophy espoused in the *2001 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 inferred during the current study;

- minimising the council's exposure to legal actions in relation to flooding;
- the council's previous development policies;
- views expressed by the Trust, various officers of the four constituent councils, the Floodplain Risk Management Committee and the Department of Land and Water Conservation;
- results of the Council workshops and the combined Flood Policy Task Group held in November 2002;
- experience gained from the development of planning controls and flood policies for various communities across NSW in recent years.

As indicated in **Table 5.1**, the 100 year flood level has been retained as the principal floor level control for residential land uses in the study area. This is an important component of the proposed planning controls and has been based on consideration of the following issues:

- the unacceptable increase in flood risks and damages, should a lower level be adopted;
- an unacceptable impost on future development, if a higher level was adopted;
- inconsistencies with recent development approvals if a level different from the 100 year flood was adopted;
- recognition that the community views the residential floor level control as the principal component of the council floodplain controls, and that changes to this control should not be made unless very strong arguments exist.

Summary of Key Controls

Based on the Planning Matrix depicted in **Table 5.1**, some of the key development controls would be as follows:

- ***High Flood Risk Precinct*** — most land uses would not be permitted and limited alterations and additions to existing residential development would only be permitted subject to stringent conditions;
- ***Low Flood Risk Precinct*** — generally all land uses would be permitted, except sensitive uses and facilities, which would include hospitals, nursing homes and others that may provide an important contribution to emergency management in times of flood. Floor levels for most residential and business development in this precinct would have to be above the 100 year flood plus 0.5m freeboard.
- ***Medium Flood Risk Precinct*** — generally most land uses would be permitted, except sensitive uses and facilities, critical utilities and the importation of fill material. All permitted development would be subject to most of the flood-

related building controls. Floor levels for most residential and business development in this precinct would have to be above the 100 year flood plus 0.5m freeboard.

- ***extensions to existing homes, and construction of garages and garden sheds*** — these types of development are referred to as"concessional development" and would generally bepermitted in all areas of the floodplain but would be subject to range of flood-related building controls relating to floor levels, building components, structural soundness, flood impact on others, access during a flood and storage of goods.

  To be classified as "concessional development", the extra area of the home must not be more than 15% of the original area or 50 square metres (30 square metres in Blacktown), whichever is the larger. Similarly, a new garage or garden shed, not attached to the main house, must not be larger than 20 square metres;

- ***rebuilding of existing homes*** — if a house is to be rebuilt to substantially reduce its risk of flooding (for example by building it at a higher level, this would also be classified as "concessional development", meaning that it would be permitted in all areas of the floodplain. Again, the development would be subject to the range of flood-related building controls listed above;

- ***new detached dwelling on a vacant block of land*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, the development would be subject to a range of flood-related building controls relating to floor levels, building components, structural soundness, flood impact on others, access during a flood and storage of goods. Importation of fill material would not be permitted in a Medium Flood Risk Precinct;

- ***commercial and industrial development*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, the development would be subject to a range of flood-related building controls floor levels, building design and evacuation issues;

- ***subdivision of land*** — this type of development would not be permitted in a High Flood Risk Precinct. In a Medium or Low Risk Precinct, an engineer's report would be required to certify that the development would not increase flood affectation elsewhere and it would have to be demonstrated that the development complies with the relevant DCP or Flood Policy;

- ***filling of land*** — generally, the importation of fill material would not be permitted in a High or Medium Flood Risk Precinct. However, as shown in the notes of the Planning Matrix (**Table 5.1**), some 'filling' may be acceptable to Council, including 'filling' that would change the Flood Risk Precinct of a particular site, provided the following conditions were met:

  - fill material is not imported onto the site that would cause an increase in ground levels of more than 100mm across 50% of the site (in Holroyd,

Baulkham Hills and Parramatta) or by more than 300mm across and area of 100 square metres in Blacktown;

- if it is desired to increase the ground levels by more than those values listed above, then only the relocation of earth material within a site would be allowed, provided this results in an insignificant change in flood storage characteristics of the floodplain (i.e. only 'compensatory works' would be permitted);

In a Low Risk Precinct, filling of the land would be permitted, however, an engineer's report would be required to certify that the development would not increase flood affectation elsewhere.

In some situations, a single block of land may be contained within more than one Flood Risk Precinct. If, for example, a small corner of the block was high risk and the remainder in a medium risk and the owner wished to build in the medium risk area, then controls for the Medium Flood Risk Precinct would apply.

It was agreed at the Council workshops and Flood Policy Task Group meeting held in November 2002 that each Council would apply its own procedure to determine the principal Flood Risk Precinct that would be noted on the Section 149 Certificate (as the Councils' GIS data base would find it difficult to assign more than precinct to one lot). It was recommended that an explanatory note be placed on the Section 149 Certificate to note that other Flood Risk Precincts may also apply to the land and these would be taken into account when determining the development controls that would apply.

5.2.5 Implementation of Recommended Planning and Policy Changes

The most appropriate mechanism for the implementation of the proposed flood policy is its adoption by Council as a DCP (in the case of Holroyd, Blacktown and Baulkham Hills) or associated Flood Policy document (Parramatta City Council are currently extracting the relevant information out of their Flood Policy document and incorporating it into their existing comprehensive DCP).

One of the key outcomes of this study is the recommendation for development controls, which would be embodied within a DCP or Flood Policy for each of the four constituent Councils. The format of the recommended DCPs (or Flood Policy) has been varied to meet the specific requirements of each Council, taking into account how they present their current DCPs or policies.

Each of the four DCP (or Flood Policy) documents would be generally similar, involving a preamble of provisions that establishes a framework to allow for the outcomes of any number of floodplain risk management plans to be incorporated into the document. The *Upper Parramatta River Catchment Floodplain Risk Management Plan* would be one of these plans. Where possible, existing or finalised, but yet to be implemented, controls from other floodplain risk management plans would be integrated into the proposed documents, to increase the convenience for Council to accelerate the adoption of the plan. The particular intricacies relevant to each of the Council's are discussed in detail of **Volume 2** of this report.

Draft Development Control Plans (DCPs) for Holroyd, Blacktown and Baulkham Hills local government areas and the draft Flood Policy for Parramatta are included as Appendices C to F in **Volume 2** of this report. These draft DCPs and Flood Policy are recommended as integral components of the draft *Floodplain Risk Management Plan* for the study area.

In addition to the preparation of the DCPs and Flood Policy, each council will need to undertake discreet changes to its Local Environmental Plan (LEP) in order to ensure consistency with definitions, special flood development control clauses, and to restrict development within the High Flood Risk Precinct. These changes are discussed in detail in Section 4.4 of **Volume 2** of this report (Don Fox Planning, 2003).

5.2.6 Summary of Recommended Planning and Policy Changes

The following planning measures and policy changes are recommended for the Upper Parramatta River catchment:

- ***Planning Matrix*** — the consideration of the application of a graded set of planning controls for different land uses relative to different levels of flood risk within the study area (see **Table 5.1**) consistent with the requirements of the current *NSW Floodplain Management Manual* (NSW Government, 2001). This would involve the adoption of the High, Medium and Low Flood Risk Precincts, as described in **Section 5.2.3**;

- ***Sydney REP No.28 — Parramatta*** — As discussed in **Volume 2** of this report, it is considered appropriate that some of the provisions and terminology adopted by Sydney REP No. 28 – Parramatta, should be amended to provide a consistent framework for flood planning controls that are either existing or proposed for each of the council's LEPs. The recommended changes to this REP, as previously discussed with PlanningNSW, are included as Appendix A in **Volume 2** of this report. It is recommended that the Trust formally endorses these changes;

- ***Changes to Council Local Environmental Plans (LEPs)*** — it is recommended that each council considers amending their LEP in the manner outlined in Section 4.4 and Appendix B of **Volume 2** of this report, to provide a consistent framework for more detailed controls to be provided in a DCP. These particularly relate to consistency with definitions, special flood development control clauses, and to restrict development within the High Flood Risk Precinct.

- ***Discouragement of Building in High Flood Risk Precinct*** — it is recommended that each constituent Council give force to discouraging building in the High Flood Risk Precinct by utilising foreshore building line provisions embodied within LEPs or by utilising alternative suitable mechanisms as outlined in Appendix B of **Volume 2** of this report.

- ***Development Control Plans*** — it is recommended each of the four constituent Councils adopt or amend their current DCPs and/or Policies that outline appropriate measures to be applied to development in the floodplain. Appendices C to F of **Volume 2** provides suggested a Model Development

Control Plan and/or Policy for each of the four Councils in accordance with the process required under the *Environmental Planning and Assessment Act, 1979*.

The above recommendations are considered to provide appropriate responses to the issues raised and evaluated within the context of the *Floodplain Risk Management Study* and the legislative framework associated with planning. The planning controls, by their nature, provide measures to address the flooding issue associated with new, infill and existing development.

5.3 COMMUNITY CONSULTATION AND AWARENESS

5.3.1 Overview and Recommendations

Flood awareness is critical to reducing the flood risk to the floodplain community and flood awareness is essential for flood readiness. In order to be 'flood ready', the floodplain community needs to know:

- what to do;
- where to go;
- who to contact.

Actual flood damages can be reduced if community awareness of flood issues is raised. Flood damage surveys undertaken throughout NSW (Water Studies Pty Ltd, 1992) have shown that potential flood damage can be greatly reduced where there are effective warning times and a flood aware community.

Recent surveys of floodplain communities in other catchments have shown that both residents and business proprietors are generally strongly in favour of gaining more information about the potential risks of flooding. These surveys have shown that people generally want answers to questions, such as:

- 'How does flooding affect my property?';
- 'How does flooding affect me personally?';
- 'Does flooding affect the way I want to improve or development my property?'.

Even with all the achievements of the Trust since 1989 in reducing the flood problems in the catchment, there are still approximately 370 residential and about 90 business properties that would be flooded above floor level in a 100 year flood. In the order of 9,000 properties would be flooded above ground level in a probable maximum flood. It could be argued that the high profile activities of the Trust has actually lead to some complacency amongst the floodplain community and many people may consider that the Trust has 'fixed all the problems'.

A comprehensive community flood awareness strategy is a key recommendation of the draft *Upper Parramatta River Catchment Floodplain Risk Management Plan*. Most of the components of this strategy relate to the release of flood information to the community.

As a result of the study's investigations and recent meetings of the Floodplain Risk Management Committee Meeting, the following mechanisms are proposed in order to raise flood awareness in the catchment and comply with the requirements of the *Floodplain Management Manual* (NSW Government, 2001) and Section 149 of the *Environmental Planning and Assessment (EPA) Act, 1979:*

- production of maps that depict the Flood Risk Precincts as described in **Section 5.4.3** (**Section 5.3.2**);
- preparation of a brochure outlining a simplified explanation of the flood-related building controls that would apply to 'typical' residential development (**Section 5.3.3**);
- preparation of 'Flood Information Packs' that would be sent to all residents in the floodplain (**Section 5.3.4**);
- issuing of Flood Certificates that would used for more formal situations, such as when Development Applications are submitted (**Section 5.3.5**);
- appropriate notification on Section 149 Certificates, which are zoning certificates that must be attached to a contract prepared for the sale of property, that are issued under the provisions of the EPA Act, 1979 (**Section 5.3.6**);
- public exhibition of this draft Floodplain Risk Management Plan for community comment (**Section 5.3.7**).

5.3.2 Flood Risk Precinct Maps

Flood Risk Precinct maps would show all known areas of the floodplain up the probable maximum flood. They would show the limits of the three Flood Risk Precincts (low, medium and high) are described in **Section 5.2.3**. Flood levels, flood depths or flood extents of floods of varying probabilities would not necessarily be shown — only areas of similar flood risk. The Flood Risk Precinct Maps would consider flooding from creeks, rivers and stormwater overland flows. The four constituent councils have been asked to provide information on local flood issues to ensure the maps are as comprehensive as possible. Holroyd Council has already provided this information, while Blacktown Council is currently collating the information applicable to their LGA.

An example of a Flood Risk Precinct map for part of another urban catchment in Sydney is provided as **Figure 5.2**. Note that such maps would include notations and advice that not all land with potential flood risks may be identified, particularly areas at risk of inundation from overland flows and surcharging piped drainage systems.

The Trust is currently preparing similar Flood Risk Precinct Maps for the Upper Parramatta River catchment for all areas covered by its MIKE-11 hydraulic modelling.

FIGURE 5.3: EXAMPLE OF STATE EMERGENCY FLOODSAFE BROCHURE AND OTHER INFORMATION

FIGURE 5.3 EXAMPLE OF STATE EMERGENCY FLOODSAFE BROCHURE AND OTHER INFORMATION (continued)


FIX INSIDE KITCHEN CUPBOARD DOOR

SES

FloodSafe
Hawkesbury-Nepean

ACTION GUIDE

ACTIONS TO TAKE

For life-threatening emergencies – 000
For help in floods (SES) – 132 500
For flood information – 1800 6 FLOOD (1800 635 663)

Listen for flood warnings
- Tune into your local radio station
- Act on warning advice

If you are advised to protect your belongings
- Stack your possessions onto benches and tables, electrical appliances on top
- Secure objects so that they don't float away
- Turn off electricity, gas and water if you leave

If you are advised to prepare to evacuate
- Make sure your neighbours are OK
- Gather all important papers, valuables, mementoes and medication and load them into your car
- If you don't have a car, put them into a small suitcase or backpack and be ready to leave by bus

If you need to evacuate
- You will be told what evacuation centre you should go to
- If you are driving, keep your radio tuned to a local station
- Bus pick-up points will be advised
- Avoid driving or walking through flood waters
- Evacuation centres can organise food and somewhere to stay, or you can stay with friends or relatives

Caring for pets?
- Don't leave your pets behind, they may die
- Put your pets on a leash or in containers
- If you are going to a friend's place, take your pets with you
- Evacuation centres will organise care for your pet, if needed

www.floodsafe.nsw.gov.au

SES

FloodSafe
Hawkesbury-Nepean

SAFETY TIPS

For life-threatening emergencies – 000
For help in floods (SES) – 132 500
For flood information – 1800 6 FLOOD
(1800 635 663)

- Listen for flood warnings on your local radio station and act on warning advice
- Be ready to evacuate and gather all important papers, valuables, mementos and medications
- If you have to evacuate, you will be advised which evacuation centre you should go to
- Avoid driving or walking through flood waters
- Make sure you take your pets
- Evacuation centres can organise accommodation for you and your pets

www.floodsafe.nsw.gov.au

In other areas within the catchment, there are locations where the flood problem has not been defined by a formal study, but anecdotal or information suggests the property may be potentially flooded. These areas are referred to as 'potentially flooded'. Each of the four constituent councils have different means of identifying these types of properties and most have quite comprehensive, albeit approximate, systems in place. There are currently discussions with the constituent councils about including their 'potentially flooded' property information on the Flood Risk Precinct maps.

It was acknowledged at the council workshops and the combined Flood Policy Task Group meeting held in November 2002 that it would not be feasible for Council to define all potentially flood-affected properties. Councils deal with this situation on an almost daily basis when assessing development applications, where flood affectation is suspected but not formally mapped. It was agreed that for situations where mapping is not available, the DCP or Flood Policy should clearly outline the process to be followed.

It is recommended that the Flood Risk Precinct maps be readily available to the public. This would preferably be via the Trust's web site, with links to and from each of the council web sites. The maps should be at least be available at the councils' inquiry counters and on their respective GIS data base systems. It should be noted that councils have a duty of care to make information about flood risks known to the public.

5.3.3 Brochure on Flood-related Building Controls

To help the community understand how the Flood Risk Precinct Maps and the associated planning controls would affect the way they may want to improve their property, a brochure outlining a simplified explanation of flood-related building controls for residential development is proposed. A draft brochure is currently with the Trust for review.
Answers to the following questions will outline the constraints and opportunities for residential development for each of the three Flood Risk Precincts:

- "Does flooding affect the way I want to improve my property?";
- "What is a 'Flood Risk Precinct'?";
- "What building controls would apply if I wanted to extend my existing home?";
- "What building controls would apply if I wanted to rebuild my existing home?";
- "What building controls would apply if I wanted to build a new home on a vacant block of land?";
- "What if I wanted to subdivide my land?";
- "Who should I contact for more information".

The answers to these questions will be taken directly from the Planning Matrix and will include whether that type of development would be permitted and the flood-related building controls that would apply.

5.3.4 Flood Information Packs

Flood notification to all residents in the floodplain (that is up to the level of the probable maximum flood) is recommended as a key means of raising flood awareness in the catchment.

It is important with such notifications that the recipients of the information understand that the supplied information actually applies to them and is not a part of a general mail out to everyone in the catchment.

The exact details of implementation of strategy would need to be discussed with each council to examine such details as the timing of the release of information, for example, all the information could be sent out at the one time at regular intervals (say every 1–2 years) or different information could be sent out every say 3–6 months.

The Flood Information Packs that would be sent to all residents (owners and occupiers) in the floodplain would include the following information:

Flood Notification Letter

The Flood Notification Letter would explain that the particular property is located in a floodplain, how flooding may affect the property, generally what development controls would apply and how more information could be obtained. It is understood that Blacktown Council has recently sent out this type of letter to all residents whose properties would be affected by a probable maximum flood from the Hawkesbury–Nepean River.

Flood Information Brochure

This A4-size folded brochure, entitled "Facts about Flooding in the Upper Parramatta River Catchment" would broadly describe flooding (i.e. what is meant by a '100 year flood' and a 'probable maximum flood') and the flood problems of the catchment, the Flood Risk Precincts, the Flood Risk Precinct Maps currently being prepared by the Trust and some key flood-related development constraints and opportunities. A draft version of this brochure is currently with the Trust for their review.

Frequently Asked Questions

A four-page handout on 'Frequently Asked Questions' on flood-related matters is also proposed for inclusion in the Flood Information Packs, as well as being available at Council's inquiry counters. A draft version of this handout is currently with the Trust for review.

The handout will provide simplified explanations to questions such as:

- "Why do councils prepare floodplain management studies and plans?";
- "What are flood studies?";

- "How are these studies funded?";
- "Why is the 100 year flood adopted as the Flood Planning Level?";
- "Why do flood levels need to be reviewed over time?";
- "How have the flood risk maps been prepared?";
- "Will my property value be altered if I am in a Flood Risk Precinct?";
- "My property was never classified as 'flood prone' or 'flood liable' before. Now it is in a Low Flood Risk Precinct. Why?";
- "Will I be able to get house and contents insurance if I am in a Flood Risk Precinct?";
- "Will I be able to get a home loan if I am in a Flood Risk Precinct?";
- "Will the Flood Risk Precinct maps be changed over time?".

SES FloodSafe Brochures and Associated Information

The NSW State Emergency Service's (SES) FloodSafe program has produced area-specific brochures that describe what to do in a flood, how the SES can help and broadly describe the flood problem of the area. These brochures have concentrated on flooding in the Hawkesbury–Nepean valley to date.

These brochures also include a broad scale map showing the approximate extent of the floodplain up to the probable maximum flood. The SES, in conjunction with Blacktown City Council, has recently produced a FloodSafe brochure for that part of Blacktown affected by flooding from the Hawkesbury–Nepean River. A copy of this brochure and other general flood awareness brochures produced by the SES are presented as **Figure 5.3**.

A FloodSafe brochure is currently being prepared for the Upper Parramatta River catchment, in conjunction with the SES.

5.3.5 Flood Certificates

In addition to the use of Flood Notification Letters, Flood Certificates are recommended for use in more 'formal' situations such as when a Development Application is submitted or a Section 149 Certificate is issued.

A flood certificate would contain information such as the expected flood levels in a range of design floods. It would also provide information on ground and floor levels where this information is available. This would allow an assessment of the depths of flooding over the property and building floor. The Flood Risk Precinct applicable to that property would also be included. Where property levels are unknown, residents could be encouraged to obtain these levels using a registered surveyor, or to request council to provide these levels for a fixed fee.

The information provided on the certificates would be derived from the information held by the Trust or the council's own investigations or studies. In respect of the flood information for the creeks/rivers in the Trust's area, this information would normally be provided by the Trust to the council and then formally adopted by the council before being issued.

Given that potentially different 'versions' of the Trust's data may exist, it is recommended as part of the draft *Floodplain Risk Management Plan* that a more formal strategy for the release and adoption of new sets of flood data (particularly some quality assurance procedures) be developed by the Trust in conjunction with the four constituent councils. This would ensure that a consistent and up-to-date set of flood levels is always being used across the catchment (see **Section 2.4.1**).

A sample flood certificate is included as **Figure 5.4**.

5.3.6 Section 149 Certificates

Overview

A Section 149 Certificate is a zoning certificate issued under the provisions of the *Environmental Planning and Assessment Act, 1979,* which can be obtained to confirm zoning controls pertaining to individual properties, and must be attached to a contract prepared for the sale of property. The current standard wording used often causes inconsistencies to arise between local councils in regard to the extent of information they provide on flooding.

The problems associated with the current procedures for wording on Section 149 Certificates generally and in the study area are detailed in Section 2.3.10 of **Volume 2** of this report (Don Fox Planning, 2003).

Section 149 Certificates should not be used as broad community education tool as they have only limited circulation. The majority of flood-affected properties would not be reached in a given year. Also, with the existing system of notifications on Section 149(2) certificates, if no notification appears, then it is often misunderstood to mean that the property is "flood-free" rather than it has no development controls.

It is important that all properties in the floodplain (that is, up to the probable maximum flood be notified. Notification should include the Flood Risk Precinct, if known, and the existence of the relevant Development Control Plan (DCP). If the property is 'potentially flood affected' this should also be notified. A notation should be provided that states that while all reasonable efforts are employed to identify lands subject to any potential flood risk, all properties so affected may not have been identified. While it is considered that the majority of potentially flood affected properties have been identified, Council may determine that a site-specific flood study is required on land not currently identified as flood affected, for the purposes of assessing a development application.

..... City Council

Flood Certificate

Certificate Issued for Property at: 16 Jones Street, Riverville
Lot 14, DP 25843

Owners Name: Mr & Mrs John Smith

1. Classification of Flood Risk

Part or all of the property is located within a Medium Flood Risk area. Council's Development Control Plan, No. ...., "Managing Our Flood Risks" applies to this property.

2. Known Floor and Ground Levels

The lowest floor level of the main building on this property:	4.6m AHD
Source of information :	Council Survey June 2000
The lowest ground level on this property is :	Not known
Source of information :	

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

3. Estimated Flood Levels

Flood levels in the vicinity of the property have been extracted from the ..... Creek Flood Study dated ..... by .....

Size of Flood*	Flood Level	Depth over Lowest Floor Level	Depth over Lowest Ground Level
Probable Maximum Flood	6.9m AHD	2.3m	not known
100 Year Flood	5.0m AHD	0.4m	not known
20 Year Flood	4.5m AHD	Not flooded	not known
5 Year Flood	4.1m AHD	Not flooded	not known

**The Probable Maximum Flood (or PMF) is extremely rare.*
A 100 year flood is a large flood. It has a 1 in 100 (i.e. 1%) chance of occurring or being exceeded in any 12 month period..
A 20 year flood has a 1 in 20 (ie 5%) chance of occurring or being exceeded in any 12 month period.
A 5 year flood is more frequent. It has a 1 in 5 (i.e. 20%) chance of occurring or being exceeded in any 12 month period.

4. Issued by _____ Date: _____

FIGURE 5.4: SAMPLE FLOOD CERTIFICATE

Types of Inundation

It should be noted that 'inundation' refers to inundation in any flood up to the probable maximum flood. There are two potential sources of inundation that need to be addressed on the Section 149 certificate notifications, namely:

- inundation from creeks and rivers;
- inundation from stormwater and overland flow.

Generally, inundation from 'local drainage', as defined in Section 1.9 of the *2001 Floodplain Management Manual*, would not be included under 'inundation from stormwater and overland flow'. It should be recognised that inundation could occur from either or both sources and the wording on the Section 149 certificates should reflect this. Usually the most severe form of inundation will dominate the planning controls to be applied to new development. However, the Section 149 Certificate should identify both sources of possible inundation.

Status of Inundation

For each of the two types of inundation listed above, it is recommended that the inundation status be defined in one of the following three ways:

- ***Category A*** — Category A would apply when the inundation of the property has been defined by a flood study. In this case, the flood behaviour at the property has been quantified and velocities and depths are known for a range of floods. There would be sufficient information available to define the flood risk as 'low', 'medium' or 'high';

- ***Category B*** — Category B would apply when the property is thought to be inundated, but the flood behaviour has not been quantified to the level described in Category A above. For example, there may be anecdotal evidence of flooding but no formal flood study has yet been carried out;

- ***Category C*** — Category C would apply when the property is not thought to be inundated having regard to available information.

Wording of Flood Notations on Section 149 Certificates

Guidance on the wording of Section 149(2) and 149(5) certificates is provided in Appendix L of the Floodplain Management Manual (NSW Government, 2001). Using this wording, **Table 5.2** presents the proposed wording for S149 (2) certificates for the four constituent councils in the Upper Parramatta River catchment. For each property in the catchment, one of the three categories listed above (A, B or C) would be applied for each type of flooding (i.e. flooding from creeks or rivers and flooding from stormwater or overland flow. **Table 5.2** shows the matrix of possible outcomes for the wording on an individual Section 149 Certificate. Not all these outcomes may apply within the study area, however all possible outcomes have been included for completeness.

TABLE 5.2: PROPOSED WORDING FOR FLOOD NOTATIONS ON SECTION 149(2) CERTIFICATES

STATUS OF INUNDATION FROM STORMWATER AND OVERLAND FLOW	STATUS OF INUNDATION FROM CREEKS AND RIVERS				
	Category 'A' and 'Low' Flood Risk	Category 'A' And 'Medium' Flood Risk	Category 'A' and 'High' Flood Risk	Category 'B' (ie. potentially inundated)	Category 'C' (ie. not thought to be inundated)
Category 'A' And 'Low' Flood Risk	Part or all of the property is located within a Low Flood Risk area. [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area. [Plus Note 2]	Part or all of the property is located within a Low Flood Risk area due to overland flow. The property is also potentially affected by creek/river flooding. [Plus Note 2]	Part or all of the property is located within a Low Flood Risk area due to overland flow. [Plus Note 2]
Category 'A' And 'Medium' Flood Risk	Part or all of the property is located within a Medium Flood Risk area due to overland flow . [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area. [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area due to overland flow. The property is also potentially affected by creek/river flooding. [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area due to overland flow. [Plus Note 2]
Category 'A' And 'High' Flood Risk	Part or all of the property is located within a High Flood Risk area due to overland flow. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area due to overland flow. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area due to overland flow. The property is also potentially affected by creek/river flooding. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area due to overland flow. [Plus Note 2]
Category 'B' (ie. potentially inundated)	Part or all of the property is located within a Low Flood Risk area. The property is also potentially affected by overland flow. [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area. The property is also potentially affected by overland flow. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area. The property is also potentially affected by overland flow. [Plus Note 2]	Part or all of the property is potentially affected by creek/river flooding and overland flow. [Plus Note 2]	Part or all of the property is potentially affected by overland flow. [Plus Note 2]
Category 'C' (ie. not thought to be inundated)	Part or all of the property is located within a Low Flood Risk area. [Plus Note 2]	Part or all of the property is located within a Medium Flood Risk area. [Plus Note 2]	Part or all of the property is located within a High Flood Risk area. [Plus Note 2]	Part or all of the property is potentially affected by creek/river flooding. [Plus Note 2]	Based on the information available to Council, the property is not affected by creek/river flooding or overland flow from major drainage.

Notes: 1. *This table provides specific wording for S149(2) notations based on the status of inundation from creeks/rivers and from stormwater/overland flow.*

2. *The following additional wording is be added to each notation where indicated in the table:*
   - *The term "Flood Risk" relates to the potential danger to personal safety and property. Further details are provided in the NSW Government's Floodplain Management Manual, 2001, or are available from Council.*
   - *Council's Development Control Plan No... "Managing Our Flood Risks" applies to this property. This DCP specifies controls on development to manage potential flood risks within the property and adjacent areas*

3. *The rows shown shaded in the table will not generally apply as mapping of Flood Risk Precincts may not be available for stormwater/overland flow.*

4. *All S149(2) Certificates shall also include within the list of applicable Development Control Plans — "Development Control Plan No. ... Managing our Flood Risks."*

For S149 (5) certificates, it is recommended that a Flood Certificate (**Section 5.3.4**) be appended to the S149 (5) certificate. In addition, where Category B applies (for creek/river flooding or stormwater/overland flow) the certificate should provide additional details of the potential flood affectation and/or suggest that the applicant contact council's Stormwater/Flooding Engineer for further details.

As discussed in **Section 5.2.4**, each council is likely to apply its own procedure to determine the principal Flood Risk Precinct that would be noted on the Section 149 Certificate (as the Councils' GIS data base would find it difficult to assign more than precinct to one lot). An explanatory note would be placed on the Section 149 Certificate to note that other Flood Risk Precincts may also apply to the land and these would be taken into account when determining the development controls that would apply.

Legal Advice on Wording Provided on Section 149 Certificates

As part of this study, legal advice has been sought to ensure, to the greatest extent possible, that any potential legal liability of the four constituent councils is minimised in relation to the provision of flood advice provided on Section 149 Certificates. The aim of this legal advice was to balance this potential legal liability with the need to inform the community of the large amount of information that is available about their flood risk. Unfortunately, definitive legal advice, in the form of written endorsement, could not be obtained on this matter. However, some legal advice was obtained and this has been incorporated in the Section 149 wording presented in **Table 5.2**.

5.3.7 Public Exhibition of This Study

The final stage of community consultation for this study is the public exhibition of the *Floodplain Risk Management Study and Plan*. It is intended that the document be exhibited for a period of 4–6 weeks, so the wider community has an opportunity to comment on the draft plan proposals.

The Floodplain Risk Management Committee and Council will then consider the submissions made during the exhibition period, with *the Upper Parramatta River Catchment Floodplain Risk Management Plan* being ultimately being adopted by the Trust, the four constituent councils and the Committee.

5.4 FLOOD WARNING

5.4.1 Overview of Flood Warning

The Emergency Management Australia's '*Flood Warning — An Australian Guide*' (1995) defines the purpose of flood warning as:

> *"... to provide advice on impending flooding so people can take action to minimise its impacts. This will involve some people taking individual actions on their own behalf and others taking action as part of agency functions.*
>
> *Flood warnings are effective if they persuade people to take action to lessen the impact of a flood and help agencies carry out their roles during flood events."*

Flood warning is an important part of floodplain risk management. It provides information to the public and to agencies which have a specific function during flood emergencies. Without this information, the ability of the public and the agencies to respond is severely restricted.

Recent surveys of floodplain communities in other catchments have shown that there is generally strong community support for improved flood warning procedures in flood-affected catchments.

The Bureau of Meteorology is normally the government agency responsible for issuing flood warnings throughout Australia. However, the Bureau has limited resources and can not provide a flood warning service for all areas.

5.4.2 Flood Warning in Upper Parramatta River Catchment

Flood warning systems generally monitor rainfall and river gauges in the upper parts of catchments in real time and, through hydrologic/hydraulic models, predict the resulting flow and flood levels at some time in the future in the lower catchment. Forecasts of continuing rain or anticipated changes in rainfall intensity can also be included in the models to provide additional forecasting ability.

The minimum 'turn-around time' between when the rainfall actually occurs and the predicted flood levels occur is about 6 hours. When there is less than 6 hours between the rainfall and the associated flood, such as is the case with the majority of the Upper Parramatta River catchment, the Bureau classifies this as 'flash flooding'. In these catchments, by the time the Bureau is aware of the excessively high rainfalls, the flooding has already occurred. As such, flood warnings are not available in these catchments.

The Upper Parramatta River catchment area responds rapidly to flood producing storms. The short time between heavy rainfall and the occurrence of flooding means that the Bureau is unable to provide a specific flood warning service for the catchment.

The only warning available in catchments that experience flash flooding is a 'thunderstorm warning'. Thunderstorm warnings are made by the Bureau within the Newcastle–Sydney–Wollongong area. This advice is based on information available from synoptic charts and Sydney radar. The warnings are made before the rainfall actually occurs. It is usually provided for general areas and is not specifically targeted at individual, small catchments, such as those within the Upper Parramatta River catchment.

Such flood warnings, based on the prediction and monitoring of heavy rainfalls are impractical in the Upper Parramatta River catchment due to its small size. However some warning, based on upstream stream levels, may be possible, albeit with limited time to take action.

The Trust operates the following four stream level gauging stations within the catchment:

- on Darling Mills Creek at the Loyalty Road flood retarding basin;
- on Darling Mills Creek at Board Street, North Parramatta;
- on Toongabbie Creek at Johnson's Bridge, Toongabbie;
- on Toongabbie Creek at Redbank Road, Westmead.

The stream levels at these gauging stations could be accessed remotely by emergency personnel, via telemetry through the Trust's website. Using the Trust's hydraulic model it would therefore be possible to identify, in advance, critical stream levels at these stations above which floodwaters can be expected to enter important downstream areas, such as the Parramatta central business district. The Trust's hydraulic model could also indicate how long after the critical level is exceeded at the upstream gauge, that overbank flooding would commence at Parramatta. This information would not give emergency personnel much time to effect road closures and evacuations, but it would provide a high degree of certainty that flooding was imminent.

However, as flooding of the Parramatta central business district is only expected to happen in floods larger than a 100 year event, it may therefore be impractical to maintain a warning system that is used so infrequently. This should be considered in the context of a Local Flood Plan for the catchment.

5.4.3 Recommendations

Unfortunately, there is limited scope to improve the flood warning in the Upper Parramatta River catchment. This catchment responds very quickly to heavy rainfall, that is, the catchment experiences 'flash flooding'. As such, the Bureau of Meteorology would be unable to provide a specific flood warning service to this catchment. Therefore, provision of a 'formal' flood warning system for the Upper Parramatta River catchment has not been considered further.

However, an informal local formal warning system for the Parramatta central business district, using the Trust's upstream stream level gauges, appears feasible, although it may operate too infrequently to be maintained. It is recommended that this option be considered during preparation of a Local Flood Plan for the catchment (see **Section 5.5.2**).

5.5 EMERGENCY MANAGEMENT

5.5.1 Overview

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations that normally provide assistance include the Bureau of Meteorology, local councils, the Department of Land and Water Conservation, Department of Community Services, police, fire brigade, ambulance and community groups.

As many organisations have important roles to play, it is imperative that there is a clear understanding of the role and responsibilities of each organisation. This should be defined, agreed, understood and acted upon in a flood situation according to a predetermined Flood Action Plan. The plan needs to be continually updated, as new information on flood behaviour becomes available and as lessons are learnt from other flood experiences.

Over the past few years there has been a growing recognition of the role of emergency services, such as the SES, in floodplain risk management and planning.

Recent surveys of floodplain communities in other catchments have shown that there is generally good support for 'better evacuation and emergency assistance plans'.

5.5.2 Emergency Management in Upper Parramatta River Catchment

Local Flood Plan

A 'Local Flood Plan', developed by the SES, covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for flooding within the catchment.

The SES has developed Local Flood Plans for the Blacktown and Baulkham Hills LGAs. The main focus of these plans however is Hawkesbury–Nepean flooding. The Blacktown Local Flood Plan also deals with flooding on South and Eastern Creeks (both tributaries of the Hawkesbury River). The respective Local Emergency Management Committees endorsed these plans in 1993. Both plans are currently under review as part of the Hawkesbury–Nepean Floodplain Management Study.

A draft Local Flood Plan for the Parramatta LGA was produced in June 1994 by the then SES Deputy Director General in conjunction with the SES Parramatta Local Controller. This plan did not reach the endorsement stage with the Parramatta Local Emergency Management Committee. This plan is currently being reviewed and initial contact has been made with the Trust to look at more detailed flood data from their GIS for the catchment.

Currently there is no Local Flood Plan for the Holroyd LGA.

As far as flood planning is concerned, SES is responsible and takes the lead role in the preparation of local flood plans. As part of its role, the SES must, however, ensure that other agencies are incorporated in the planning process.

The SES has an established flood planning process that involves the Local Emergency Management Committee constituted under the *State Emergency and Rescue Management Act, 1989*. Local Emergency Management Committees and the SES endorse the final SES Local Flood Plans.

The Upper Parramatta Catchment Floodplain Risk Management Committee has an important part to play in the development of the Local Flood Plan(s) for the catchment. The flood problem in the Upper Parramatta River catchment area extends over four

local government areas. Whilst the current three Local Flood Plans are being reviewed there may be a case for an integrated flood plan for the catchment as part of the SES Sydney Western Division Flood Plan or as a separate flood plan. This will be need discussed with the SES's Deputy Director General and the SES's State Planning Coordinator (SES, 2002).

Flood Intelligence

The flood information (or 'flood intelligence') available from the Trust would be an invaluable addition to the Local Flood Plan for the catchment. This includes information on flood levels, the estimated extent of flood inundation for various floods, and the mapping of the different flood risk precincts.

The Trust is currently undertaking a survey of all floor levels of properties in the floodplain. This information, combined with the Trust's geographical information system (GIS) (see **Section 3.4**), will also provide valuable data on which properties are likely to be affected by a range of flood sizes up to the probable maximum flood (PMF) event. This is likely to be an extremely useful tool for the local SES when planning for a large flood in the catchment.

Flood intelligence information could be used to carry out detailed analysis of some flood-affected areas (particularly low risk) to determine the flood impact from an emergency management perspective. The Trust's information could also be utilised by the SES to determine the potential impacts at critical transport locations within the catchment and, together with the SES's response, be incorporated in the Local Flood Plan.

'Reliable Access' and Evacuation Issues in Flash Flood Areas

As part of recent studies in the Wollongong area, there have been a number of recent discussions with the SES regarding evacuation in flash-flood areas. In August 1998, many parts of Wollongong were devastated by flash floods that were in the order of a 100 year event or higher. As a result of experiences in the Wollongong floods, the current thinking of the SES is that the safest course of action for people flooded in flash flood areas is for them to actually stay in their house (provided that house is not in danger of structural collapse). This is now considered safer than people attempting to drive out along flooded roads, when it often dark and it is pouring with rain.

These new thoughts are now being reflected in the planning controls being adopted for these areas. Planning controls are being developed to reflect this type of evacuation where there is essentially no warning time — the first 'warning' people get is when water physically enters the house. The controls require that ground floor levels should be at least at the 100 year flood plus some freeboard, but for floods larger than the 100 year flood, there should be a 'safe haven' above the PMF. This 'safe haven' would generally be in the form of an upper storey.

This is generally possible in flash flood areas, such as in the Upper Parramatta River catchment, because the PMF is usually less than one storey higher than the 100 year flood. This 'safe haven' above the level of the PMF would also only be needed for a relatively short period of time as floods pass through this catchment quite quickly.

This type of 'vertical evacuation', however, is not practical and is even dangerous, if the PMF is greater than one storey (about 2.4m) above the level of the 100 year flood. A submerged upper floor may mean there would be little or no way for occupants to evacuate. There are only very few areas in the Upper Parramatta River catchment where this more dangerous situation would occur.

Therefore, second storey additions may be permitted in areas of even high flood risk as they provide added safety for flood-affected residents. They also provide an area for people to take their possessions, if they have time, thereby reducing the overall damage sustained by the community. Non-habitable areas are encouraged in all lower storey areas.

From an emergency management perspective, it is unknown how many residences in the floodplain currently have a 'reliable access' to an area above the PMF.

FloodSafe Brochure

The NSW State Emergency Service's (SES) FloodSafe program has produced area-specific brochures that describe what to do in a flood, how the SES can help and broadly describe the flood problem of the area. These brochures have concentrated on flooding in the Hawkesbury–Nepean valley to date.

The brochures also include a broad scale map showing the approximate extent of the floodplain up to the probable maximum flood. The SES, in conjunction with Blacktown City Council, has recently produced a FloodSafe brochure for that part of Blacktown affected by flooding from the Hawkesbury–Nepean River. A copy of this brochure and other general flood awareness brochures produced by the SES were provided presented in **Figure 5.3.**

A FloodSafe brochure is currently being prepared, in conjunction with the SES, for the Upper Parramatta River catchment. This brochure, together with other, more general flood awareness information prepared by the SES, would be included in the 'Flood Information Packs' described in **Section 5.3.3**.

5.5.3 Recommendations

The following emergency management recommendations have been made as part of this study:

- support for the continued development of the Local Flood Plan is considered to be an important outcome of this *Floodplain Risk Management Study*. The Trust and the Floodplain Risk Management Committee have important roles in assisting the SES in the future development of the Local Flood Plan(s) for the catchment. This may involve a separate flood plan for each local government area or an integrated flood plan for the whole catchment as part of the SES Sydney Western Division Flood Plan. Discussions are recommended between the Trust, the Committee, the SES's Deputy Director General and the SES's State Planning Coordinator on this matter;

- flood intelligence data readily available from the Trust, be included in the SES Local Flood Plan;

- that the planning controls developed for the catchment reflect the current thinking that it is safer for people to actually stay in their homes in flash-flood areas (in lower flood risk areas), where there is essentially no warning time, and that there be a 'safe-haven' above the level of the probable maximum flood, generally in the form of a upper-storey;

- that a FloodSafe brochure be produced for the Upper Parramatta River catchment. This brochure, together with other, more general flood awareness information prepared by the SES, would be included in the 'Flood Information Packs' described in **Section 5.3.3**.

6. DRAFT UPPER PARRAMATTA RIVER CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

This chapter presents the draft *Floodplain Risk Management Plan*, showing the preferred floodplain risk management measures, for the Upper Parramatta River catchment. This chapter gathers all the recommendations that have been made through this report and presents them all together. Most of the text presented in this chapter has been taken directly from **Chapters 4** and **5**. This allows this **Chapter 6**, as the draft *Floodplain Risk Management Plan*, to be easily produced as a separate document in the future if required.

Figure 6.1 shows the locations of the measures recommended in this draft *Floodplain Risk Management Plan*. The draft *Floodplain Risk Management Plan* involves a combination of capital and non-capital measures with the following key elements:

- ***capital measures*** — flood modification, voluntary purchase and house raising works and investigations identified in the 1991 *Catchment Management Priorities Study* (Webb, McKeown & Associates, 1991a) and identified and updated by the Trust and the four constituent Councils since that time (**Section 6.1**);

- ***non-capital measures*** —

  - the adoption of consistent planning controls and policies across the four constituent Councils, consistent with the requirements of the *Floodplain Management Manual* (NSW Government, 2001) (**Section 6.2**);

  - the implementation of a comprehensive community flood awareness strategy (**Section 6.3**);

  - the instigation of emergency management measures, in conjunction with the SES, in recognition of the growing role of emergency services in floodplain risk management and planning (**Section 6.4**).

6.1 FLOOD MODIFICATION MEASURES, VOLUNTARY PURCHASE AND HOUSE RAISING

As part of the 1991 *Catchment Management Priorities Study* (Webb, McKeown & Associates, 1991a) a total of 83 possible flood mitigation measures were identified to address 62 separate flood problems in the Upper Parramatta River catchment. The majority of these works were 'flood modification works' with some voluntary house purchase and house raising.

A comprehensive method for assessing and prioritising this large number of floodplain risk management measures identified in the catchment was developed as part of the 1991 study. DVA Consulting reviewed this methodology in 2000 in *A Review of the Trust and Councils' Flood Mitigation and Trunk Drainage Program.* (see **Section 4.2**).

A combination of both these ranking procedures is currently used by the Trust to prioritise works across the catchment and within each Council area. The procedure has proved to be useful and successful in the past and hence there is no justification to change it as part of this study. This ranking procedure has therefore been retained in this current study for the flood modification measures already identified by the Trust. Therefore, it is recommended that the prioritised list currently used by the Trust and the four constituent Councils (UPRCT, 2001b) be adopted, as is, in the draft *Floodplain Risk Management Plan*.

Table 6.1 summarises each of the outstanding flood modification, voluntary purchase and house raising 'works' measures that are recommended as part of this draft Floodplain Management Plan. Similarly, **Table 6.2** summarises the 'investigation' measures'. The measures in **Tables 6.1** and **6.2** have been listed in order of priority in accordance with the latest information provided by the Trust (UPRCT, 2001b). Also provided in **Tables 6.1** and **6.2** is a breakdown of measures for each of the four constituent Councils and hence the priority of works for each Council.

As shown in **Tables 6.1** and **6.2**, the recommended works involve a combination of:

- flood retarding basins (or detention basins);
- enlargement of creek channels and the construction of floodways;
- erosion and scour protection works for existing creek channels;
- modifications to urban areas to provide overland flow paths;
- enlargement of culverts and bridge structures at creek crossings;
- augmentation of piped drainage systems;
- improvements to existing levee systems;
- voluntary purchase of several severely flood-affected homes;
- raising or flood-proofing of several flood-affected homes;

The latest 'factored' cost estimates are also given in **Tables 6.1** and **6.2** based on 2001 dollar values. These measures represent about $36 million of outstanding works in the catchment. The total cost for all the proposed 'works' measures would be about $19.4 million, while all the 'investigation' measures would nearly $17 million. The total costs for each of the four constituent Councils are as follows:

- Baulkham Hills Shire Council — $6.6 million, involving $5.14 million for 'works' and $1.44 million for 'investigations';

- Parramatta City Council — $16.2 million, involving $11.43 million for 'works' and $4.79 million for 'investigations';

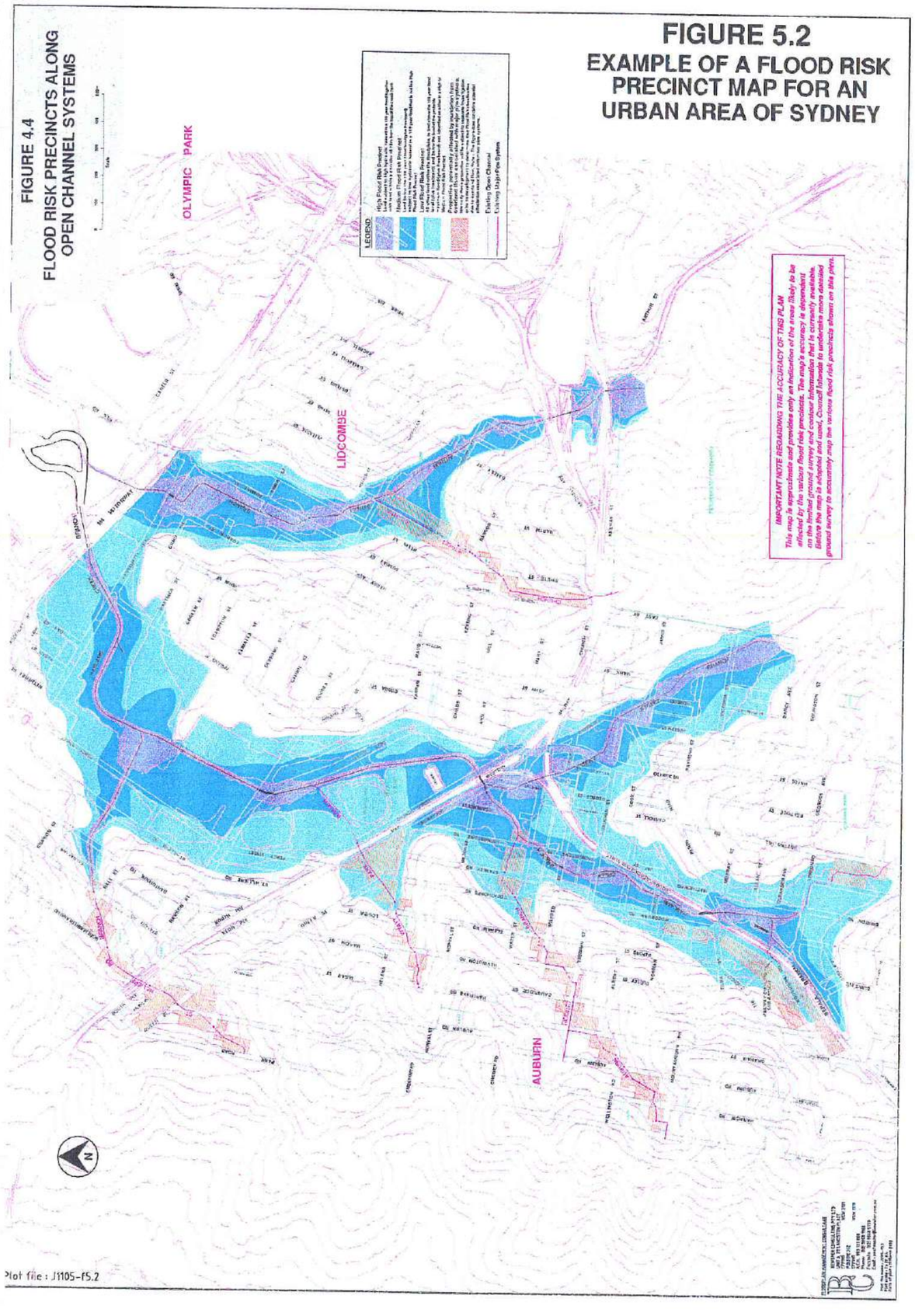
- Holroyd City Council — $9.4 million, involving $0.75 million for 'works' and $8.66 million for 'investigations';

- Blacktown City Council — $3.9 million, involving $2.07 million for 'works' and $1.86 million for 'investigations'.

Timing of the proposed works will depend on the Trust's and the Councils' overall budgetary commitments, and the availability of funds from other sources.

FIGURE 4.4
FLOOD RISK PRECINCTS ALONG OPEN CHANNEL SYSTEMS

FIGURE 5.2
EXAMPLE OF A FLOOD RISK PRECINCT MAP FOR AN URBAN AREA OF SYDNEY



Plot file : J1105-F5.2

FIGURE 6.1
RECOMMENDED MEASURES FOR DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

N

0 0.5 1 2 km

Scale (1:50000)

CATCHMENT WIDE MEASURES

- consistent planning controls and policies across the catchment
- comprehensive community flood awareness strategy :
  - flood risk precinct maps
  - brochure on flood-related building controls
  - flood information packs (including flood notification letter, flood information brochure, handout on frequently asked questions and SES FloodSafe Brochures
  - flood certificates
  - consistent wording of flood notations on Section 149 Certificates
  - quality assurance system for release of flood data
- emergency management :
  - support for continued development of Local Flood Plan
  - inclusion of flood intelligence data in Local Flood Plan

BAULKHAM HILLS SHIRE COUNCIL

BLACKTOWN CITY COUNCIL

HOLROYD CITY COUNCIL

PARRAMATTA CITY COUNCIL

Castle Hill · Baulkham Hills · Lalor Park · Seven Hills · Blacktown · Toongabbie · Old Toongabbie · Pendle Hill · Girraween · Wentworthville · Westmead · North Parramatta · West Pennant Hills · North Rocks · Carlingford · Oatlands · Winston Hills · Northmead · Loyalty Road D.B. · Sierra Pl D.B. · McCoy Park D.B. · Duncan Reserve D.B. · Fox Hills D.B. · Boral Planning D.B. · CSIRO D.B. · Darling Street D.B's. · Greystanes · South Wentworthville · Merrylands West · Parramatta · Lake Parramatta

2	North Rocks	25	Pendle Hill
4	Baulkham Hills	26	Toongabbie
5a	Baulkham Hills	27	Pendle Hill
5b	Baulkham Hills	32b	Old Toongabbie
7	Winston Hills	35	Girraween
8	West Pennant Hills	36	Girraween
10	Castle Hill	37	Greystanes
11	Northmead	39	Girraween
12b	Sierra Pl D.B.	40	Pendle Hill
15	Toongabbie	42	Wentworthville
16	Toongabbie	43	Merrylands West
17	Toongabbie	44	South Wentworthville
18	Old Toongabbie	45	South Wentworthville
19	Toongabbie	47	Wentworthville
20	Old Toongabbie	48	Greystanes
21	Old Toongabbie	49	Greystanes
22	Old Toongabbie	50	Wentworthville
23	Winston Hills	53a	Prospect
24	Pendle Hill	54	Blacktown
28	Oatlands	61	Lalor Park
30	North Parramatta	62	Seven Hills
31	North Parramatta	63	Blacktown

LEGEND

- External Catchment Boundary
- Tributary Catchment Boundary
- Local Government Boundary
- Flood Retarding Basin (Detention Basin)
- CSIRO D.B. Flood Retarding Basin / Wetland (Detention Basin / Wetland)
- 30 Proposed future project recommended for further consideration as part of this study
- Probable Maximum Flood (Pmf) extent

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UPPER PARRAMATTA RIVER CATCHMENT TRUST

TABLE 6.1: PRIORITISED LIST OF RECOMMENDED FLOOD MITIGATION 'WORKS' MEASURES FOR DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

PRIORITY	ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL	TRUST CODES		APPROX COST (2) ($mil)	PRIORITIES FOR COUNCILS			
					Problem	Measure		BHSC	PCC	HCC	BCC
1	2	Bray Court, Yalding Avenue, Paragon Drive and McDonald Street, North Rocks — modification of buildings and improvements to provide overland flow path.	tributary of Hunts Creek	Baulkham Hills	BHP1H	BHM1H1	$0.32	1			
2	32 B	North Wentworthville Floodplain Risk Management Study and Plan — Upgrading of Briens Road culvert, voluntary acquisition of 3 homes.	Toongabbie Creek	Parramatta	PP1C	PM1C1	$2.25		1 current design with acquisit-ions in 2003		
3	4	Excelsior Avenue to Reiby Drive, Castle Hill — modification of buildings and improvements to provide overland flow path, plus possible flood retarding basin.	Quarry Creek	Baulkham Hills	BHP2QC	BHM2QC1	$1.02	2			
4	16	Oakes Road, Old Toongabbie House Raising (6 homes) and Flood Proofing (4 homes).	Toongabbie Creek	Parramatta	PP3T	PM3T1	$0.32		2		
5	54	Station Road, Seven Hills — construction of new road bridge and channel formalisation.	Blacktown Creek	Blacktown	BLP3BL	BLM3BL2	$1.68				1
6	5	Lindsay St, Coronation Rd & Mulgray Ave, Baulkham Hills — establishment of overland flow path including acquisition of two houses.	tributary of Quarry Creek	Baulkham Hills	BHP3QC	BHM3QC1 BHM4QC1	$0.41 $1.35	3 and 5			
7	24	Wentworth Avenue to Burrabogee Road, Pendle Hill channel formalisation, culvert upgrade and construction of drop structure.	Pendle Hill Creek	Parramatta	PP1PH	PM1PH1	$1.80		3 current design		
8	25	Burrabogee Road to Barangaroo Road, Pendle Hill — Pendle Hill Creek Floodway.	Pendle Hill Creek	Parramatta	PP2PH	PM2PH1	$3.32		4		
9	8	Oakes Road Trunk Drainage — Carmen Drive, Watton Road, Mahers Road West, Oakes Road, Sylvia Avenue and Morton Avenue, Carlingford — pipe enlargement and construction of five small flood retarding basins.	tributary of Blue Gum (Darling Mills) Creek	Baulkham Hills	BHP2DM	BHM2DM1	$2.04	4			

PRIORITY	ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL	TRUST CODES		APPROX COST (2) ($mil)	PRIORITIES FOR COUNCILS			
					Problem	Measure		BHSC	PCC	HCC	BCC
10	17	Edison Pde and Einstein Street, Winston Hills — Diversion of drainage around existing levee.	Toongabbie Creek	Parramatta	PP4T	PM4T1	$0.65		5		
11	26	Barangaroo Road to Fitzwilliam Road, Pendle Hill — channel improvements and additional cell in Fitzwilliam Road culverts	Pendle Hill Creek	Parramatta	PP3PH	PM3PH1	$1.35		6		
12	39	Main Western Railway Culvert in the vicinity of Civic Park, west of Pendle Hill Shopping Centre — upgrading of railway culverts and channel upgrading to Wentworth Avenue culvert. The Trust may not support these works unless it can be proven that flood levels would not be increased in downstream areas.	Pendle Hill Creek	Holroyd	HP2PH	HM2PH1	$0.75			1	
13	22	O'Connell, Ferris, Iron, Barney and Church Streets, North Parramatta — pipe upgrade and augmentation.	Darling Mills Creek	Parramatta	PP1DM	PM1DM	$0.65		7		
14	23	Bellotti Avenue, Churchill Drive, Jerome Avenue, Defoe Place and Twain Street, Winston Hills— pipe upgrade and augmentation including modification of pits (some works have been completed).	tributary of Quarry Branch Creek	Parramatta	PP1QB	PM1QB1	$0.42		8		
15	53 A	Kisdon Crescent, Prospect — voluntary purchase of one house.	Blacktown Creek	Blacktown	BLP2BL	BLM2BL1	$0.39				2
16	28	Belmore Street transition chamber and Belmore Park, North Parramatta flood retarding basin.	Brickfield Creek (Belmore Park Branch)	Parramatta	PP1BR	PM1BR3	$0.67		9		
						TOTAL COSTS (million)	$19.39	$5.14	$11.43	$0.75	$2.07

Abbreviations *BHSC = Baulkham Hills Shire Council; PCC = Parramatta City Council; HCC = Holroyd City Council; BCC = Blacktown City Council.*

*Notes: (1) See **Figure 6.1** for locations of floodplain risk management measures.*

(2) Factored cost = estimated cost x cost multiplier based on certainty factor from UPRCT (2001b) (see Section 4.2 for definitions of cost multipliers).

TABLE 6.2: PRIORITISED LIST OF RECOMMENDED 'INVESTIGATION' MEASURES FOR DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

PRIORITY	ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL	TRUST CODES		APPROX COST (2) ($mil)	PRIORITIES FOR COUNCILS			
					Problem	Measure		BHSC	PCC	HCC	BCC
1	31	Doyle Ground and Dan Mahony Reserve, North Parramatta — construction of two flood retarding basins.	Brickfield Creek	Parramatta	PP2BR	PM2BR3	$0.60		1		
2	21	Fletcher Close, Old Toongabbie — Flood Wall.	Toongabbie Creek	Parramatta	PP8T	PM8T1	$0.06		2		
3	30	Old Saleyards Flood Retarding Basin upstream of Gladstone Street near Macarthur Street, North Parramatta.	Brickfield Creek	Parramatta Baulkham Hills	PP2BR	PM2BR2	$0.73		3		
4	20	Campbell's Cash and Carry at Kleins Road and Boundary Road, Northmead — investigation into pipe augmentation or trunk drainage diversion works.	Darling Mills Creek	Parramatta	PP7T	PM7T1	$0.30		4		
5	43	Holroyd High School, Greystanes — investigation into construction of flood retarding basin.	Finlaysons	Holroyd	HP1F	HM1F1	$0.31			1	
6	44	Centenary Road, South Wentworthville — pipe augmentation and culvert enlargement.	Finlaysons	Holroyd	HP2F	HM2F1	$0.54			2	
7	36	Toongabbie Road pipe augmentation works between Gilba and Portia Roads, Toongabbie	Greystanes Creek	Holroyd	HP4GE	HM4GE1	$0.40			3	
8	10	Orange Grove Pipe Augmentation — Orange Grove and Francis Street — investigation into pipe upgrading.	tributary of Darling Mills Creek	Baulkham Hills	BHP4DM	BHM4DM1	$1.00	1			
9	50	Austral Avenue to Alexander Avenue, Westmead — Investigation into M.J. Bennett Reserve flood retarding basin and channel improvement works.	tributary of Toongabbie/ Finlaysons Creeks	Holroyd	HP1T	HM1T	$0.36			4	
10	7	Watkins Road, Baulkham Hills — investigation into pipe augmentation (currently being designed).	tributary of Toongabbie Creek	Baulkham Hills	BHP2T	BHM2T1	$0.44	2			
11	42	Great Western Highway, and Emert Street/ Fream Street (Cumberland Highway), Wentworthville — investigation into channel improvements.	Coopers Creek	Holroyd	HP3C	HM3C1	$2.00			5	

PRIORITY	ID No. (1)	DESCRIPTION	CREEKS AND CATCH-MENTS	COUNCIL	TRUST CODES		APPROX COST (2) ($mil)	PRIORITIES FOR COUNCILS			
					Problem	Measure		BHSC	PCC	HCC	BCC
12	27	Scott Street, Andrews Avenue and Lamonerie Street, Pendle Hill— pipe augmentation and channel works.	Pendle Hill Creek	Parramatta	PP4PH	PM4PH1	$0.90		5		
13	35	Portia Road, Toongabbie Road and Oramzi Road, Toongabbie — voluntary purchase of properties to create overland flow path.	Greystanes Creek	Holroyd	HP3GE	HP3GE1	$0.40			6	
14	49	Fullagar Road, Wentworthville — upgrade of culvert under road.	Finlaysons	Holroyd	HP7F	HM7F1	$0.60			7	
15	63	"Grantham" Poultry Research Station Flood Retarding Basin and bank protection works — investigation into need for basin to alleviate flood problems between the research station to Best Road to the railway line to Santiago Place and Chile Place.	Grantham Creek	Blacktown	BLP2GA	BLM2GA1	$0.56				1
16	48	Great Western Highway to Old Prospect Road, South Wentworthville — upgrade of culvert.	Finlaysons	Holroyd	HP6F	HM6F1	$1.00			8	
17	45	Pitt Park, South Wentworthville — flood retarding basin to alleviate flooding in Pearson Street, South Wentworthville.	Finlaysons	Holroyd	HP3F	HM3F1	$0.29			9	
18	47	Veron Street, Wentworthville to Railway Line — upgrade of culvert.	Finlaysons	Holroyd	HP5F	HM5F1	$0.60			10	
19	18	Sherwood Street, Old Toongabbie levee (voluntary purchase completed in 1993).	Toongabbie Creek	Parramatta	PP5T	PM5T1	$1.60		6		
20	62	Jura Place, Seven Hills — investigation into amplification of pipe drainage system.	Grantham Creek	Blacktown	BLP1GA	BLM1GA1	$1.00				2
21	19	Lister Street, Winston Hills levee extension and pump out — these works would be additional to the major diversion drain constructed in 1990 to prevent flooding from behind the existing levee.	Toongabbie Creek	Parramatta	PP6T	PM6T1	$0.60		7		
22	61	Thomas Street, Seven Hills — investigation into amplification of pipe drainage system.	Lalor Creek	Blacktown	BLP3L	BLM3L1	$0.30				3
23	40	M4, Great Western Hwy, Magowar to Gilba Roads, Pendle Hill— gabion lining of creek	Pendle Hill Creek	Holroyd	HP5PH	HM5PH1	$2.16			11	
						TOTAL COSTS (million)	$16.75	$1.44	$4.79	$8.66	$1.86

Abbreviations *BHSC = Baulkham Hills Shire Council; PCC = Parramatta City Council; HCC = Holroyd City Council; BCC = Blacktown City Council.*

Notes: (1) See Figure 6.1 for locations of floodplain risk management measures.

(2) Factored cost = estimated cost x cost multiplier based on certainty factor from UPRCT (2001b) (see Section 4.2 for definitions of cost multipliers.

6.2 PLANNING CONTROLS AND POLICIES

Land use planning, development controls and specific flood-related policies are key components of the recommended draft *Upper Parramatta River Catchment Floodplain Risk Management Plan*.

It will be important, however, that each council ensures that the planning outcomes derived from this study are integrated with all other existing and future floodplain risk management studies currently under preparation in their LGA, to provide a consistent platform for dealing with the issue of flooding with future development.

Chapter 3 of **Volume 2**, entitled *Planning Issues and Outcomes* (Don Fox Planning, 2003) presents a detailed discussion on the proposed approach to floodplain planning recommended in this study.

6.2.1 The Planning Matrix Approach

The Planning Matrix Approach to floodplain risk management considers the range of land uses, and their potential risk to flooding, within the floodplain up to the level of the probable maximum flood. 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.

The Planning Matrix Approach is fully consistent with the Floodplain Management Manual (NSW, Government, 2001).

6.2.2 Flood Risk Precincts

A key component of the Planning Matrix Approach is to divide the floodplain into different areas of similar risk, known as Flood Risk Precincts. Different parts of the floodplain are subject to different degrees of hazard, or flood risk. This study recognises that different development controls should apply to different flood risk areas, or precincts.

Flood Risk Precincts have previously been identified for those parts of the Eastern Creek and Tributaries Floodplain located north and south of the Castlereagh Freeway Reservation and for the North Wentworthville area. These were originally referred to as 'hazard bands'. Three Flood Risk Precincts have been adopted for these areas — low risk, medium risk and high risk. In the case of Eastern Creek, four Flood Risk Precincts have been adopted.

Using the definitions of flood hazard from the Floodplain Management Manual and **Figure 5.1**, three Flood Risk Precincts have been recommended for the Upper Parramatta River catchment, namely 'high risk', 'medium risk' and 'low' risk. These Flood Risk Precincts have been defined as follows:

- ***High Flood Risk Precinct*** — This has been defined as generally the area of land below the 100 year flood level subject to a high hydraulic hazard (in accordance with the provisional criteria outlined in the *Floodplain Management Manual*). The High Flood Risk Precinct is where high flood damages, potential risk to life, or evacuation problems would be anticipated. Most development should be restricted in this precinct. In this precinct, it would be difficult to achieve a substantial reduction in flood damages or to ensure safe evacuation with reasonable flood-related building and planning controls.

- ***Medium Flood Risk Precinct*** — This has been defined as generally land below the 100 year flood level subject to low hydraulic hazard in a 100 year flood. In this precinct there would still be a significant risk of flood damage or risk to life, but these could be minimised with the application of appropriate development controls.

- ***Low Flood Risk Precinct*** — This has been defined as all other land within the floodplain, namely above the 100 year flood level and below the level of the PMF. The Low Flood Risk Precinct would be where risk of damages would be low for most land uses and so it the application of compulsory flood-related development controls are not likely to be cost effective.

  Most land uses would be permitted within this precinct. However, this area would be still subject to some flood-related risk and those uses that may be considered critical, or should be afforded maximum protection against risk from flooding, would be identified as undesirable land uses in this precinct.

  The other major purpose of the Low Flood Risk Precinct is to identify and recognise the potential flood risk for all persons and properties affected by the PMF, regardless of whether any specific development controls are to be applied. This provides a basis for flood awareness programs, evacuation and emergency planning and to maximise the preparedness of the community.

It is acknowledged that generally only 'hydraulic' considerations have been used to define the Flood Risk Precincts at this stage. In locations where a Medium Flood Risk Precinct is an 'island' surrounded by a High Flood Risk Precinct, then the Medium Risk land has been defined as High Risk. When evacuation and other emergency management risks are more thoroughly assessed in the future, this may also alter some of the precinct boundaries.

6.2.3 Summary of Recommended Planning and Policy Changes

The following planning measures and policy changes are recommended for the Upper Parramatta River catchment:

- ***Planning Matrix*** — the consideration of the application of a graded set of planning controls for different land uses relative to different levels of flood risk within the study area (see **Table 5.1**) consistent with the requirements of the current *NSW Floodplain Management Manual* (NSW Government, 2001). This would involve the adoption of the High, Medium and Low Flood Risk Precincts, as described above **Section 6.2.2**;

- ***Sydney REP No.28 — Parramatta*** — As discussed in **Volume 2** of this report, it is considered appropriate that some of the provisions and terminology adopted by Sydney REP No. 28 – Parramatta, should be amended to provide a consistent framework for flood planning controls that are either existing or proposed for each of the Council's LEPs. The recommended changes to this REP, as previously discussed with PlanningNSW, are included as Appendix A in **Volume 2** of this report. It is recommended that the Trust formally endorses these changes;

- ***Changes to Council Local Environmental Plans (LEPs)*** — it is recommended that each Council considers amending their LEP in the manner outlined in Section 4.4 and Appendix B of **Volume 2** of this report, to provide a consistent framework for more detailed controls to be provided in a DCP. These particularly relate to consistency with definitions, special flood development control clauses, and to restrict development within the High Flood Risk Precinct.

- ***Discouragement of Building in High Flood Risk Precinct*** — it is recommended that each constituent Council give force to discouraging building in the High Flood Risk Precinct by utilising foreshore building line provisions embodied within LEPs or by utilising alternative suitable mechanisms as outlined in Appendix B of **Volume 2** of this report.

- ***Development Control Plans*** — The most appropriate way to implement the proposed flood policy is its adoption by Council as a DCP (in the case of Holroyd, Blacktown and Baulkham Hills) or associated Flood Policy document (in the case of Parramatta).

One of the key outcomes of this study is the recommendation for development controls, which would be embodied within a DCP or Flood Policy for each of the four constituent Councils. The format of the recommended DCPs (or Flood Policy) has been varied to meet the specific requirements of each Council, taking into account how they present their current DCPs or policies.

Each of the four DCP (or Flood Policy) documents would be generally similar, involving a preamble of provisions that establishes a framework to allow for the outcomes of any number of floodplain risk management plans to be incorporated into the document. The *Upper Parramatta River Catchment Floodplain Risk Management Plan* would be one of these plans. Where possible, existing or finalised, but yet to be implemented, controls from other floodplain risk management plans would be integrated into the proposed documents, to increase the convenience for Council to accelerate the adoption of the plan. The particular intricacies relevant to each of the Council's are discussed in detail of **Volume 2** of this report.

It is recommended each of the four constituent Councils adopt or amend their current DCPs and/or Policies that outline appropriate measures to be applied to development in the floodplain (Parramatta City Council are currently extracting the relevant information out of the Flood Policy and incorporating it into their existing comprehensive DCP). Appendices C to F **of Volume 2** provide

suggested Model Development Control Plan and/or Policy for each of the four Councils in accordance with the process required under the *Environmental Planning and Assessment Act, 1979*.

6.3 COMMUNITY CONSULTATION AND AWARENESS

Flood awareness is critical to reducing the flood risk to the floodplain community and flood awareness is essential for flood readiness.

A comprehensive community flood awareness strategy is a key recommendation of the draft *Floodplain Risk Management Plan* for the Upper Parramatta River catchment. Most of the components of this strategy relate to the release of flood information to the community.

As a result of the study's investigations and recent meetings of the Floodplain Risk Management Committee Meeting, the mechanisms described below are proposed in order to raise flood awareness in the catchment and comply with the requirements of the *Floodplain Management Manual* (NSW Government, 2001) and Section 149 of the *Environmental Planning and Assessment (EPA) Act, 1979.*

6.3.1 Flood Risk Precinct Maps

Flood Risk Precinct maps would show all known areas of the floodplain up the probable maximum flood. They would show the limits of the three Flood Risk Precincts (low, medium and high). Flood levels, flood depths or flood extents of floods of varying probabilities would not necessarily be shown — only areas of similar flood risk. The Flood Risk Precinct Maps would consider flooding from creeks, rivers and stormwater overland flows.

The Trust is currently preparing Flood Risk Precinct Maps for the Upper Parramatta River catchment for all areas covered by its MIKE-11 hydraulic modelling.

In other areas within the catchment, there are locations where the flood problem has not been defined by a formal study, but anecdotal or information suggests the property may be 'potentially flooded'. Each of the four constituent councils have different means of identifying these types of properties and most have quite comprehensive, albeit approximate, systems in place. There are currently discussions with the constituent councils about including their 'potentially flooded' property information on the Flood Risk Precinct maps.

It is recommended that the Flood Risk Precinct maps be readily available to the public. This would preferably be via the Trust's web site, with links to and from each of the council web sites. The maps should be at least be available at councils' inquiry counters and on their respective GIS data base systems. It should be noted that councils have a duty of care to make information about flood risks known to the public.

6.3.2 Brochure on Flood-related Building Controls

To help the community understand how the Flood Risk Precinct Maps and the associated planning controls would affect the way they may want to improve their

property, a brochure outlining a simplified explanation of what type of development would be permitted and the flood-related building controls for residential development, is proposed. This information would be taken directly from the Planning Matrix. A draft brochure is currently with the Trust for review.

6.3.3 Flood Information Packs

Flood notification to all residents in the floodplain (that is up to the level of the probable maximum flood) is recommended as a key means of raising flood awareness in the catchment. It is important with such notifications that the recipients of the information understand that the supplied information actually applies to them and is not a part of a general mail out to everyone in the catchment.

The Flood Information Packs that would be sent to all residents (owners and occupiers) in the floodplain would include the following information:

- ***flood notification letter*** — this would explain that the particular property was located in a floodplain, how flooding may affect the property, generally what development controls would apply and how more information could be obtained. It is understood that Blacktown Council has recently sent out this type of letter to all residents whose properties would be affected by a probable maximum flood from the Hawkesbury–Nepean River;

- ***flood information brochure*** — This A4-size folded brochure, entitled "Facts about Flooding in the Upper Parramatta River Catchment", would broadly describe flooding (i.e. what is meant by a '100 year flood' and a 'probable maximum flood') and the flood problems of the catchment, the Flood Risk Precincts, the Flood Risk Precinct Maps currently being prepared by the Trust. and some key flood-related development constraints and opportunities. A draft version of this brochure is currently with the Trust for review;

- ***frequently asked questions*** — a four-page handout on 'Frequently Asked Questions' providing a simplified explanation on flood-related matters is also proposed for inclusion in the Flood Information Packs, as well as being available at Council's inquiry counters. A draft version of this handout is currently with the Trust for review;

- ***SES FloodSafe Brochures and associated information*** — The NSW State Emergency Service's (SES) FloodSafe program has produced area-specific brochures that describe what to do in a flood, how the SES can help and broadly describe the flood problem of the area. These brochures have concentrated on flooding in the Hawkesbury–Nepean valley to date. These brochures also include a broad scale map showing the approximate extent of the floodplain up to the probable maximum flood. The SES, in conjunction with Blacktown City Council, has recently produced a FloodSafe brochure for that part of Blacktown affected by flooding from the Hawkesbury–Nepean River. A copy of this brochure and other general flood awareness brochures produced by the SES are presented as **Figure 5.3**. A FloodSafe brochure is currently being prepared for the Upper Parramatta River catchment, in conjunction with the SES.

6.3.4 Flood Certificates

In addition to the use of Flood Notification Letters, Flood Certificates are recommended for use in more 'formal' situations such as when a Development Application is submitted or a Section 149 Certificate is issued.

A flood certificate would contain information such as the expected flood levels in a range of design floods. It would also provide information on ground and floor levels where this information is available. The Flood Risk Precinct applicable to that property would also be included.

A sample flood certificate is included as **Figure 5.4**.

6.3.5 Section 149 Certificates

A Section 149 Certificate is a zoning certificate issued under the provisions of the *Environmental Planning and Assessment Act, 1979,* which can be obtained to confirm controls pertaining to individual properties, and must be attached to a contract prepared for the sale of property. The current standard wording used often causes inconsistencies to arise between local councils in regard to the extent of information they provide on flooding.

It is important that all properties in the floodplain (that is, up to the probable maximum flood be notified. Notification should include the Flood Risk Precinct, if known, and the existence of the relevant Development Control Plan (DCP). If the property is 'potentially flood affected' this should also be notified. A notation should be provided that states that while all reasonable efforts are employed to identify lands subject to any potential flood risk, all properties so affected may not have been identified. While it is considered that the majority of potentially flood affected properties have been identified, Council may determine that a site-specific flood study is required on land not currently identified as flood affected, for the purposes of assessing a development application.

Using the wording presented in the Floodplain Management Manual (NSW Government, 2001) as a guide, **Table 5.2** presents the proposed wording for S149 (2) certificates for the four constituent councils in the Upper Parramatta River catchment.

For S149 (5) certificates, it is recommended that a Flood Certificate be appended to the S149 (5) certificate.

6.3.5 Quality Assurance of Flood Data Released to the Public

The flood-related information provided on Flood Certificates, Section 149 Certificates and released to the public during the development approval process would be derived from the information held by the Trust or the Council's own investigations or studies. In respect of the flood information for the creeks/rivers in the Trust's area, this information would normally be provided by the Trust to the council and then formally adopted by the council before being issued.

Given that potentially different 'versions' of the Trust's data may exist, it is recommended as part of the draft *Floodplain Risk Management Plan* that a more formal

strategy for the release and adoption of new sets of flood data (particularly some quality assurance procedures) be developed by the Trust in conjunction with the four constituent councils. This may include more comprehensive documentation of flood modelling activities, possibly in the form of an up-to-date *Upper Parramatta River Catchment Flood Study*. This would ensure that a consistent and up-to-date set of flood levels is always being used across the catchment.

6.4 FLOOD WARNING

Unfortunately, there is limited scope to improve the flood warning in the Upper Parramatta River catchment. This catchment responds very quickly to heavy rainfall, that is, the catchment experiences 'flash flooding'. As such, the Bureau of Meteorology would be unable to provide a specific flood warning service to this catchment. Therefore, provision of a 'formal' flood warning system for the Upper Parramatta River catchment has not been considered further.

However, an informal local formal warning system for the Parramatta central business district, using the Trust's upstream stream level gauges, appears feasible, although it may operate too infrequently to be maintained. It is recommended that this option be considered during preparation of a Local Flood Plan for the catchment.

6.5 EMERGENCY MANAGEMENT

The following emergency management recommendations have been made as part of this draft Floodplain Risk Management Plan:

- support for the continued development of the Local Flood Plan is considered to be an important outcome of this *Floodplain Risk Management Study*. The Trust and the Floodplain Risk Management Committee have important roles in assisting the SES in the future development of the Local Flood Plan(s) for the catchment. This may involve a separate flood plan for each local government area or an integrated flood plan for the whole catchment as part of the SES Sydney Western Division Flood Plan. Discussions are recommended between the Trust, the Committee, the SES's Deputy Director General and the SES's State Planning Coordinator on this matter;

- flood intelligence data readily available from the Trust, be included in the SES Local Flood Plan;

- that the planning controls developed for the catchment reflect the current thinking that it is safer for people to actually stay in their homes in flash-flood areas (in lower flood risk areas), where there is essentially no warning time, and that there be a 'safe-haven' above the level of the probable maximum flood, generally in the form of a upper-storey;

- that a FloodSafe brochure be produced for the Upper Parramatta River catchment. This brochure, together with other, more general flood awareness information prepared by the SES, would be included in the 'Flood Information Packs' described in **Section 6.2.3**.

7. REFERENCES

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8. BIBLIOGRAPHY

There have been more than 100 studies, investigation, designs and other documents prepared about flood-related issues within the Upper Parramatta River catchment in the past twenty-five years. These documents are presented in **Table 8.1**. The numbering system presented in the bibliography was originally developed in the early 1990s and was added to up until the late 1990s. The bibliography has not been formally updated as part of this study.

TABLE 8.1: BIBLIOGRAPHY OF FLOOD-RELATED DOCUMENTS FOR THE UPPER PARRAMATTA RIVER CATCHMENT

NO.	TYPE	TITLE	AUTHOR	DATE
1	Report	North Parramatta Rezoning Drainage Study	Sinclair Knight And Partners Pty Ltd	1991
2	Report	Parramatta River Basin Drainage Study	SMEC	1991
3	Report	Toongabbie Creek Flood Study (Draft No.2)	DWR	1991
4	Report	August 86 Flood Study Oakes Rd Toongabbie, Toongabbie Creek. Catchment Development	Sinclair Knight And Partners Pty Ltd	1990
5	Report	Greystanes Creek and Pendle Hill Creek. Flood Mitigation Study		1991
6	Report	Excelsior Reserve Plan of Management – Drainage Management Issue	Willing and Partners Pty Ltd	1990
7	Report	Toongabbie Creek Flood Mitigation Works Stage 1	Paterson	1992
8	Tech. Spec.	Toongabbie Creek Flood Mitigation Works Stage 1	Willing and Partners Pty Ltd	1991
9	Report	Toongabbie Creek Flood Mitigation Works Stage 2	Willing and Partners Pty Ltd	1991
10	Tech. Spec.	Toongabbie Creek Flood Mitigation Works Stage 2	Willing and Partners Pty Ltd	1991
11	Report	Toongabbie Creek Flood Mitigation Works Stage 3	Willing and Partners Pty Ltd	1991
12	Report	Toongabbie Creek Flood Mitigation Works Stage 4	Willing and Partners Pty Ltd	1991
13	Report	Toongabbie Creek Flood Mitigation Works Stage 5	Willing and Partners Pty Ltd	1991
14	Report	Drainage Strategy Report, Part I - Physical Works	Holroyd Municipal Council	1991
15	Report	Parramatta Drainage	Sinclair Knight And Partners Pty Ltd	1990
16	Report	Parramatta River Flood Mitigation Investigation	SMEC/Willing and Partners Pty Ltd	1990
17	Database	Baulkham Hills Shire Flood Database Report	Baulkham Hills	1991
18	Report	Shire Engineer's Report No. 88/59	Baulkham Hills	1988
19	Report	Shire Engineer's Report, Special Meeting 8/5/90	Baulkham Hills	1991
20	Report	Blacktown, Grantham & Lalor Creeks Trunk Drainage Strategy Report	Nichols, Watts	1991
21	Report	Lake Parramatta, Toongabbie Creek & Parramatta River Water Quality Monitoring	John Laxton	1991

NO.	TYPE	TITLE	AUTHOR	DATE
22	Loose	Various submissions for flood relief funds	Parramatta City Council	1991
23	Report	Engineer's Report 90/43 to Council 1/5190	Holroyd Municipal Council	1991
24	Report	Engineer's Report 90/16 to Council 20/2/90	Holroyd Municipal Council	1992
25	Plans	Catchment Maps Nos. 1,2,3,4,5,9,10,11,12,13,19,20,21,22,23,27,28	Sinclair Knight And Partners Pty Ltd	1992
26	Plan	Flood Prone Land Investigation Map 11454-K	Parramatta City Council	Oct 1991
27	Plan	Drainage & Flooding Constraints Map 12889	Parramatta City Council	May 1992
28	Plans	Working plans for various Local flooding problems in Catchment	Baulkham Hills	Feb & Mar 1993
29	Plan	Upper Parramatta River Catchment Trust - Area of Operation	DWR	1993
30	Plans	Municipality of Holroyd Stormwater Drainage Register	Holroyd Municipal Council	May 1993
31	Report	Greystanes Creek Retarding Basins – Design Report	Willing and Partners Pty Ltd	Nov 1992
32	Report	Parramatta River Basin Flood Estimates Review	Willing and Partners Pty Ltd	Jan 1994
33	Report	Retarding Basin 2B & Associated Channel Works - Design Report	Willing and Partners Pty Ltd	Aug 1993
34	Report	Toongabbie Creek Retarding Basin 3	SMEC/Willing and Partners Pty Ltd	Sept 1994
35	Report	Toongabbie Creek Retarding Basin3 - Design Report	Willing and Partners Pty Ltd	
36	Report	Pendle Hill Creek. Darting St. Reserve Basin 1 Stage 1 Specification	Willing and Partners Pty Ltd	Oct 1994
37	Report	Greystanes Creek Trunk Drainage Study	Willing and Partners Pty Ltd	Sep 1995
38	Report	Tech. Report on Calibration of RAFTS Model of Toongabbie Creek. for April 88 Flood	Lyall & Macoun	Nov 1997
39	Report	Tech. Report on Calibration of HEC-2 Model of Toongabbie Creek. For April 88 Flood	Lyall & Macoun	Sep 1998
40	Report	Drainage Investigation of Lance Crescent/Adrian Place Greystanes	Bewsher Consulting Pty Ltd	Dec 1999
41	Report	Investigation of Potential Flood Retarding Basins Above Braeside Road	Bewsher Consulting Pty Ltd	Sep 2000
42	Report	Potential Flood Losses in the Parramatta Central Business District	Environmental Management Pty Ltd	2000
43	Plans	Blacktown City Council Flood Maps	Blacktown City Council	1989
44	Plans	Blacktown City Council Drainage Maps	Blacktown City Council	
45	Plans	Blacktown Creek. Channel Improvements - Lancelot St. to Tudor Ave. Basin	Blacktown City Council	1989
46	Plans	Proposed Retention 8asin Church Lane/Lorne St, Prospect	Blacktown City Council	1988
47	Plans	Contour & Detail Survey Blacktown Creek. Myrtle St. to Lancelot St.	Blacktown City Council	1988
48	Plans	Drainage Amplification Foss St./Lorne St., Prospect to Blacktown Creek	Blacktown City Council	1988
49	Plans	Mitchell Park Working Plans	McDonald Wagner	1988
50	Plans	1:16000 Aerial Photos	QASCO	1987

NO.	TYPE	TITLE	AUTHOR	DATE
51	Plan	Cooper's Creek Flood Map	Holroyd Municipal Council	
52	Plan	Greystanes Creek Flood Map	Holroyd Municipal Council	
53	Plan	Pendle Hill Creek Flood Map	Holroyd Municipal Council	
54	Plan	Finlaysons Creek flood Map	Holroyd Municipal Council	
55	Plan	Blacktown City Council Flooding "Black Spot" Map	Blacktown City Council	
56	Plan	Baulkham Hills Shire Council Flooding "Black Spot" Map	Baulkham Hills	
57	Report	Pendle Hill Creek Trunk Drainage Study	Willing and Partners Pty Ltd	1983
58	Plan	Holroyd Municipal Council Flooding "Black Spot" Map	Holroyd Municipal Council	1990
59	Report	Meurants Lane Urban Release Drainage Study	Kinhill Engineers Pty Ltd	1989
60	Report	Brickfield Creek. SWC No.18 Belmore Park Branch Flooding Investigation	Water Board	1989
61	Plan	Proposed Improvements Pennant Hills Road to Bettington Road	Baulkham Hills	1989
62	Paper	Muirfield Golf Course Retarding Basin	Baulkham Hills	1990
63	Loose	Council Response to Trust Sept. '90	Councils	1990
64	Letter	Letter from Trust	UPRCT	1990
65	Report	Drainage Engineer's Report 10/5/89	Baulkham Hills	1989
66	Report	Drainage Engineer's Report 13/12/90	Baulkham Hills	1989
67	Report	Drainage Engineer's Report 28/4/88	Baulkham Hills	1988
68	Report	Drainage Engineer's Report 20/10/87	Baulkham Hills	1987
69	Report	Drainage Engineer's Report 22/8/89	Baulkham Hills	1989
70	Report	Darling Mills Creek Flood Mitigation Study (Stage 1)	Bewsher Consulting Pty Ltd	1990
71	Report	Trust Meeting 1/8/90	UPRCT	1990
72	Report	Trust Tour 31/8/90	UPRCT	1990
73	Report	Trust Meeting 26/10/90	UPRCT	1990
74	Survey	Drainage Problems Wentworthville Estate	Residents Group	1990
75	Report	Design to Alleviate Flooding at Lennox Bridge in Parramatta (Minimum Energy Proposal).	R Woodward	1991
76	Report	Proposed Minimum Energy Structure for Lennox Bridge at Parramatta.	C Apelt	1991
77	Report	Objection to Development Proposal for Demolition of Lennox Bridge (U Tube Proposal)	B McMullen	1991
78	Report	Statement of Environmental Effects, Proposal for Demolition and Replacement of Lennox Bridge.	RTA	1990
79	Report	Planning Report for Redevelopment, Oakes Road, Old Toongabbie.	N Nielsen	1991
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81	Report	Darling Mills Creek Stormwater Management Strategy.	Bewsher Consulting Pty Ltd	1992
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88	Plans	Pendle Hill Creek Channel Improvements.	GHD	1991
89	Plans	Pendle Hill Creek Floodway, Stages 1 & 2,	Rankine & Hill	1990
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91	Report	Duncan Park Retarding Basin Design.	UPRCT	1991
92	Report	North Rocks Road, North Parramatta Flood Study.	Bewsher	1988
93	Report	Proposed F2 Freeway, Dam/Road Embankment over Darling Mills Creek.	SMEC	1991
94	Report	Renown Road, New Bridge over Darling Mills Creek.	RTA	1991
95	Report	The Flooding of Toongabbie Creek.	C Moir/Tasg	1991
96	Report	Upper Pendle Hill Creek, Old Prospect Rd, Greystanes, Drainage Studies.	Bewsher Consulting Pty Ltd	1991
97	Report	Report on Flooding in Toongabbie Road, Toongabbie in the June 1991 Storm.	HCC Engineers	1991
98	Report	Report on Proposed Foundry Road Bridge at Seven Hills.	Dalland & Lucas For Blacktown City Council	1992
99	Report	Brickfield Creek Flood Study. Connell Wagner (Rankine & Hill)	For Parramatta City Council	1992
100	Report	Safety Study	SMEC For Trust	Oct 1991
101	Report	Flood Review Study, Wentworthville Estate, Wentworthville	Dalland And Lucas Pty Ltd For Trust	May 1992
102	Development Application	Greystanes Creek Restoration Project: Stage 1 and 2 and Supplementary Report;	SMEC And Nielsen For Trust	Feb & Mar 1993
103	Plans	Creek Works on Metella Road Branch of Greystanes Creek, downstream of Blacktown Road,	Blacktown City Council	1993
104	Report	Revision of Flood Damages Estimates for the Parramatta Area .	Environmental Management Pty Ltd	May 1993
105	Report	Clay Cliff Creek Catchment Flood Study.	Dalland & Lucas Pty Ltd For Parramatta City Council	Nov 1992
106	Report	Gooden Reserve, Baulkham Hills, Catchment Drainage Study.	SMEC For Trust	Jan 1994
107	Report	Brickfield Creek Flood Study.	Connell Wagner For Parramatta City Council	Aug 1993
108	Report	Toongabbie, Pendle Hill and Greystanes Creeks Confluence Area, Flood Mitigation Study.	Willing & Partners For Trust, Final Report	Sept 1994

NO.	TYPE	TITLE	AUTHOR	DATE
109	Meeting Agenda item	Toongabbie Confluence Area Flood Mitigation. Agenda item 3.2 in Upper Parramatta River Catchment Trust Business Papers for meeting of 24 March 1995.		
110	Report	Oakes Road Flood Mitigation Study.	Gamtron Pty Ltd For Trust	Oct 1994
111	Report	Brickfield Creek Flood Study: RAFTS-XP and EXTRAN-XP Models. Draft No 1.	Upper Parramatta River Catchment Trust	Sep 1995
112	Report	Flood Mitigation Strategy for Pendle Hill Creek Industrial Area. Job No. 1700/97	Dalland & Lucas Pty Ltd.	Nov 1997
113	Report	Bridge over Blacktown Creek, Station Road, Seven Hills. Design Report.	SMEC For Upper Parramatta River Catchment Trust	Sep 1998
114		Blacktown Creek Orana Park (North) Flood Management Options.	Webb McKeown & Associates Pty Ltd For Blacktown City Council	Dec 1999
115	Paper	Papers on Proposed Development of 8-10 Metella Road, Toongabbie on Trust files Nos. 0264904 and 035693A		Sep 2000
116	Report	Design Report for Myrtle Street to Ollier Crescent Flood Mitigation and Trunk Drainage Works (in preparation).	Blacktown City Council	2000

Source: Nos. 1 to 74 Webb, McKeown & Associates (1991b)
Nos. 75 to 116 UPRCT (2001b)

9. 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)**.
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)**.
5 year flood	A **flood** that occurs on average once every 5 years. Also known as a 20% 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 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**, **20 year flood**, **5 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**, **20 year flood**, **5 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.
design flood	A theoretical **flood** likely to occur, on average, every "x" years, eg a 100 year ARI flood is a design flood likely to occur, on average, every 100 years. see **average recurrence interval (ARI)** and **annual exceedance probability (AEP)**. The height of the design flood is called the '**design flood level**'.
designated flood	The size of **flood** selected for planning purposes. Traditionally only one 'designated flood' has been adopted for a particular locality. However, more than one 'designated flood' can be used for planning, building and development controls. Unless the designated flood is a **probable maximum flood (PMF)**, floods larger than the designated flood can occur. This term is now referred to as the **flood planning level (FPL).**

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.
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. Since May 1995, this is the new name for the Department of Water Resources (DWR), the Department of Conservation and Land Management (CALM) and flood sections of the Public Works Department (PWD). DLWC has been used in this report, except for work and/or studies carried out by these departments prior to May 1995.
DUAP	Department of Urban Affairs and Planning (NSW). Now the Department of Planning (NSW) to be referred to as **PlanningNSW**.
DWR	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.
EPA 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 (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (e.g the flood level was 7.8 mAHD). 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 level (FPL)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain risk management studies** and incorporated in **floodplain risk management plans**. Formerly called the **designated flood** or the **flood standard**. It should be noted that in the Upper Parramatta River Catchment, the Flood Risk Precincts are based on the flood level without the inclusion of freeboard.
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 identifies the **flood levels** for a range of flood sizes.
floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**.
Floodplain Risk Management Study	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 risk management measures/options', try 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 and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.

high flood hazard	For a particular size **flood**, usually at the **flood planning level**, 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. $1km^2 = 1,000,000m^2 = 100ha = 250$ acres.
Local Government Area (LGA)	The Upper Parramatta River catchment includes parts of the Baulkham Hills, Parramatta, Holroyd and Blacktown Local Government Areas (LGAs).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, usually at the **flood planning level**, 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 = 2.7m/s.
m^2	square metres. $1m^2 = 10.8$ square feet.
m^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek flows or **discharges**. It the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the *Floodplain 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.
planningNSW	Formerly the **Department of Urban Affairs and Planning (NSW)** and now the preferred name of the Department of Planning (NSW).
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 this **Floodplain Risk Management Study**.
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.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
SMEC	Snowy Mountains Engineering Corporation.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to described 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.