Parramatta City Council

Lower Parramatta River

FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

VOLUME 1 – MAIN REPORT

- Final
- August 2005

Lower Parramatta River –

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Glossary

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

Term	Description
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.

Term	Description
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.
Flood standard (or designated flood)	The 1986 Floodplain Development Manual defined it "the flood selected for planning purposes. The selection should be based on an understanding of flood behaviour and the associated flood risk. It should take into account the social, economic and ecological considerations". This term is no longer in use and 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.
DIPNR	Department of Infrastructure, Planning and Natural Resources. DIPNR drives, coordinates and streamlines land-use and transport planning, infrastructure development and natural resource management in New South Wales. DIPNR incorporates the departments previously known as **Land and Water Conservation (DLWC)** and **Planning NSW**.
DWR	Department of Water Resources. This department became a major component of the Department of Land and Water Conservation (DLWC) in May 1995.

Term	Description
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 evacuate people and transport their possessions, move farm equipment, move stock and raise furniture.
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.

Term	Description
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**.

Term	Description
Floodplain Risk Management Study	The current study. These studies are carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) 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).

Term	Description
km	kilometres. 1km = 1,000m = approximately 0.62 miles.
km^2	square kilometres. 1km^2 = 1,000,000m^2 = 100ha = approximately 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 above **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 is the rate of flow of water measured in terms of volume per unit of time.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State’s rivers and **floodplains**.

Term	Description
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	A subsequent name of the Department of Planning (NSW). Now incorporated in DIPNR.
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 the **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.

Term	Description
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to 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.

Executive Summary

Reasons for the Study

In 1999, Parramatta City Council (PCC) reviewed flood information in order to provide appropriate input to PCC's vision for the waterways of Parramatta. The review also included the methodology utilised in mapping flood inundation extents and how Council used the information to implement Council's Flood Prone Land Policy.

The principal flood study used by PCC for lands downstream of the Charles Street weir was the *"Lower Parramatta River Flood Study"*, prepared in 1986. However, the review identified that the results predicted in the 1986 study would now be subject to variability due to changes in the catchment. Consequently, Council's information relating to flooding, the assessment of development applications and the potential rezoning of land, needed to be revised.

As a result of this investigation PCC initiated the preparation of the Lower Parramatta River Floodplain Risk Management Study (FRMS), which included development of revised flood levels for the Parramatta River and its tributaries.

This report is the third stage of a five stage study and reporting process as outlined below.

Stage 1- Data Collection (Identify additional data required for the study and acquire the data)

Stage 2 – Flood Study (Define the extent of flooding using a computer model)

Stage 3 – Floodplain Risk Management Study (Using the results of Stage 2, develop options for flood management)

Stage 4 – Floodplain Risk Management Plan (In consultation with the community, develop preferred options for inclusion in the 'Plan')

Stage 5 – Implementation of the Plan (After adoption of the Plan by PCC, implement agreed elements of the Plan).

Background

The study area extends from the Charles Street Weir down the Parramatta River to Ryde Bridge and included the tributaries of Parramatta River, up to their tidal limits. The extent of the study area is shown in **Figures 2-1** and **2-2.** The study area also included the whole of Clay Cliff Creek which discharges into Parramatta River just upstream of James Ruse Drive. Within the study area there are a variety of land uses including residential, commercial, industrial and open space. There is also some remnant native vegetation along the river and creek banks.

Medium to severe flooding has occurred in the Parramatta River on average once every ten years although there has not been any significant flood since 1991.

It is estimated that within the study area, approximately 56,000 people reside. Nearly 50% of the residents speak a second language and were born overseas. Census data shows that the study area contains people from a number of ethnic origins and with a varied education level. There are also a high proportion of elderly people in some areas.

In a floodplain management strategy for an urban area, planning controls play a vital part of the overall strategy and in this area is no exception. PCC have a variety of planning instruments and associated controls to guide development in Council's area. As part of this study, these instruments have been reviewed and modifications recommended to conform to best practice in floodplain management.

Flood Impacts

As part of this study, the area inundated up to the probable maximum flood (for definition of this flood, see Glossary) has been mapped and assessed in terms of depth of flooding and velocity of water. This analysis has provided an overall hazard rating for the whole of the floodplain, see **Figures 3-3** and **3-4**. These hazard maps have been used to develop a Flood Risk Precinct Map for the study area.

Also as part of the study, an assessment was carried out to determine the likely cost of flood damage in a major flood. For the 100 year average recurrence interval flood, approximately 315 properties would be flooded above the floor level, with another 153 properties flooded below floor level. The estimated direct damages were estimated at $10.7 million. There would also be a large indirect cost related to disruption, accommodation, provision of services etc.

Consultation

This study has been managed by PCC and a Floodplain Management Committee consisting of representatives of the public, government agencies and special interest groups. The Committee has met a total of eight times during the course of the study.

There have also been two community meetings to explain the study process and seek feedback from the community. This was supplemented by two questionnaires which sought the views of the community. There has also been a number of 'Fact Sheets' and posters prepared to advise residents of critical stages of the process.

Flood Modification Measures

In a densely developed catchment such as Parramatta, there is little opportunity for construction of major works, such as levees, dams or flood diversions to reduce the impact of flooding.

However, in the Clay Cliff Creek catchment where the flood impacts are quite severe, there are a number of structural options to reduce flooding. This report recommends the construction of a low, simple detention basin in Ollie Webb Park and consideration given to a flood channel to take water from Clay Cliff Creek downstream of Harris Street and discharge it into Parramatta River near the Gas Works Bridge. The benefit of this work would be a reduced level and risk of flooding for residents in the floodplain.

Other structural measures that have been recommended include regular maintenance of the creeks feeding into Parramatta River to ensure that the flood capacity of the creeks is maintained. It is recommended that PCC would continue to adopt the On-Site Detention Policy of the Upper Parramatta River Catchment Trust.

Property Modifications

A major initiative of this report has been the development of the Planning Matrix Approach. For outline details see **Section 7** of this Volume and for a more detailed description, see **Volume 2**. Using this approach, a matrix of development controls, based on the flood hazard and the land use, has been developed which balances the risk exposure across the floodplain. The resulting matrix of planning controls has been pivotal in the new draft planning instruments recommended for implementation as part of this report. The two critical elements of this approach are the Flood Risk Precinct Maps which are shown in **Figures 7-3** and **7-4** and the Planning Matrix which is shown in **Figure 7-5.**

Volume 2 of this report outlines the changes needed to Council's planning instruments to allow implementation of the Planning Matrix approach and to provide a consistent planning framework. This also includes changes to the Section 149 Certificates to identify areas that are floodprone up to the Probable Maximum Flood extent.

An important part of land use planning is to define the land where it is undesirable to build. PCC have already developed a Foreshore Building Alignment in order to preserve, primarily the scenic qualities of the river. In conjunction with PCC the consultant has now extended this concept to exclude the high flood risk areas and native vegetation, including a buffer zone. This has resulted in revised Foreshore Building Alignment Maps shown in **Figures 7-6** and **7-7**.

PCC already has a Voluntary House Purchase (VHP) Scheme for severely floodprone houses in the Wentworthville area and in this report, it is recommended that the program be extended to some of the most floodprone areas particularly around Oak and Alfred Streets. Given the large cost of VHP, it is recommended that PCC consider Voluntary House Raising (VHR) which is far cheaper than purchasing houses. A total of 31 houses have been identified as being suitable for VHR.

Response Modification Measures

The third type of flood management option is to improve the knowledge of flood levels and the impact of flooding within the community. It has been shown that residents can reduce the cost of flood damage and the risk to life if they are aware of the risk and the measures that can be taken to minimize this risk.

This report recommends that the State Emergency Service be asked to prepare a Flood Plan in conjunction with PCC to provide the framework for an integrated dissemination of information on flooding in the study area.

Options for Flood Risk Management Plan

Flood management options for consideration by Council and the Community in Stage 4 of the Floodplain Management Program, are summarized in **Section 9** and are based on the recommended works detailed in this report and outlined above.

1. Introduction

The need and objectives for this study is identified in Parramatta City Councils policy document titled 'Rivers of Opportunity'. Council's vision for the waterways in Parramatta, is that they need to be safe, clean and environmentally diverse – 'a place where we want to live'.

Within this policy document are a number of strategies aimed at delivering Council's vision. The strategy particularly relevant to this study is Strategy 3 which is to 'develop and implement actions to reduce the impact of mainstream flooding, protect life and property as well as enhancing riverine ecosystems.'

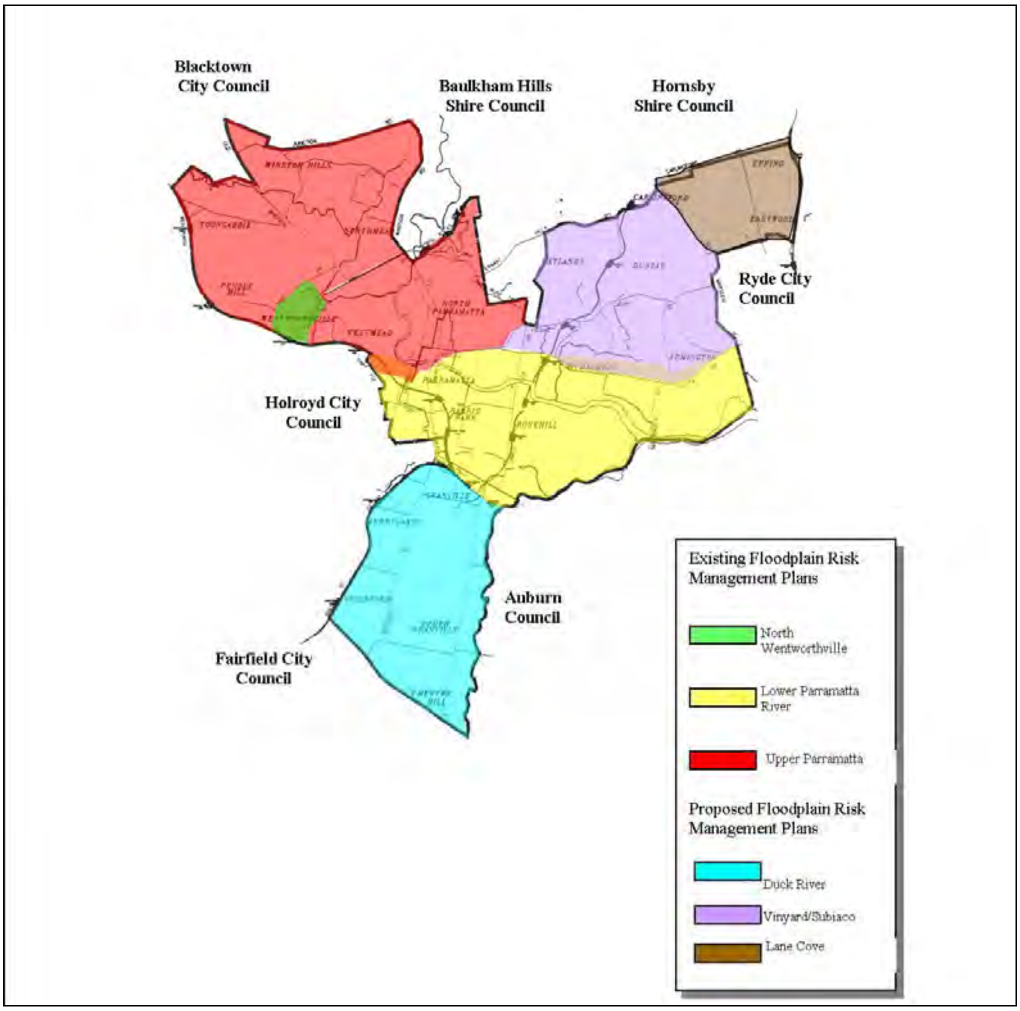
This study therefore focuses on aspects of flooding in Lower Parramatta River which can provide an outcome that supports Council Strategy and vision for the waterways.

1.1 Parramatta River – Context of this Study

The Upper Parramatta River catchment rises on the eastern side of Prospect reservoir and includes parts of Blacktown, Holroyd, Baulkham Hills and Parramatta Local Government Areas (LGA). **See Figure 1-1**. The major tributaries include Blacktown Creek, Toongabbie Creek and Darling Mills Creek. This catchment is known as the Upper Parramatta River catchment and activities relating to the waterways are co-ordinated on behalf of the four Councils by the Upper Parramatta River Catchment Trust (UPRCT). The eastern boundary of the Upper Parramatta River is the Charles Street Weir in the Central Business District (CBD) of Parramatta.

Lower Parramatta River commences at the Charles Street Weir and extends eastwards to about the suburb of Birchgrove where the river joins Lane Cove River and becomes Port Jackson. However for the purposes of this study, the eastern extent of the study area is Ryde Bridge. As the Parramatta River flows eastwards, a number of creeks join the river including Clay Cliff Creek, Vineyard Creek, Subiaco Creek, Duck River, Haslams Creek and Powells Creek. These creeks are in the LGAs of Parramatta, Auburn, Strathfield and Ryde.

■ **Figure 1-1 Map of Catchment Areas**



1.2 Reasons for This Study

In March 1999 Parramatta City Council (PCC) undertook a review of flood information held by Council and the methodology utilised in mapping flood inundation extents. Council also reviewed the way in which flood information is utilised while implementing Council's existing Flood Prone Land Policy. The review focussed on those parts of the Parramatta River and its tributaries that lie downstream of the Charles Street weir.

The principal flood study used in Council's flood inundation extents mapping and for the application of its relevant policy referred to above, for lands downstream of the Charles Street weir is the *"Lower Parramatta River Flood Study"*. This document was prepared in 1986 by Willing and Partners for the NSW Public Works Department. Numerous other flood studies for the major tributaries rely on the results of the 1986 study.

The PCC review identified that the results predicted in the 1986 study would now be subject to variability due to changes in the catchment (such as urbanisation, flood mitigation in the upper catchment areas of the Parramatta River, etc). This would have led to changes in a range of significant hydrologic and hydraulic elements utilised in the 1986 flood modelling processes. Because of the issues identified, Council's information relating to flooding used for S149(2) and (5) certificates, the assessment of development applications and the potential rezoning of land, needed to be revised.

It was also recognised that the existing flood extents mapping was based on the best information available to staff, but was of varying levels of reliability and that Council's mapping reflected predicted inundation *(ie flood depths only*). Modern Floodplain Management requires a floodplain to be assessed and mapped in terms of flood risk which is a function of flow depth, flow velocity and other factors such as evacuation routes.

As a result of this investigation PCC initiated the preparation of the Lower Parramatta River Floodplain Risk Management Study (FRMS), that included a complete review of existing flood studies for the Parramatta River and its tributaries.

1.3 Stages for Flood Study

Parramatta City Council (PCC) commissioned Sinclair Knight Merz (SKM) in October 2001 to undertake a study entitled "Lower Parramatta River Floodplain Risk Management Study" (LPR-FRMS). The overall study encompassed the first three stages of the five stages in the process set out by the NSW Government's Floodplain Development Manual (FDM) (2005), shown in **Table 1-1**. This report, the Flood Risk Management Study completes the third stage of the process.

- **Table 1-1: Stages of Flood Study**

Stage	Study Stage	Scope of Work
1	Data Collection	Compile existing data and collection of additional data
2	Flood Study	Define the nature and extent of flooding using a hydraulic computer model. Calibrate model. Understand the nature and extent of flooding within the floodplain environment.
3	Floodplain Risk Management Study (FRMS)	Evaluates management options for management of the floodplain as well as addressing both existing and future development. Consider property, response and flood modification measures
4	Floodplain Risk Management Plan (FRMP)	In consultation with the community, develop preferred options for management of the floodplain for the benefit of all users and the environment. Strategies designed to support the natural functions of the floodplain whilst reducing the impact of flooding and flood liability

		on users and occupiers.
5	Implementation of the Plan	After adoption of the Plan by Council, develop an implementation plan to implement the agreed elements of the Plan

Outlined below are some details of the work undertaken and the reports prepared leading up to this report.

1.4 Summary of Reports Prepared

To-date the following reports have been prepared to provide background and supplementary information. The information also was used as input to this report, the Lower Parramatta River Flood Risk Management Study.

1.4.1 Flood Study Review, 2002

As a component of the *(LPR-FRMS)* the consultant carried out a review of existing flood studies for the Parramatta River and its tributaries and developed a priority list for implementing revised Flood Studies and Floodplain Risk Management Plans within Parramatta LGA. The review recommended that flood studies be undertaken for the following rivers and creeks in the Lower Paramatta River Study area.

- Lower Parramatta River*;
- Clay Cliff Creek*;
- Vineyard Creek;
- Subiaco Creek;
- Duck River;
- Duck Creek;
- A'Becketts Creek.

*Being undertaken as part of this study.

A number of the recommended studies are currently being undertaken.

1.4.2 Data Compilation Report, 2002

Existing and required data was assessed and summarised in a report which formed the basis for using and acquiring the data used in this study.

Data for this study was available from a number of sources and additional data was obtained where required. A summary of the data sources is included below. For more detailed description see the Flood Study Review, 2005.

Topographic Data

Topographic data was available from the following sources:

- An Airborne Laser Survey (ALS) was available for the whole of the study area with levels accurate to 0.01 metres and with 200 mm locational accuracy,
- Bathymetric soundings were available from the Waterways Authority covering most of Parramatta River,
- Additional survey of approximately 70 cross-sections was commissioned for waterways where data was required for the computer modelling,
- Some details of road and railway bridges in the study area were obtained from the Roads and Traffic Authority (RTA) and State Rail Authority (SRA) respectively,
- Cross section data for some creeks was available from previous studies.

Tide Level Data

PCC commissioned Sydney Ports Corporation to monitor tide level data for the period from 8 March 2002 to 10 April 2002 to provide additional data on tide movement.

Flood Levels

Historical flood levels were obtained from Parramatta Council, Department of Infrastructure of Planning and Natural Resources (DIPNR), previous reports and from community consultation.

Vegetation Assessment

It was determined that there was insufficient information about native fauna and flora and in particular riparian vegetation within the study area and so a separate study was undertaken to obtain the required base data.

Heritage Assessment

A small study was undertaken to assess the heritage value of sites within the study area.

1.4.3 Vegetation Assessment, February 2003

As discussed above there was a need to identify native fauna and flora and a Vegetation Assessment Report was prepared. This report also included a GIS map layer which identifies the location of significant vegetation which will be considered in conjunction with proposed land uses within the study area. A matrix of buffer zone widths for different landuses and vegetation was prepared which will provide guidance for planners and developers.

1.4.4 Fact Sheets and Poster

Several Fact Sheets and a Poster were prepared to provide details of aspects of the project for the community. These Fact Sheets were available in the Council Offices.

1.4.5 Development within Study Area

The RTA decided to provide a cycleway adjacent to the F3 freeway which could have impacted on flood levels and a small supplementary report was prepared. Similarly some changes on the floodplain in the vicinity of Charles Street required additional modelling and a supplementary report to be provided to PCC.

1.4.6 Flood Study Review, 2005

A revised and updated Flood Study was undertaken as Stage 2 of the LPR-FRMS. This report reviewed previous studies and developed additional hydrological models where necessary.

A detailed MIKE 11 hydraulic computer model was set up to represent the Lower Parramatta River. The model included over 600 cross sections and included a detailed model of the Clay Cliff Creek waterway system.

The model was calibrated against known tidal data and as far as possible against historical flood data. The model was run for five different flood events, these being the 20%, 5%, 2%, 1% average exceedance probability (AEP) and the Probable Maximum Flood (PMF).

The results of the modelling is presented in Lower Parramatta River Floodplain Risk management Study - Flood Study Review, 2005.

During the course of this study, further information on flooding in Duck Creek became available and the report was amended to incorporate this data. Flood levels were reassessed, some additional information was included about historical flooding and the effects of some new development within Parramatta CBD was also included in the updated report. This report completes Stage 2 of the stages outlined in **Table 1-1**.

2. Background

2.1 Parramatta River Catchment Area

The section of river in the study area is called the Lower Parramatta River and is located within the broader catchment area of Sydney Harbour. The Study Area comprises the waterways, tributaries, foreshores and adjacent low lying lands of the Lower Parramatta River from the Charles Street Weir to Ryde Bridge and includes the tributaries up to their tidal limits.

The catchment is highly urbanised with some development extending into the floodplain and consequently some development within the study area is prone to flooding with potentially high hazard and damage.

Within the broad Study Area the *LPR-FRMS* concentrates on the following areas:

- Lower Parramatta River from the Charles Street weir to Ryde Bridge;
- The entire drainage system associated with Clay Cliff Creek
- Vineyard Creek to estuarine limit;
- Subiaco Creek to estuarine limit;
- A'Becketts Creek to estuarine limit;
- Duck Creek to estuarine limit;
- Duck River to estuarine limit; and
- Other trunk drainage mains that outfall to the Lower Parramatta River or its tributaries between Charles St weir and Ryde Bridge.

The study area is shown in **Figure 2-1** and the major creeks are shown in **Figure 2-2**.

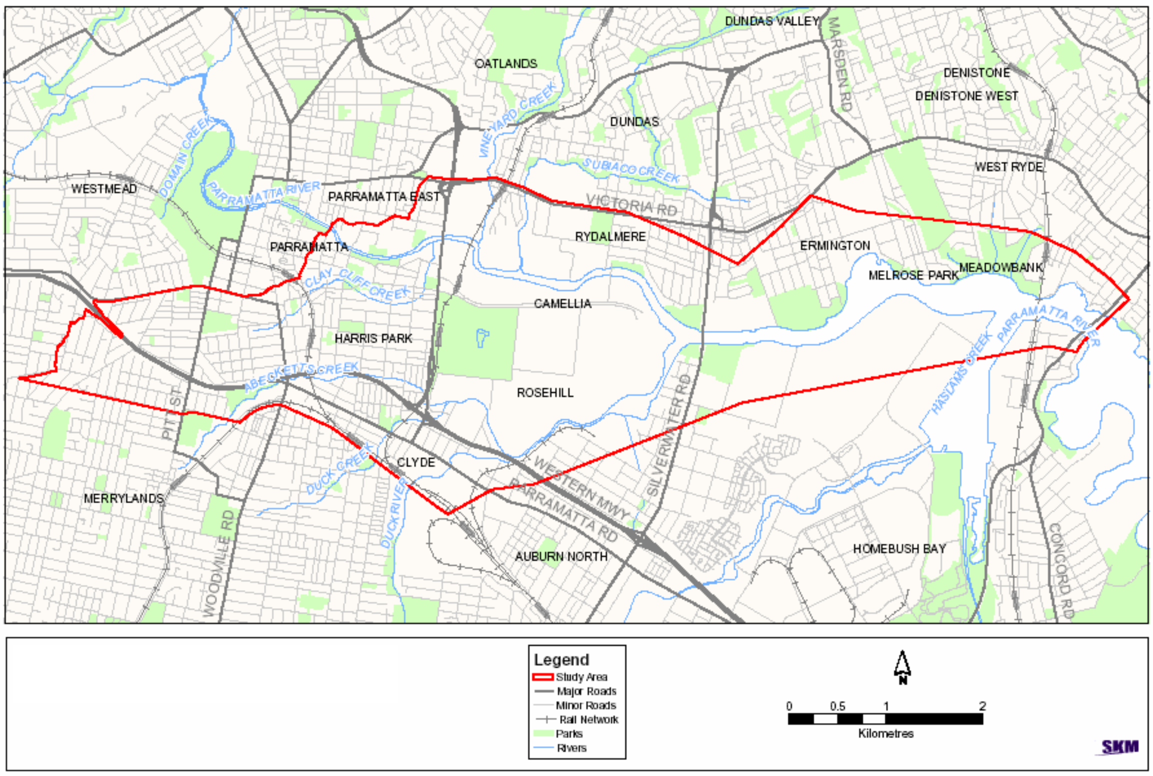
The total catchment area upstream of Ryde Bridge is 212 square kilometres. The catchment area divides into two sections. The Upper Parramatta River catchment area of 108 square kilometres extends from Baulkham Hills to Charles Street Weir and includes Toongabbie and Darling Mills Creek, which joins 3 kilometres upstream of Parramatta and forms the start of the Parramatta River. In 1998, a major detention basin was constructed on Darling Mills Creek in order to reduce the peak floods in Parramatta.

The lower section of the catchment starts at Charles Street Weir and includes Duck Creek, Duck River and Haslams Creek catchments on the south side and Vineyard and Subiaco Creeks on the north side.

SKM

- **Figure 2-1: Lower Parramatta River Study Area**

- **Figure 2-2: Major Rivers and Creeks in the Study Area**



2.2 Climate

The study area is relative low lying and lies close to the coast. Consequently the climate is quite mild with an average summer day time temperature of 27^0 C and a night temperature of 12^0C. The winter temperature ranges from an average of 12^0C during the day to a low of 1^0C at night.

The average annual rainfall for Parramatta is about 1 200 mm with the average lowest rainfall occurring in July with 46 mm for the month. The wettest month on average is February with 120 mm of rain.

2.3 Flooding

Historical flooding has occurred in 1898, 1914, 1956, 1961, 1967, 1969, 1974, 1975 (Willings 1986). Since that report (Willings 1986) there has been major flooding in 1986, 1988, 1990 and 1991.

Flood level data for these floods is very limited, perhaps due to the relatively few houses and businesses that directly access the river or because the flood rise and fall is too rapid to be recorded effectively.

Set out in Appendix D of the Flood Study Report is a list of flood data that has been extracted from a number of flood studies and flood reports. The source of the data is also shown. It was difficult to calibrate the model to historical flood levels due to one or more of the following reasons:

- Not sufficient recorded levels and rainfall data from past floods;
- Changes to the catchment resulting in increased flood discharges (such as increased impervious areas);
- Provision of storages such as Darling Mills Retarding Basin and other flood retarding basins within the Upper Parramatta River Catchment; and
- The combination of a major flood event in tributary catchments together with an Upper Parramatta River flood is capable of triggering a major flood in Lower Parramatta River. However, adequate data is not available to verify the mechanism of major flooding in Lower Parramatta River.

2.4 Land Use

The catchment area of the Lower Parramatta River is essentially a fully developed urban environment. The majority of the catchment is residential with significant areas of retail and commercial centred on Parramatta CBD. East of James Ruse Drive, there are significant areas on the floodplain where the land use is recreational, such as Rosehill Garden Racecourse or parkland such as Riverside Park and the new Millennium Park close to the Olympic site.

There are also large areas of commercial and industrial land on both sides of Parramatta River between James Ruse Drive and Silverwater Road. Further commercial properties lie along Parramatta Road.

2.5 Heritage

Details of Heritage sites, both indigenous and non-indigenous, were obtained from a variety of sources including:

- National Parks and Wildlife Service – Site Register
- Australian Heritage Commission
- National Native Title Register
- National Parks and Wildlife Service - Heritage Council and Trust Register
- LEP Heritage Schedules
- S170 Schedules for Public Utilities
- REP Schedule

The issue of heritage is of significance in regard to the forming and understanding of the social and cultural context of the floodplain and to ensure that any flood mitigation measures do not impact upon the heritage of the study area. PCC’s LEP provides listings of heritage items, as does the Parramatta Regional Environmental Plan.

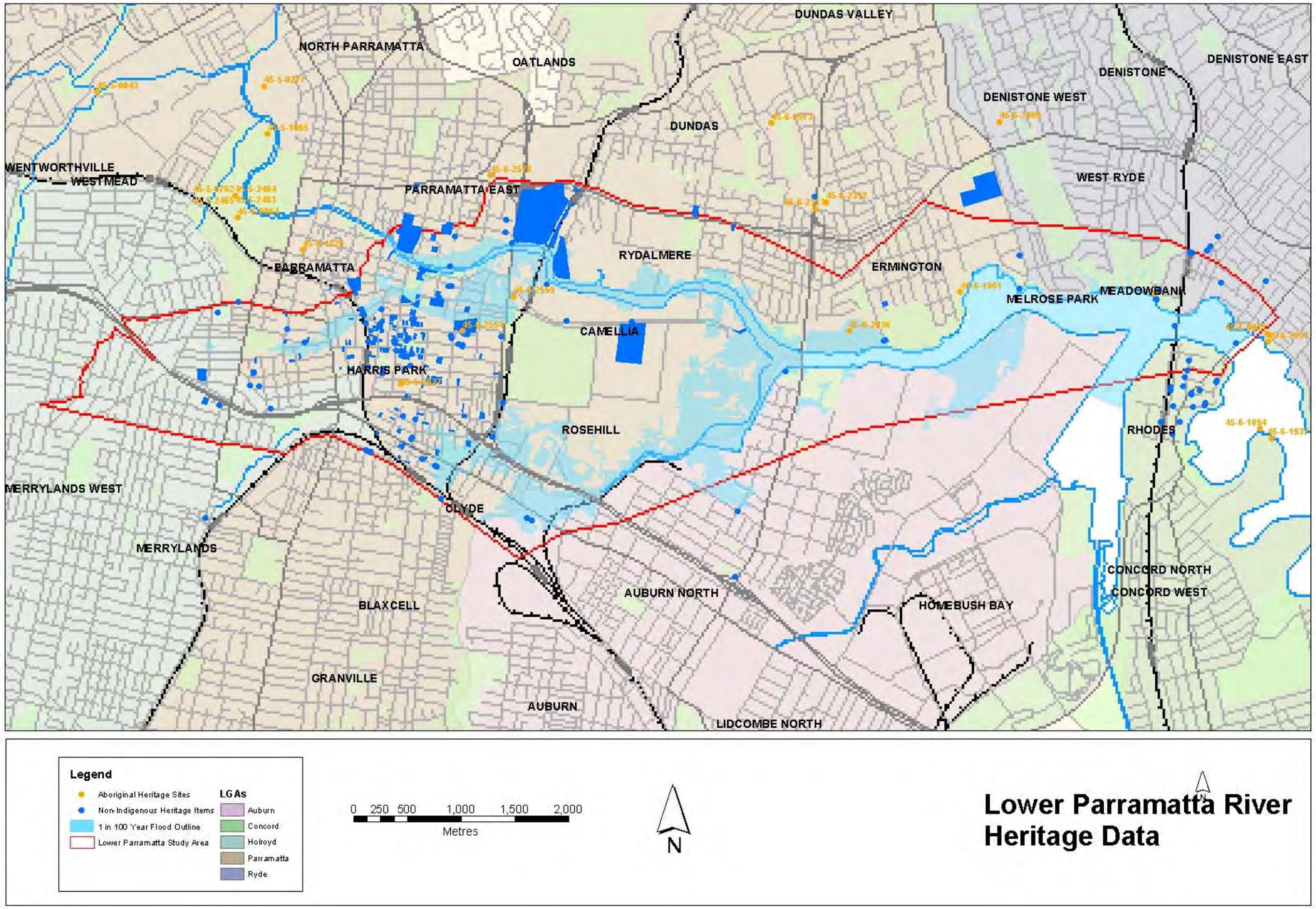
Parts of the river and creek system retains potential Aboriginal archaeological relics and sites. There remains evidence today of Aboriginal occupation within the boundaries of Lake Parramatta Reserve in the form of remnant shelters, hand stencils, flaking scars and deposits.

Each of the sites identified was given a unique ID number and spatially mapped. The location of the sites are shown in **Figure 2-3**. A knowledge of the location of each site is important when considering land uses, changes to zonings and if any proposed works are planned in the areas. The heritage GIS layer can also be superimposed over other GIS maps such as Flood Risk Precincts, land zoning, depth of inundation etc.

Some of these sites are in areas where the floodwaters in a 100 year ARI flood is quite deep and there is a possibility of damage to the site. In the section on recommendations, the most ‘at-risk sites’ have been identified and it is recommended that an assessment is undertaken of each of these sites to determine if specific flood management measures should be undertaken.

SKM

- **Figure 2-3 Heritage Areas within the Project Area**



2.6 Ecology of the Study Area

Summarised below are details of the remnant vegetation within the project area. Further details can be found in a separate report titled 'Vegetation Assessment', 2003. It was important to identify the remnant vegetation in the study area to provide base data on which to assess the practicality of providing planning controls, such as a buffer zone to protect important areas of vegetation.

2.6.1 Historical Vegetation in the Study Area

Based on previous studies and reports of the study area undertaken in the recent past (approximately 20 years), there appears to be similar remnant vegetation types as are presently represented. Although community distribution and remnant size are somewhat different, generally the areas of Mangroves are larger and all other natural vegetation types are much reduced.

Prior to the European settlement, the study area is likely to have contained over 10 broad vegetation types. These vegetation types are based on an extrapolation of the presence of the existing remnants and what has been indicated in past. Prior to European disturbances, such as agriculture, logging, housing and urban development, the following broad vegetation types were likely to have occurred and dominated the locality:

- Mangrove Forest;
- Saltmarsh;
- Casuarina Forest (Riparian);
- Riparian Forest (Cabbage Gum / Forest Red Gum)
- Rainforest Areas;
- Dry Eucalypt Woodland / Open Forest (several associations);
- Moist Eucalypt Open Forest (several associations);
- Swamp Forest;
- Sedgelands and freshwater Swamps;
- Low Closed Forest (Paperbark); and
- Extensive areas of native Grassland.

Previous studies suggest that at the turn of the century, the section of Parramatta River in the area downstream of the current Church Street Bridge comprised Grey Box and Forest Red Gum (Cumberland Plain Woodland), of which some individuals are still present in Parramatta Park. They also infer that some areas of Grey Mangrove would have been present downstream of the same area. Large areas of the Turpentine Ironbark Forest were present, in particular the south Parramatta area and eastward along Parramatta Road. They also indicate that large stands of Blackbutt forest and Blue Gum High Forest were present on sandstone areas to the north of the river in the Rydalmere to Meadowbank localities. The Auburn section of the text indicates that large areas of mud flats, saltmarsh and some areas of Mangroves were well represented, although the areas of saltmarsh are much more extensive than at present. Also, in the late 1800's, it is estimated that areas in the vicinity of Rhodes in the Uhrs Point area there were Eucalypt forests on Hawkesbury Sandstone, Turpentine Ironbark Forest in the areas with a shale influence and large sections of Mangroves, which extend into Homebush Bay.

The Department of Environment and Planning (1986) indicate from a study into the Parramatta River Regional Environmental Study that extensive areas of mangroves are present along Parramatta River from the Charles Street Weir to Meadowbank. These mangroves are of varying quality, height and density and appear to be expanding into areas which previously were saltmarsh and along areas of seawall where sediment has collected. A similar situation is present for the Duck River area. Reductions in the amount of saltmarsh were evident from the findings of this study. With the most extensive areas located in the Duck River area, on both the eastern and western banks. Eucalypt Woodland and forested habitat is present in the area but in small stands, no extensive areas are present. The report also provides anecdotal information that corresponds to the location of stands of mangroves and the areas of reclaimed land.

2.6.2 Current Extent and Condition of Riparian Vegetation

The overall quality of the riparian vegetation of the study area was generally poor with the exception of most areas of mangrove forest, although small remnant stands and regrowth were present. **Table 2-1** indicates the condition of the riparian vegetation along the watercourses, which at a minimum contain scattered elements of the original vegetation.

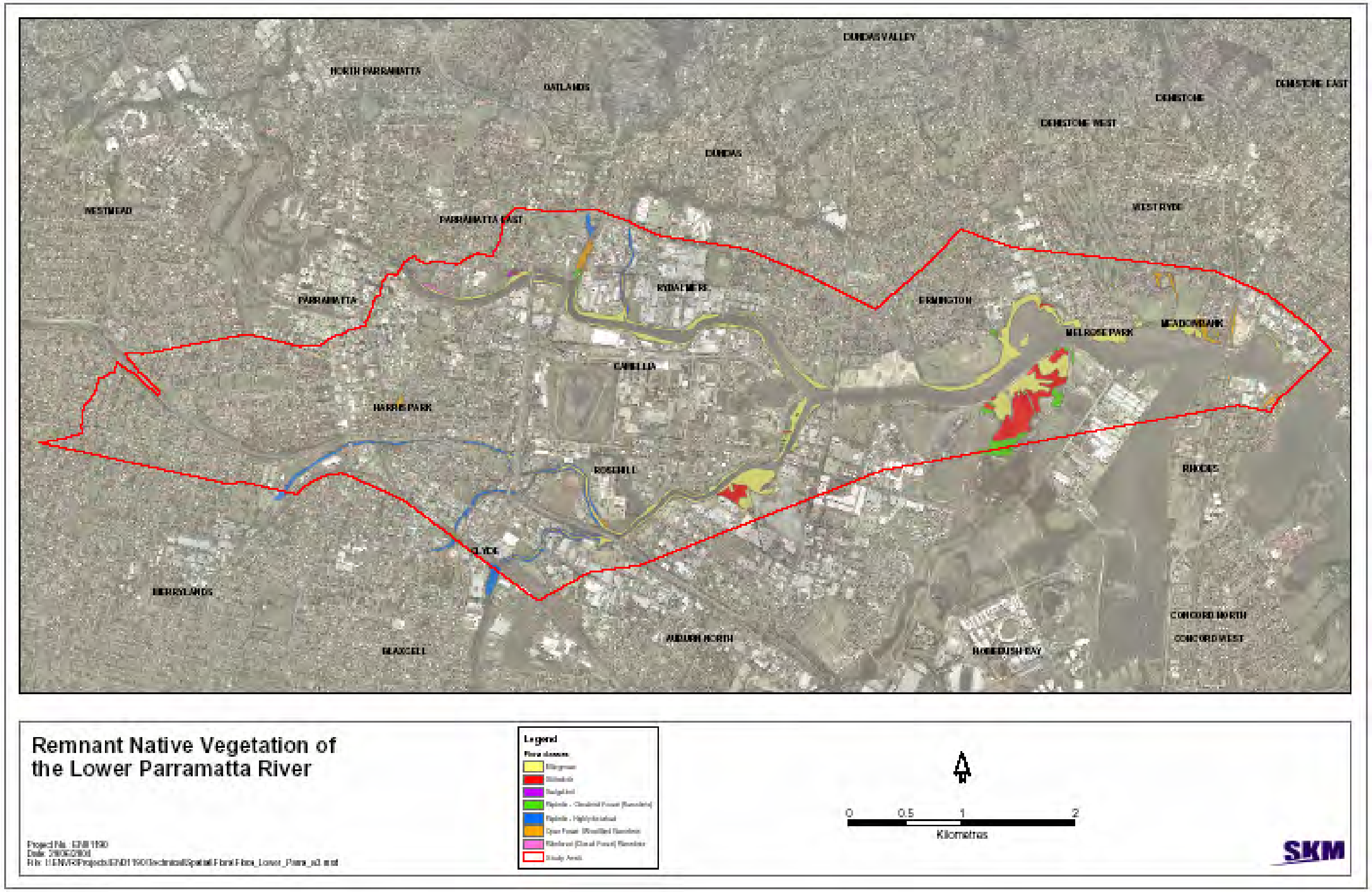
Figure 2-4 shows the extent of existing native vegetation within the riparian zones in the study area.

- **Table 2-1: Summary of the Vegetation within the Riparian Zones**

Watercourse	Vegetation Condition
Parramatta River	▪ Overall the vegetation comprised numerous large and small stands of Mangrove vegetation, dominated by the Grey Mangrove, although small stands and isolated individuals of River Mangrove were evident. Width 1 – 50m. ▪ Small pockets of saltmarsh in the areas behind the mangrove vegetation were in a poor condition. Ranging in size from $1m^2$ to $40\ m^2$ ▪ Small stands and individuals of Swamp Oak were also evident, generally this community type was extremely fragmented and often not obvious. ▪ Areas of riparian / floodplain forest containing Cabbage Gum and Rough-barked Apple were present, but again in a highly fragmented state and invaded by numerous weeds. ▪ Similarly, were small areas of poor quality vegetation containing

Watercourse	Vegetation Condition
	rainforest elements.
Duck River	▪ The vast majority of the vegetation comprised of areas of dense mangrove forest. Dominated primarily Grey Mangrove with small areas of River Mangrove. Community width was in the vicinity of 10 – 30m and fairly constant along the length of Duck River until the constructed weir near the rail bridge. ▪ A moderately large area of high quality saltmarsh was present, containing several significant flora species. Located in the vicinity of Derby Street, Silverwater. ▪ Scattered remnant species, which are representative of the original riparian vegetation are evident, although often intermixed with numerous introduced species (ie mature canopy tree species). ▪ Small intact sections of sedgeland in the vicinity of the junction of the Duck Creek are apparent.
Vineyard Creek	▪ The area contains a small section of mangrove forest in the vicinity of Vineyard Creek and Parramatta River confluence. The stand is intact although small in size. ▪ Additional to the mangrove area are small sections of relatively intact riparian woodland vegetation. The Eucalypt dominated vegetation is in a degraded and weed invaded condition although many of the original vegetative elements are apparent. ▪ This woodland area has had some restoration work undertaken and would appear to have potential for further rehabilitation works.
Subiaco Creek	▪ Beyond the small stand of Grey Mangroves in the vicinity of the junction with Parramatta River, the vegetation is of very poor quality with only a few scattered remnant trees / shrubs present. The majority comprises introduced weed species.
Duck Creek / A'Becketts Creek	▪ Stands of mangroves in the tidal zone, which are of a high quality and a width of 15 – 25m. Mangroves appear to be of an age and size representative to their relative position along the watercourse, ie young trees and seedlings are present in areas of new sediment, larger trees in original / older sediments. ▪ Beyond the area of mangroves further up-stream few if any native remnant species are represented. Areas of replanting have been initiated.
Archer Creek	▪ Primarily a constructed drainage-line containing a small stand of original Swamp Oak Forest. ▪ Additionally, remnant trees and scattered stands of riparian forest / woodland are present, with representative species including Sydney Blue Gum and Turpentine.

■ **Figure 2-4 Native Vegetation in the Lower Parramatta River Study Area**



All other watercourses are of constructed drainage lines, almost completely devoid of representative vegetation and at best contain isolated scattered remnant trees.

The majority of watercourses in the study area have been highly modified and all show evidence of major disturbance, particularly fill. Additionally, several original watercourse alignments have been removed and concrete channels have been constructed, in effect producing a drainage channel and removing the qualities of a natural watercourse. Also the vegetation of creek-lines is limited as the adjacent areas are often comprised of dwellings, factories and infrastructure. With modifications such as these across the study area, in addition to the large amounts of weed invasion and rubbish present, it is apparent that little intact native remnant vegetation would remain.

2.6.3 Buffer Zones

Native vegetation is susceptible to degradation from human settlement. The degree of degradation is, in part, a function of the type of development and the proximity of the development to the particular type of vegetation. In **Table 2-2** details can be found of the appropriate minimum buffer zones that should be allowed from the edge of significant native vegetation. Column 2 of **Table 2-2** shows the adopted width of buffer zones used for each vegetation types to ensure that sufficient width is provided from development. See **Section 7.2** for further details of the process of integrating the buffer zones with Foreshore Building Alignment.

2.6.4 Fauna Species

Overall, the number of species recorded in the study area is relatively high, considering the survey was only comprised of opportunistic sightings within native vegetation remnants of a small size and of poor quality. In all a total of 30 fauna species were recorded within the study area. Comprising two (2) mammals, four (4) reptiles, one (1) frog and twenty-three (23) avian species. Of the total, three (3) avian species present were regarded as introduced.

No threatened fauna species were identified from the site, although one species, the White-bellied Sea Eagle, is regarded as significant in the locality. One specimen was located in the vicinity of Melrose Park on the northern side of the Parramatta River. A list of all fauna species recorded in the study area is presented in the **Vegetation Report** prepared by SKM in 2003 for PCC.

Table 2-2 Table of indicative minimum buffer widths (metres)

Vegetation Type	Adopted Buffer Width	Single Resi-dential Developme nt	Medium Density, Town House, Villas	Multi-storey Units	Private Open Space/park etc	Public Open Space	Road Reserve	Commercial	Industrial
Rainforest	20	20 - 25	20 - 30	20 - 30	10	10	10 - 15	20 - 30	30
Swamp Oak	10	10	10	10	5 - 10	5	5 - 10	10 - 15	10 - 15
Disturbed Riparian Vegetation	15	10 - 15	15 - 20	15 - 20	10 - 15	10	10 - 15	20 - 30	30
Open Forest/Woodland	10	10	10 - 20	10 - 20	5 - 10	5 - 10	10	20	20
Mangroves	25	20	25 - 30	25 - 30	20	15	25	30	30 - 50
Sedgeland	30	20 - 30	30 - 40	30 – 40	20	15 – 20	20 - 30	30 - 50	50
Saltmarsh	30	20 - 30	30	30	20	15 - 20	20 - 30	30 - 50	50

Note: buffer widths are regarded as estimates and as a minimum. Site specific assessments will be necessary

Vegetation that is considered of significance and or is very susceptible to changes in conditions (ie Saltmarsh and areas of intact Sedgeland) will need to have the largest and most efficient buffers. Since the completion of the original report, Saltmarsh vegetation in the NSW North Coast, Sydney Basin and South East Corner bioregions, has been preliminarily listed by the NSW Scientific Community as an Endangered Ecological Community (EEC) under the Threatened Species Conservation Act 1995.

2.7 Water Quality

Water quality in the Parramatta River has been evaluated in the document *Proposed Interim Environmental Objectives for NSW Waters – Coastal Rivers* (NSW Environment Protection Authority, 1997). This document reports on the existing water quality at four sites within the study area:

- Parramatta River at Charles Street weir;
- Parramatta River, just downstream of the confluence with Duck River;
- Homebush Bay; and
- Parramatta River, in the vicinity of Ryde Bridge.

Water quality was assessed at these sites against a number of environmental values. Results are summarised in **Table 2-3**.

- **Table 2-3: Water quality in the Lower Parramatta River**

Sites	Proportion of time (%) water quality criteria for the following environmental values are met			
	Protection of Aquatic Ecosystems	Primary Contact Recreation	Secondary Contact Recreation	Human Consumption of fish, crustaceans and shellfish
Charles Street Weir	<25%	50-75%	>75%	<25%
Duck River Confluence	<25%	50-75%	>75%	<25%
Homebush Bay	<25%	50-75%	>75%	25-50%
Ryde Bridge	<25%	>75%	>75%	25-50%

The water quality in the Lower Parramatta River is rarely suitable for protection of aquatic ecosystems and is often unsuitable for human consumption of fish, crustaceans and shellfish. The water quality is usually suitable for secondary contact recreation and often suitable for primary contact recreation. It can be seen in **Table 2-3** that the water quality tends to improve at the downstream end of the Parramatta River. This trend continues into Sydney Harbour.

The document *Water Quality and River Flow Interim Environmental Objectives – Sydney Harbour and Parramatta River Catchment* (NSW Environment Protection Authority, 1999) reviews the environmental values assessed in the 1997 report and sets objectives for water quality in the Parramatta River. Within the study area, the following water quality objectives apply:

- Protection of aquatic ecosystems;
- Visual amenity;
- Secondary contact recreation;
- Primary contact recreation (to be achieved in the long-term); and
- Human consumption of aquatic foods (cooked) (to be achieved in the long-term).

In addition, the following river flow objectives apply:

- Maintain wetland and floodplain inundation;
- Manage groundwater for ecosystems;
- Minimise effects of weirs and other structures; and
- Maintain or rehabilitate estuarine processes and habitats.

2.8 Social Characteristics

The demography of those living within the study area was examined using the 2002 Census Data broken down into the Census Collection Districts (CCD) which are the smallest areas available for information.

The study area used for the assessment is the same as shown in **Figure 2-1**. This area is divided into 95 CCDs covering approximately 39 square kilometres. In this area 56,000 people reside. Approximately 10,000 are under 15 years old, 40,000 are in the 15 to 65 age bracket and 6,000 are over 65 years old. Nearly 50% of the residents (24,000) speak a second language and were born overseas.

The population density in each of the 95 CCDs varies from a low of about 1 or 2 persons per hectare in commercial and industrial areas to a maximum of 265 persons per hectare for the unit area lying between Great Western Highway and Campbell Street.

The CCD census data shows that the study area contains a mix of people from a number of ethnic origins and with a varied education level. There is also a high proportion of elderly people in some areas. It will therefore be important when any information is provided to the community that the sociological mix of the population is understood and the messages formulated in a form that they can assimilate.

2.9 Existing Planning and Development Controls

2.9.1 Introduction

This section of the report outlines various forms of planning instruments and associated controls which apply to the study area and may have potential for use for the purposes of implementing planning controls to guide future development within the study area. See **Volume 2** of the **Floodplain Risk Management Report** for further details.

2.9.2 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared by PlanningNSW which deals with matters of significance for environmental planning for the State.

State Environmental Planning Policy - Seniors Living 2004 replaced SEPP 5 in May 2004 and applies to urban land or land adjoining urban land where dwellings, hospitals and similar uses are permissible. Seniors Living SEPP would apply to the majority of the study area, and would effectively override Council's planning controls to permit residential development for older and disabled persons to a scale permitted by the SEPP. However this policy does not allow development in areas identified as "floodways" or "high flooding hazard."

2.9.3 Regional Environmental Plans (REPs)

A Regional Environmental Plan (REP) is prepared by PlanningNSW and provides objectives and controls for environmental planning for a region, or part of a region and normally refers to more than one LGA.

The study area is affected by the following two REPs:

- Sydney Regional Environmental Plan No. 22 – Parramatta River 1998
- Sydney Regional Environmental Plan No. 28 – Parramatta 1999

Sydney REP No. 28 is of particular relevance to the FRMS and FRMP as it contains a number of planning controls which relate to addressing flood risk. Accordingly, this REP has recently been reviewed by the consultants on behalf of the Upper Parramatta River Catchment Trust, Parramatta City Council and PlanningNSW.

This review has resulted in recommendations for amendments to the REP, to provide for changes to definitions and objectives to ensure consistency with the approach recommended at the conclusion of this report. The recommended changes are detailed in **Volume 2.**

2.9.4 Advisory Circulars

DIPNR is responsible for providing advice to local councils to ensure that best practice is maintained in the planning process. A Planning and Environment Commission (PEC) Circular was issued in 1977 advocating prescriptive floodplain planning controls and the adoption of the 100 year ARI flood standard. Subsequently, the former Department of Planning (DOP), issued a Departmental Circular (No. 122) and more Circular No. C9 was issued to assist Councils to relate the current flood policy of the State Government.

The current State Flood Policy (1984) disbanded the 100 year ARI flood standard and requires local Councils to implement floodplain management based on a merits based approach. The Circular states that in accordance with the FDM, Councils should prepare single comprehensive local environmental plans to implement their FRMPs, and so avoid an ad hoc, piecemeal approach to planning within floodplains.

In recognition that the preparation of such LEPs may take some time, Councils were advised that in the interim, adequate supporting data for decision-making should be obtained inclusive of:

- any relevant FRMPs or interim policy;
- details of flooding in the area;
- social and economic impact of flooding;
- environmental impacts of development in the floodplain (eg. on water quality, flood behaviour, etc);
- the availability of alternative flood free sites and reasonable alternative uses for the subject site;
- cumulative adverse impacts;
- matters of state and regional significance (eg. the impact of development on a floodplain beyond local government boundaries); and
- increased risk of flood damage to regional infrastructure, reduction in flood storage capacity, etc.

2.9.5 Section 117 Directions

This direction is aimed specifically at enforcing the principles contained within the FDM, and specifies a number of matters including the following:-

- LEPs should not rezone flood liable land from a zone such as rural, open space or special uses - flood, to a higher potential zone such as residential or industrial;
- the LEP should not, in respect to flood liable land, permit a significant increase of development potential or create a necessity for structural flood mitigation measures, and should require development consent for the majority of uses (other than minor development and additions);

- land defined as *high hazard flood liable or floodway* in accordance with the Floodplain Management Manual should be zoned Special Uses - High Hazard Flood Liable (or Floodway) Rural, Open Space, Scenic Protection, Conservation, Environmental Protection, Water Catchment, or Coastal Land Protection or a zone with a similar description.

The firm application of this latter principle would result in a small proportion of the residential and industrial zones within the study area being considered within a 'high hazard' area and accordingly required to be zoned in a highly restrictive manner.

2.9.6 PCC Local Environmental Plans (LEPs)

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

Parramatta LEP 2001 applies to the Lower Parramatta River Catchment (LPRC), within the Parramatta Local Government Area (LGA). This LEP deals with management of flood risk in various ways including defining flood liable land, outlining special considerations for development within flood liable land, the exclusion of development from being considered as exempt and complying development where located on flood liable land or areas within proximity to creeks and rivers.

The Parramatta LEP was reviewed on behalf of Council, as part of a separate exercise. The recommendations of this review are included within later sections of this report, for completeness.

There are components of the study area, particularly within the vicinity of the Parramatta CBD and the Harris Park locality, subject to pressures for urban growth and change. These areas have many attributes providing incentives for growth including substantial public transport (eg. both existing and programmed railway lines), commercial/retail activities and associated employment opportunities, and community facilities and services. In accordance with the objectives of the FDM (2005), flood risk is required to be balanced with social and economic criteria to determine on balance what the appropriate planning outcome should be for different localities and individual sites. That is, for example it may be appropriate to allow development on a particular site that is exposed to greater flood risk if its development for a particular use was considered to be a highly desirable planning outcome for the community for economic and social reasons due to proximity of the site to a railway station.

The current planning controls for the Parramatta LGA incorporate a residential 2(e) zone which primarily relates to residential zoned land identified as having some flood or drainage affectation.

The objectives of the 2(e) zone are as follows:-

“(a) To limit the erection of structures on land subject to flood inundation, and

(b) To identify land that is subject to flood inundation and is considered to be unsuitable for intensification of development, and

(c) To ensure that the adverse affect of inundation is not increased through development, and

(d) To maintain the amenity and existing characteristics of areas predominantly characterised by dwelling houses, and

(e) To permit only large scale development which has regard to the residential amenity of the locality, and

(f) To provide opportunities for people to carry out a limited range of activities from their homes where such activities will not adversely affect the amenity of the neighbourhood.”

The above zone was imposed upon different localities within the Parramatta LGA prior to the completion of any specific FRMS or FRMP. Council has recognised that the 2(e) zone was intended effectively to act as a holding zone until such time as an FRMP has been prepared for individual localities. The FRMS and consequent FRMP would subsequently provide the opportunity to evaluate the broader economic social and environmental issues together with flood risk to determine the appropriate planning outcome for land within the 2(e) zones.

Accordingly, a major planning outcome is to review the areas currently zoned 2(e) within the confines of the study area in the Parramatta LGA, and to provide recommendations in regard to their preferred zoning. This review has commenced as part of this study but is to be completed by Council as separate exercise to enable the consideration of all relevant planning issues, of which only one is flooding.

2.9.7 PCC Development Control Plans (DCPs)

A Development Control Plan (DCP) is a plan prepared in accordance with Section 72 of the Environmental Planning & Assessment Act, which provides detailed guidelines for the assessment of development applications. Various DCPs of some relevance apply in the study areas, as discussed below.

Parramatta DCP 2001 is a comprehensive Development Control Plan applying to the whole LGA. This document outlines the majority of Council’s controls in regard to planning and development.

Clause 4.1.3 of the DCP provides Council's primary controls in regard to floodplain risk management. These controls basically refer to the need for compliance with Council's FRMPs, Policy for the Development of Buildings on Flood Prone Land and the Floodplain Management Manual. Council has expressed a preference to retain a structure which adopts an independent flood policy which is not embodied within the DCP, but referred to by the DCP. The overall approach should, therefore, be to provide for minimal change to Council's DCP (incorporating provisions which relate only to controls on development) and to provide for a new Flood Prone Land Policy which adopts the more comprehensive recommendations of this study, as outlined and discussed later in this report.

2.9.8 Council Policies

In addition to formal regulations such as a DCP or an LEP, Councils may from time to time adopt specific policies with regard to their long-term vision for development within the floodplain or to deal with specific matters such as flooding. Normally, such policies are translated into DCPs or other planning instruments such as an LEP.

The State Government Flood Policy introduced in 1984 specifically abandoned the application of the 100 year ARI flood standard as the designated flood standard for the State of New South Wales, and required each LGA to determine their flood standard or standards based on merit. The FDM introduced in 1986 and the more recent FDM released in 2001 provide guidelines to assist councils in determining the relevant standards and policies, through the preparation of FRMSs and FRMPs.

Until the adoption of an FRMP, Councils under the 1986 FDM were required to produce interim flood policies. The ability to rely on interim policies was removed from the 2005 FDM which increases the urgency to prepare FRMPs for flood affected areas in the LGAs.

The procedures now outlined within the 2005 FDM provide Council with indemnity pursuant to the limitations provided by Section 733 of the Local Government Act 1993, and accordingly is very important to Council's overall risk management procedures. The eventual outcome of all FRMPs, including this FRMP will be to translate relevant planning recommendations of these documents into principally LEP and DCP requirements (or referenced by these documents). Recommendations for translating relevant recommendations of these documents into these instruments are made later within this report.

2.9.9 Development Application Assessment

Development applications for proposals which are permissible with consent must have regard to the Environmental Planning and Assessment Act 1979. Accordingly, Council is required to have regard to the provisions of the applicable LEPs which specify various matters to consider with respect to flood liable land.

The act requires that Council also consider any DCP in force. Such an instrument would provide a desirable mechanism for Council to comprehensively assess development applications with respect to the issue of flooding. In the case of Parramatta, the preference is for the formal adoption of development controls in a policy document to be referred to within Council's comprehensive DCP.

The Environmental Planning and Assessment Act 1979 and accompanying Regulations 2000 also identify certain developments which are deemed to be "designated development". Designated developments are generally large scale developments which have been identified as potentially causing greater impacts on the environment. Hence, designated development proposals require the preparation of an Environmental Impact Statement (EIS) and more specialised assessment procedures including statutory notification of the development application with third party rights of appeal for any objectors.

Schedule 3 of the Environmental Planning and Assessment Regulation 2000 identifies those developments which are designated development by virtue of their processing capacity, site requirements or location near environmentally sensitive features. Developments such as certain industries, local works, extractive industries, mines and the like are permissible in the zoning of the study area and adjoining land. Some of these developments may be regarded as designated development when located within a certain distance of a natural water body or wetlands or on flood prone land or a floodplain.

Schedule 3 of the EPA Regulation 1994 defines floodplain as follows:

> *"Floodplain means the floodplain level nominated in a Local Environmental Plan or those areas inundated as a result of a 100 year flood event if no level has been nominated."*

Accordingly, there are a number of potential outcomes of the FRMP process which may have implications in regard to the manner in which Development Applications are dealt with.

2.9.10 Section 149 Certificates

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

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

The wording of the above prescribed matter is such that inconsistencies arise between local councils in regard to the extent of information they provide on flooding. It has been argued that on literal interpretation, councils are only required to provide a 'yes' or 'no' answer as to whether such a policy exists. Further, there is potential equivocation when a council is aware of a flood risk, (eg. that a property is known to be located between the 100 year ARI and PMF extents), and there are no policies restricting development subject to the risk. A principal issue which arises is whether there is a legal or moral obligation for council to advise of the risk.

A certificate issued under Section 149(5) of the Act simply requires that Council "include advice on such other relevant matter affecting the land of which it may be aware". While this certificate type would necessitate Council advising of all flood information it holds, it is a more expensive certificate and is not mandatorily attached to property sale contracts.

Council may have flood information and policies for different properties at various standards from no flood studies or preliminary assessment by an engineer through to a comprehensive floodplain risk management Plan.

At present, Parramatta has completed a Floodplain Risk Management Study and Plan for a subcatchment (North Wentworthville) and for the Upper Parramatta River Catchment (in association with the UPRCT and other constituent Councils) covering a part of its area.

Councils generally may have additional flood information for the top catchment areas and some have maps or local knowledge of these affected areas (e.g. through a history of complaints). However it could not be expected that Councils will be able to unequivocally confirm that they have mapped all areas subject to potential flooding, although they would be able to say that they confidently believe they have identified the majority of properties affected by significant flooding.

There are a number of notations for Section 149 Certificates on flood affected land. These Section 149 notices should ultimately be reviewed upon adoption of the FRMP, to recognise the existence of the FRMP and any policies emanating from that document, as well as the findings of the flood study preceding the FRMP. Generally, the recommendations of this study are to advise all persons, through the use of Section 149 Certificates (and other methods) of all potential flooding (ie. up to the PMF). This is consistent with the current provisions of the Floodplain Development Manual (2005) and the recommended new definition for flood liable land to be incorporated within LEPs. It should be recognised that this revised approach for notifications on Section 149 Certificates, inclusive of the definitional change in LEPs, DCPs and Policies will not lead to any significant alteration to the permissibility of development but is more directed towards increasing awareness of the potential flood risk known to Council and the relative degree of such risk.

A detailed outline of appropriate 149 Certificate notations is provided later in this report. The various options for notations will need to take into consideration flooding from both main stream and overland flow situations. These notations were the subject of a separate legal advice obtained by the UPRCT, to ensure that the interests of PCC were appropriately covered. PCC would use these notations for the entire LGA.

2.9.11 Section 94 Contributions Plans

Section 94 Contributions Plans under the EPA Act 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.

As structural flood mitigation options are limited and potential development growth in the subject floodplain is also minimal, it is likely that a Section 94 Contributions Plan would only provide limited funding. This should however be monitored by Council and reviewed should expected development rates increase or if large individual developments would warrant a site specific Section 94 Contributions Plan.

3. Flood Impacts

As part of any Floodplain Risk Management Study, it is necessary to understand the magnitude of the risks relating to flooding. These risks include not only the risk of floodwater damage such as damage to property but also the risk to life from deep or fast flowing water. As a first step to understanding and quantifying the risk, a procedure has been developed to quantify the risk relating to deep or fast flowing water and is called the 'flood hazard'. This procedure is described below.

3.1 Flood Hazard Classification

The FDM (2005) recommends defining the floodplain in terms of two hazard categories:

- High hazard; and
- Low hazard.

High hazard areas are those where there is possible danger to personal safety, evacuation by trucks would be difficult, able-bodied adults would have difficulty wading to safety or there is potential for significant structural damage to buildings.

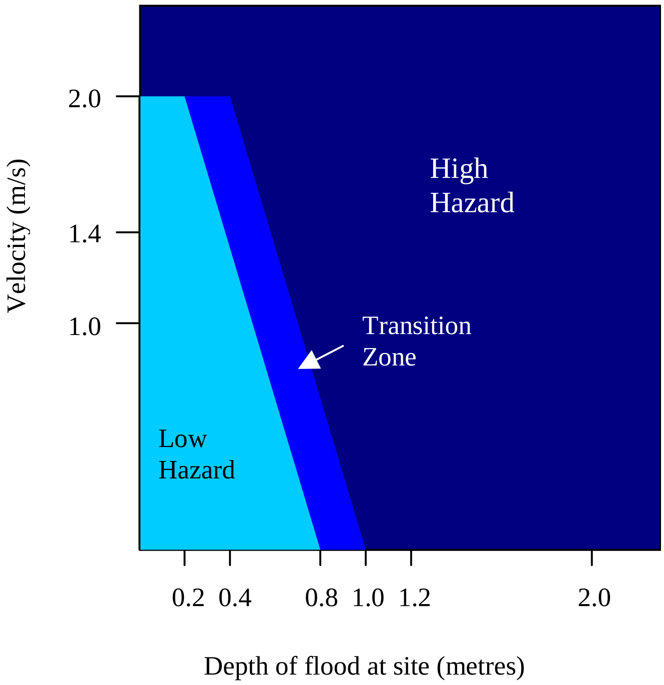
Low-hazard areas are those areas subject to shallow flooding where trucks could evacuate people and their possessions and able-bodied adults would be able to wade to safety.

A guide to the provisional flood hazard is shown in **Figure 3-1** adapted from the FDM (2005). The High Hazard definition adopted is in accordance with that used for by UPRCT for the Upper Parramatta River Floodplain Risk Management Study and is a slightly modified version of **Figure L2** of FDM (2005). (Reproduced as **Figure 3-1** on the next page).

High Hazard areas are defined as where:

- Flow Velocity greater than 2 m/s' or
- Depth greater than 1.0 m; or
- Velocity*depth>1.0.

■ **Figure 3-1: Provisional Hydraulic Hazard Categories**



3.2 Hazard Mapping

The FDM (2005) requires consideration of the PMF as well as a flood planning level (often the 100 year ARI flood) and so the hazard mapping needs to take into account the hazard category for the area from the edge of the 100 year up to the PMF area of inundation.

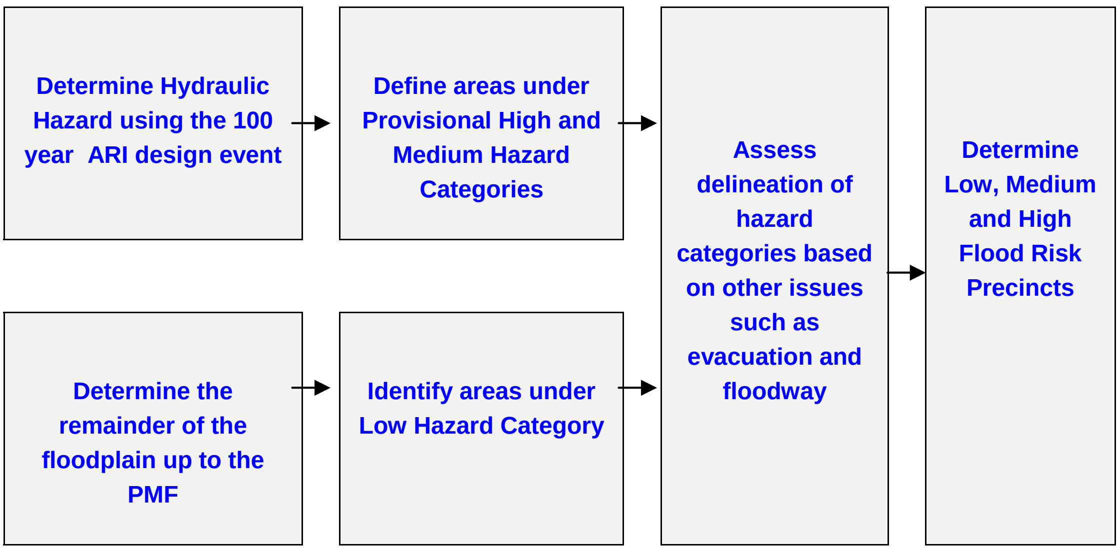
In the PMF event, the area that was designated as low hazard in the 100 year ARI event will be subject to deeper and faster water. Therefore in order to account for this increased risk, the low hazard area in the 100 year ARI event, has been re-named as a 'Medium Hazard' and the Low Hazard area is defined as the area from the 100 year ARI flood extent to the PMF line. These categories are summarised in **Table 3-1**.

- **Table 3-1 Definition of Hazard Categories**

Hazard	Hazard for the 100 year ARI Event	Adopted Hazard Category
High Hazard	Provisionally calculated in accordance with the graph in **Figure 3-1**	Area as for the 100 year ARI event
Medium Hazard	Not used or defined	Area defined as low hazard for the 100 year ARI event
Low Hazard	Remainder of area up to the 100 year ARI level	Area between the 100 year ARI and the PMF line

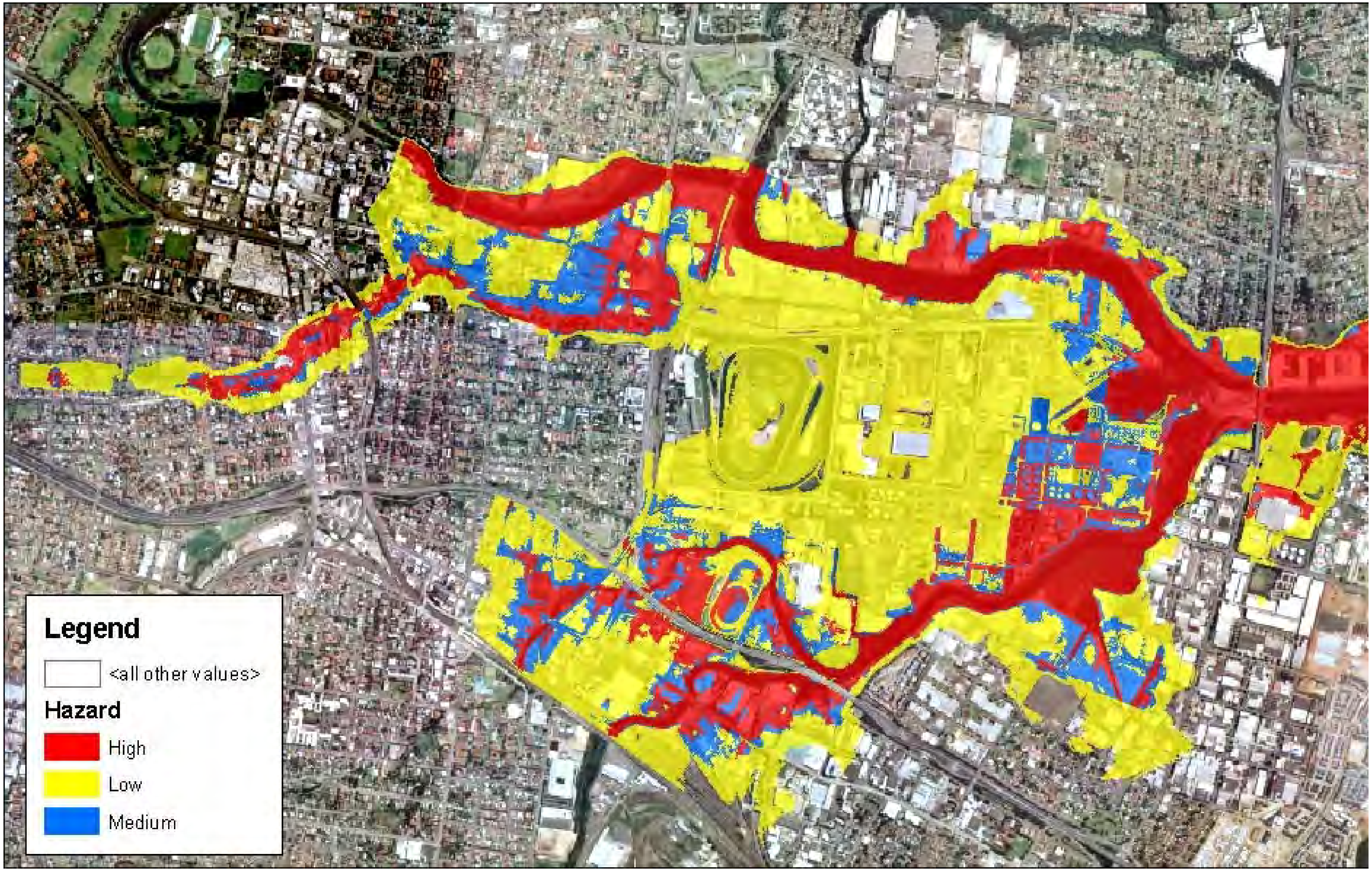
Based on the above criteria, Flood Hazard Maps have been prepared for the study area. It should be noted that these are provisional hydraulic assessment of hazard zones and later in this report where options are considered, have been amended in some areas to reflect such matters as danger, access, land use and other risk issues. This process of modifying the hazard Categories and providing Flood Risk Precincts, is shown diagrammatically in **Figure 3-2**.

- **Figure 3-2 Flowchart of Flood Risk**



The Hazard Map using the above definitions, for the western part of the study area is shown in **Figure 3-3** and for the eastern part in **Figure 3-4.**

- **Figure 3-3 Lower Parramatta River Western Area Hazard Map**



▪ **Figure 3-4 Lower Parramatta River Eastern Area Hazard Map**

3.3 Flood Damage

The floodprone buildings in the study area are subject to different frequencies of flooding depending upon their location. Some areas are subject to flooding in a 20 year ARI flood, while other buildings would only be flooded in an extremely rare flood. In order to assess the potential losses due to flooding, a comprehensive flood damage assessment has been performed, quantifying flood damages that would occur in the 20 year and 100 year ARI events and the PMF. The flood damage assessment methodology and results are summarised in this section and detailed in **Appendix B**.

Approximately 200 properties are contained within the high hazard area and a further 250 properties in the Medium Hazard Area. In a PMF event, a further 720 properties would be inundated.

3.3.1 Methodology

The 100 year ARI inundation mapping from the Flood Study Report (2005), were used to identify all of the properties affected by flooding in the 100 year ARI event. Where possible, these properties were identified in the field, in order to determine the type of property and estimate the height of the floor above ground level.

For each of the properties identified, the following steps were undertaken:

- At each property, the ground level (m AHD) was estimated from the airborne laser survey data;
- The floor level (in m AHD) was calculated from the ground level plus the estimated height of the floor above ground level;
- The flood levels were compared to the floor levels to determine which properties were affected by above-floor and below-floor flooding in each event; and
- For those properties affected by flooding above floor level, the flood depth above floor level was calculated for each event.

In the PMF, many properties in addition to those flooded by the 100 year ARI inundation area would also be flooded. The properties in this area were identified on the PMF inundation map and the number and location of properties in this category identified.

3.3.2 Cost of Flood Damages

Flood damages were estimated from a series of standard flood damage curves (ANUFLOOD, 1993). The damage curves were updated from 1993 dollars to 2003 dollars based on the consumer price index between 1993 and 2003. The flood damage assessment methodology, the damage curves for each property category and results are detailed in **Appendix B**. A summary of the flood damage assessment is presented in **Table 3-2**.

- **Table 3-2: Flood damages**

Event	20 year ARI	100 year ARI	PMF
Number of properties flooded above floor level	142	315	Approx. 850
Number of properties flooded below floor level	65	153	Approx. 350
Total number of properties flooded	207	468	1200
Estimated cost of damages	**$4.3M**	**$10.7M**	**$60M**

Using the losses summarised in **Table 3-2**, the average annual cost of flood damages can be calculated by integrating a damage cost-probability curve. For the project area of the Lower Parramatta River, the estimated average annual flood damage losses were assessed as $1 million dollars.

3.3.3 Indirect Costs

In addition to direct costs of damage to property, there is a cost associated with the on-going management of the disaster. These costs include emergency services, temporary accommodation, traffic diversion etc. These main areas of indirect cost are discussed below.

Deployment of Emergency Services

Organisations that would be involved in the provision of emergency services include the SES, local authorities, DIPNR, Waterways Authority, UPRCT, Department of Defence, major volunteer groups and small volunteer groups.

Transport Disruption

Indirect transport cost include, disruption to traffic flows, additional vehicle operating costs (VOC), travel time costs and accident costs.

Temporary Accommodation

As well as the costs of disruptions to commerce and destruction of property, there are other costs associated with temporary residential accommodation. These costs are borne by the individuals, the community and the local region.

Commercial and Industrial Losses of Income

Commercial and industrial properties are likely to suffer losses due to the need to close while the enterprise is being repaired or stock replaced.

3.3.4 Intangible Losses

The intangible impacts of disasters are those that cannot be evaluated in terms of market processes. Intangible losses can accrue to all sectors. The effects on residents whose homes are damaged or destroyed and who may suffer physical injury or psychological trauma are among the most significant. These intangible costs are discussed below.

Business Losses

In the commercial sector the owner may receive recompense for direct damages and indirect losses in terms of business interruption, both of which are often covered by insurance. If the building is destroyed long-term contracts are often lost to competitors and, when the rebuilt enterprise resumes service or production, for it to go into liquidation. This is commonly the case for buildings destroyed by fire and re-built with insurance payments.

Recreation Facilities

Often there is a social cost of recreation facilities not being available or the need to travel further to enjoy the amenity, such as tennis courts, open space or a golf course.

Effects on Health and Well-being

The tangible losses, to those who experience floods, are well documented and there are accepted techniques for assessment. This is not the case for the intangible effects on the health and well being of individuals or communities. A review of the effects on health, written in an Australian context, is available in Smith et al (1980) and Handmer and Smith (1983).

The key element is the degree to which the stress of the flood event provides a trigger for adverse effects on health. These can be for defined physical illnesses and for a range of psychological problems. A classic study of the former is by Bennett (1970) for the Bristol (UK) floods of 1968. This states:

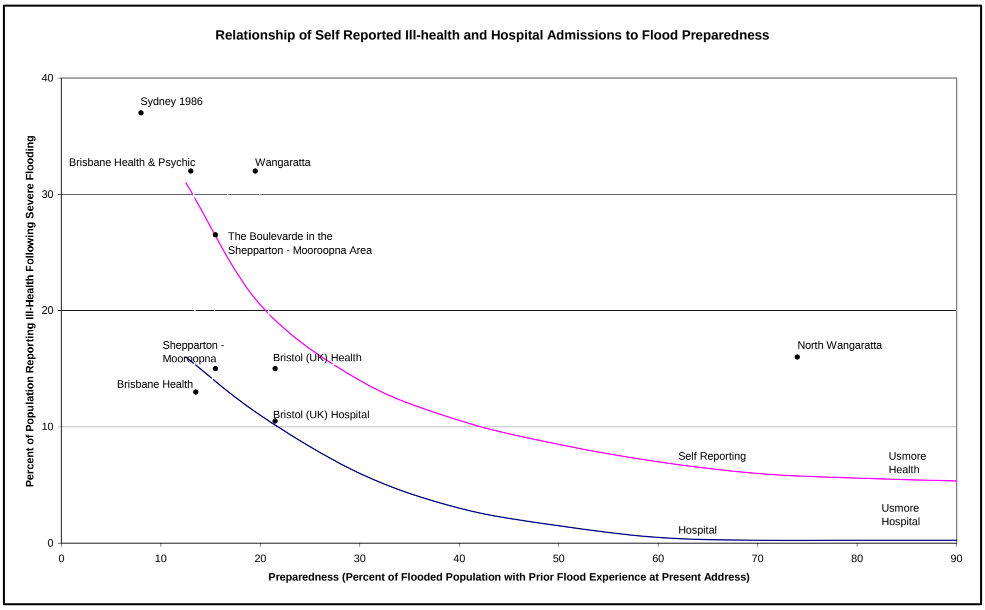
… there was a 50% increase [over a 12 month period] in the number of deaths among those whose homes had been flooded, with a conspicuous rise in deaths from cancer. Surgery attendances rose by 53%.

This study is one of the most thorough and scientifically sound in the literature. The sample was large, the author an international authority on epidemiology and it was published in the *British Medical Journal*.

Figure 3-5, from Smith (1984) illustrates data from hospital admissions and self-reporting, mainly from Australian flood studies. The key variable is that of `preparedness', which can be equated to prior flood experience at the flooded location.

Figure 3-5 clearly indicates that adverse health effects are inversely related to the degree of preparedness.

Figure 3-5: Relationship of Self Reporting Ill- Health and Hospital Admissions to Flood Preparedness



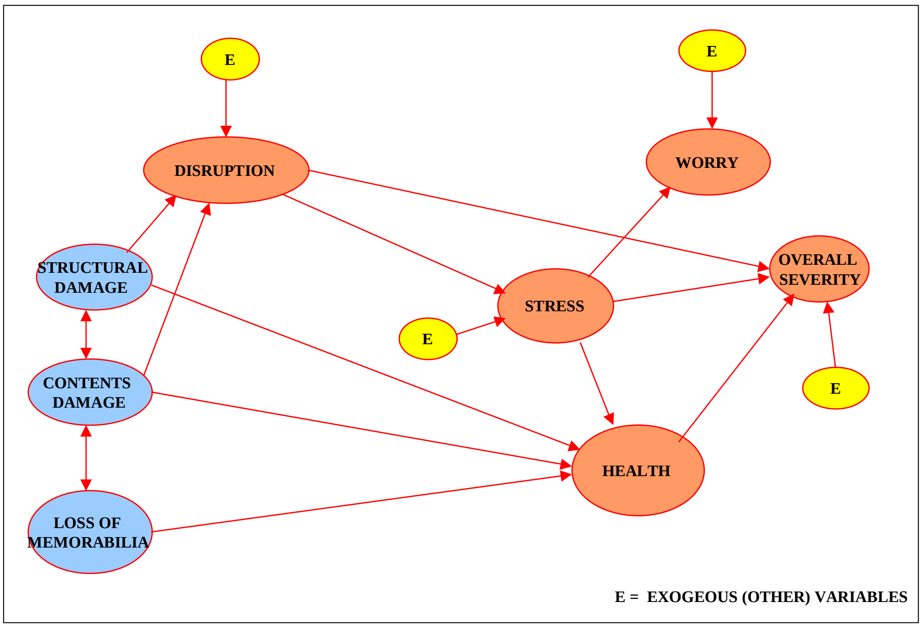
Source: Smith, D.I. (1984) *Urban flooding in New South Wales – a background for planning and policy* Unpublished, prepared for the Water Resources Commission.

The Flood Hazard Centre at Middlesex University (UK) has undertaken research specifically designed to give an indication of the perception of flood victims of the intangible losses in comparison to the tangible. Direct injury, such as a fractured limb, are of minor importance compared to the stress-related effects on health. **The summary of this work is that the intangible effects are rated as at least of equal severity to the tangible**.

The components of intangible loss are many and include loss of memorabilia, disruption, evacuation, stress and all effects on health. A problem with many of the health effects, especially those that are trauma-related, is that they are long-term. Trauma can last for months or years and the availability of medical treatment does not solve the problem, at best it reduces the duration of such intangible effects.

Figure 3-6 shows a causal analysis between householders concerns with flooding and the long-term effects.

- **Figure 3-6 Possible Health Trajectories Over Time Following a Flood**



Source: Green, C.H. & Penning-Rowsell, E.C. (1988) Flooding and the quantification of 'intangibles'. Procs. Institute of Water Engineers and Managers, Symposium, *Risk Management in the Water Industry*, London.

Environmental Costs

Environmentally sensitive areas that may be affected by flooding include:

- Riverine Systems;
- Wetlands;
- Threatened Species;
- Aboriginal and Heritage Sites;
- Parks and Reserves.

The impacts of increased flow on a riverine system is particularly difficult to ascertain without a detailed knowledge of the geomorphology of the river channel (including width, level of incision of the channel), amount and type of riparian vegetation cover, and location of different substrate types. These factors contribute greatly to the effects of increased flow on the in-stream organisms, as does the existence of refuges from high velocities. If refuges exist, the in-stream fauna have a much better chance of withstanding a high flow event. The valuation and impact assessment conclusions below were made without this detailed information and must therefore be interpreted conditionally.

Threatened Species

Threatened fauna may be injured or killed in a flood or may have their habitat damaged or destroyed. Threatened flora may be washed away or be covered by mud or sand deposits.

Aboriginal and Heritage Sites

The Heritage Assessment carried out for this study identified many sites that are flood prone but the assessment of the likely damage of each site is beyond the scope of this study and it might well prove to be impossible to put a monetary value on any damage.

Parks and Reserves

Within the study area's inundation area there were no National Parks or State Forests. However the numerous areas of vacant crown land provide areas of important remnant vegetation. In addition there are also numerous parks and reserves. These may be damaged as a result of the flooding.

Industry Effects

Major industries, such as those in the Camellia area are likely to be inundated in a major flood and are likely to cause significant environmental impact or pollution if pollutants are not contained on-site and treated.

3.4 Summary of Flood Impact

A 100 year ARI flood in the Lower Parramatta River study area, would have a major impact on the community. A total of about 450 properties would be flooded causing approximately $10 million direct damages. In a PMF event a total of approximately 1200 properties would be flooded with an estimated direct flood damage bill of about $56 million.

In addition there would be indirect costs, risk to life due to deep water, high velocities and cars being swept away.

Flooding has a large economic and social impact and as far as possible the risk needs to be managed. **Sections 6 to 9** outline the options for structural and non structural measures to reduce the impact of the floods in the study area.

4. Community Consultation

A number of community consultation activities have been undertaken throughout the floodplain risk management process in the Lower Parramatta area. These included:

- A questionnaire to residents and property owners in the study area;
- Two community workshops:
  - One to introduce the floodplain risk management process and present results of the initial questionnaire; and
  - One to present the results of the flood study and discuss the floodplain management study and plan; and
- A questionnaire for attendees of the second workshop, to gauge their opinions on planning issues in the floodplain.

Results from the initial questionnaire were presented in the *Flood Study Review* report (SKM, 2005) and are summarised below. Results from the latter questionnaire are summarised in the following section. Further community consultation meetings will take place to discuss the recommendations for the FRMP.

4.1 Questionnaire on Flooding Issues

A questionnaire was distributed to residents and businesses within the study area, in order to understand the community's experience of flooding, identify areas that are flood-prone and to gauge the community's priorities regarding floodplain management.

It was found that 22% of people who responded to the survey had some experience of flooding either at home or at work. These respondents were asked to identify the location where they had experienced flooding.

In order to gauge the community's priorities regarding floodplain management, respondents were asked to respond to the following:

- To rank various development types according to what they considered should be assigned greatest priority in protecting from flooding;
- What notifications they consider Council should give about the potential flood affectation of individual properties;
- To rank various flood protection measures;
- To rank various catchment management measures; and
- To rate their level of satisfaction with Council's service in drainage and flooding areas.

The results indicate that the community places high importance on protecting residential areas and critical utilities from flooding, and low importance on protection of minor development and recreational areas from flooding.

In terms of notifications, most respondents agreed that Council should:

- Advise every resident and property owner on a regular basis of the known potential flood affectation;
- Advise every resident and property owner on a regular basis of Council's policies on the control of land potentially affected by flooding; and
- Advise prospective purchasers/developers on the control or development on land potentially affected by flooding.

Only a few respondents indicated that Council should provide no notifications.

In terms of flood protection and catchment management activities, respondents ranked the following activities of highest importance:

- Protecting residents/businesses from flooding; and
- Removing litter from creeks and rivers.

Also highly ranked were the following activities:

- Protecting land of residents/businesses from flooding;
- Improving water quality; and
- Preservation of creeks and waterways in a natural state.

Respondents tended to rank the following activities as being of lower importance:

- Maintaining flood-free access to property;
- Providing flood warning; and
- Protecting plants and animals in the study area.

In terms of satisfaction with Council's service, the majority of respondents indicated that they were satisfied with each of the areas listed. Respondents were particularly satisfied with flood protection during minor storms, the effectiveness of street drainage and protection of plants and animals in the study area. Respondents were somewhat dissatisfied with flood protection in major storms and advice from Council staff on flood issues.

4.2 Community Workshops

Two community workshops were held during the flood study phase of the LPR-FRMS process. The first was held in May 2002 to discuss the following:

- Introduction, reason for Floodplain Risk Management Study, linkages between flooding, engineering and planning and desired outcomes;
- Description of process for Lower Parramatta River Flood Study Review and Floodplain Risk Management Study;
- Hydrology, flooding and flood modelling;
- Presentation of results of questionnaire;
- Discussion of participants' flood experience; and
- Discussion of what could be done to reduce the impact of flooding.

A second community workshop was held in December 2002 to discuss the following:

- Progress report on flood modelling, environment, hazard mapping and flood damage assessment;
- Overview of the planning framework including land use planning and planning instruments;
- Overview of the flood management process including risk, reducing flood impacts, structural and non-structural flood management measures and assessment of the impact of blockage; and
- Update on the flood planning process including flood planning levels, flood risk precincts and potential for rezoning.

4.3 Floodplain Risk Management Questionnaire

A copy of the questionnaire is included in **Appendix C**. A total of 13 respondents returned completed questionnaires.

Respondents were asked about what kinds of development would be acceptable in the High Risk precinct:

- 46% of respondents agreed that development in the High Risk precinct should be limited to open space, roads, parks and sporting facilities; and
- 38% of respondents suggested other land uses that would be acceptable in the High Risk precinct, including existing uses, minor structures, elevated developments and car parks.

All respondents agreed that new residential development should be allowed in flood-prone areas, provided it was raised above flood level:

- 8% of respondents placed no restrictions on this statement;

- 23% of respondents agreed that new residential development should be allowed in flood-prone areas, providing that filling of the block was not required or it was proven that no change to the flood risk to other properties would arise; and
- 62% of respondents agreed that new residential development should be allowed in flood-prone areas, providing it did not cause any amenity impacts and/or remained consistent with the streetscape.

All respondents agreed that carports and car parking areas should be allowed in flood-prone areas:

- 8% of respondents placed no restrictions on this statement; and
- 92 % of respondents agreed that carports and car parking areas should be allowed in flood-prone areas, providing the risk of flood damages was low and/or the potential damages were minor.

Respondents were asked whether they thought that residents should be able to evacuate in available warning times from flooded areas:

- 62% of respondents agreed that residents should be able to evacuate by walking and/or by car; and
- 38% of respondents indicated that it didn't matter if residents couldn't evacuate, providing they had a second storey or floor level above flood level.

Respondents were asked to indicate which sorts of development should not be allowed in the medium risk precinct:

- 62% indicated that nursing homes should not be allowed;
- 54% indicated that schools should not be allowed;
- 54% indicated that retirement units should not be allowed;
- 85% indicated that hospitals should not be allowed;
- 23% indicated that standard industrial should not be allowed;
- 54% indicated that hazardous industry should not be allowed;
- 31% indicated that shopping centres should not be allowed; and
- 54% indicated that critical utilities should not be allowed.

Respondents were asked to indicate what sort of flooding notifications they thought Council should provide:

- 69% indicated that annual notifications to residents and property owners;
- 92% indicated that notifications should be provided to property purchasers; and
- 8% of respondents indicated that Council should provide no notifications on flooding.

4.4 Conclusions from Community Consultation

From the questionnaires and from community consultation, the results indicate that the community places high importance on protecting residential areas and critical utilities from flooding, and low importance on protection of minor development and recreational areas from flooding.

Most respondents agreed that Council should advise every resident and property owner on a regular basis of the known potential flood affectation; on the control of land potentially affected by flooding; and advise prospective purchasers/developers on the control or development on land potentially affected by flooding.

In terms of flood protection and catchment management activities, respondents ranked protecting residents/businesses from flooding; and removing litter from creeks and rivers as the most important. Also highly ranked were protecting land of residents/businesses from flooding; improving water quality; and preservation of creeks and waterways in a natural state.

Respondents tended to rank the following activities as being of lower importance; maintaining flood-free access to property; providing flood warning; and protecting plants and animals in the study area.

These comments and opinions are important when the options for flood management are considered.

5. Floodplain Risk Management Measures

5.1 Floodplain Management Options

One of the objectives of this FRMS is to identify and compare various floodplain risk management options to deal with existing flood risk in the study area considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts. The FDM (2005) describes floodplain risk management measures in three broad categories which are summarised below and described in more detail in **Appendix E**:

1) **Flood modification measures** involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area;
2) **Property modification measures** involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions); and
3) **Response modification measures** involve modifying the response of the population at risk to better cope with a flood event (for example, improving community flood readiness).

Potential floodplain risk management measures are summarised in **Table 5-1**.

- **Table 5-1: Potential floodplain Risk Management Measures**

Category	Potential Floodplain Management Measures	
Flood Modification	■ Flood mitigation dams ■ Retarding basins ■ On-site Detention (OSD) ■ Levees ■ Bypass floodways	■ Channel modifications ■ Floodgates ■ Catchment treatment ■ Monitor filling of floodplain
Property Modification	■ Development controls ■ Rezoning ■ Voluntary purchase of high hazard properties	■ House-raising ■ Flood-proofing of buildings ■ Flood access
Response Modification	■ Flood education ■ Community flood readiness ■ Flood prediction and warning	■ Local flood plans ■ Recovery planning ■ Flood insurance

Options for Property Modification, relating to planning, can be found in Volume 2 of this FRMS.

Each of the measures listed in **Table 5-1** is described in more detail in the next section, in the context of its suitability in the Lower Parramatta area.

6. Flood Modification Measures

6.1 Clay Cliff Creek Options

Dalland and Lucas (D&L) (1992) undertook the *Clay Cliff Creek Catchment Flood Study* for Parramatta City Council. They investigated existing flooding conditions in Clay Cliff Creek and considered a number of potential flood modification measures to lower flood levels in flooding problem areas. The specific flood modification measures considered by D&L were:

1) Reconstruction of the Clay Cliff Creek channel along its entire length;
2) A detention basin in Ollie Webb Reserve;
3) Widening the channel from the culvert outlet upstream of Wigram Street to a location 20 m downstream of the Harris Street bridge;
4) A detention basin in Jubilee Park; and
5) A diversion channel to convey flows from Harris Street directly to the Parramatta River in a northerly direction.

Option 1 was not recommended by D&L, due to its high cost and the large amount of disruption it would cause to residents, businesses and services. The other options were investigated in more detail, and found to result in some significant benefits. Two potential scenarios were proposed by D&L:

1) Combine Options 2, 3 and 5; or
2) Combine Options 2, 4 and 5.

These five options have now been considered as part of this updated study and each of the options is described in more detail in the following sections. Each option was assessed using the MIKE-11 model of the study area; to determine what impacts it would have on flood levels. In a number of options, the sizing and configuration was modified to improve the performance of the option.

6.1.1 Option 1 – Enlarge Clay Cliff Creek along its entire Length

This option was considered but review of the existing development on each side of Clay Cliff Creek showed that it would be quite impractical to consider this as a viable financial or planning or environmental option. This option was therefore not considered further.

6.1.2 Option 2 – Detention Basin in Ollie Webb Reserve

Clay Cliff creek runs across Ollie Webb Reserve in an underground box culvert and is in an ideal location to reduce flood peaks in the reach downstream of Marsden Street. by providing a detention basin which will take the extra floodwaters when the culvert surcharges.

D&L proposed a basin layout involving a total basin volume of 41,000 m^3. They modelled the basin with a culvert outlet, 2.4 m wide by 1.5 m high. They found that this configuration would reduce the peak outflow from the basin to 17 m^3/s in the 100 year ARI event.

D&L's detention basin design was reviewed as part of this study. The design was modified so that it would be possible to retain the playing fields at Ollie Webb Reserve while still having the site act as a detention basin. It was also considered important that the playing fields should not be inundated too frequently.

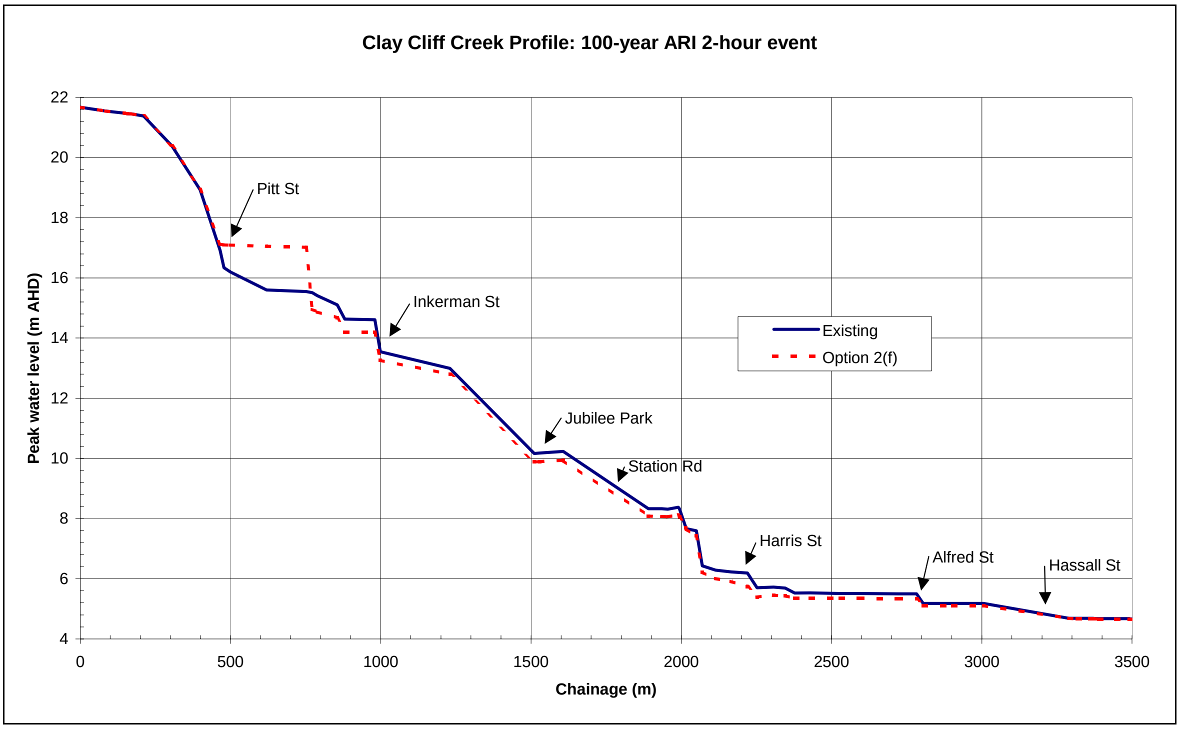
The detention basin design investigated as part of this Floodplain Management Study would involve constructing an embankment around the eastern and southern sides of Ollie Webb Reserve, to a maximum height of 18.0 m AHD. No excavation would be involved. It was assumed that this embankment would have side slopes of 1 (vertical) in 5 (horizontal). The detention basin would have an outlet consisting of a culvert 2.0 m wide by 1.8 m high. A spillway would need to be provided for the very rare flood. This would be constructed in a location that would minimise risk to property or life.

It was found that the above detention basin configuration would result in a reduction in peak flow downstream of Ollie Webb Reserve; in the 100 year ARI 2 hour event, which is the critical duration in Clay Cliff Creek, the peak flow would reduce from 35 m^3/s to 19 m^3/s. The basin would flood approximately once every 5 years. Peak flood levels downstream of the basin in the 100 year ARI 2 hour event would decrease by about 0.6 m immediately downstream of the basin (at cross-section chainages 772-855) and approximately 0.3 m in the reach from chainage 880 to 2050. Peak flood levels for the existing case and Option 2 are plotted in **Figure 6-1**.

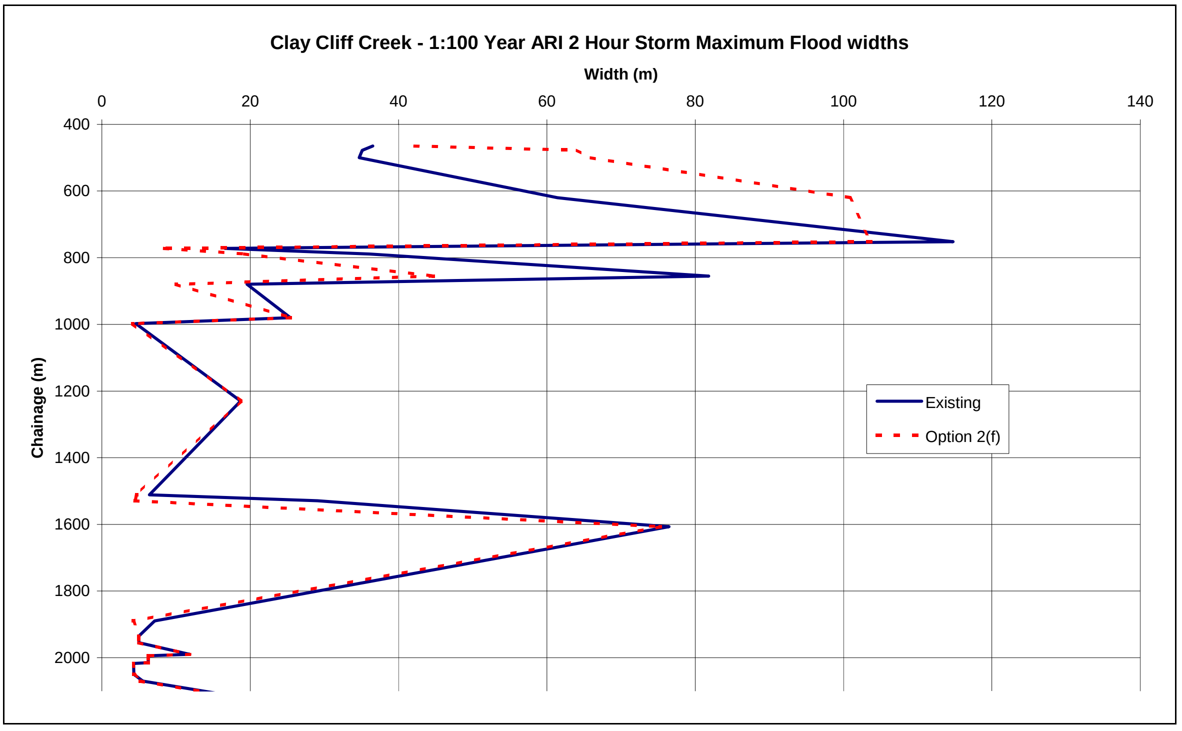
The reduction in peak flood levels would reduce flooding impacts for flood-affected properties along Clay Cliff Creek between Ollie Webb Reserve and Wigram Street. Flooded widths with and without the proposed works were compared over this reach of Clay Cliff Creek. Flood widths would reduce significantly in the first 200 m downstream of Ollie Webb Reserve; changes would be minor downstream of chainage 1000. Flood widths with and without the proposed works are plotted in **Figure 6-2**.

In all sections of the Clay Cliff Creek, the channel was checked for the risk of supercritical flow and where there was a risk of this occurring the deeper sub-critical depth was provided.

- **Figure 6-1: Peak flood levels for Option 2(f) in the 100 year ARI 2 hour event**



- **Figure 6-2: Flood widths for Option 2(f) in the 100 year ARI 2 hour event**



6.1.3 Option 3 – Localised Channel Widening

This option would involve widening the open channel from where it emerges from underground upstream of Wigram Street to a location 20m downstream of Harris Street. D&L recommended widening the channel by one metre over this distance of approximately 370 m, in order to reduce peak flood levels along this reach. This option has become increasingly difficult since it was proposed in 1992, due to additional development taking place along this reach of the Creek. Meriton Apartments are adjacent to this section of creek and the proposed extension of Charles Street would also cross this section of creek.

Option 3 was considered in the context of the current situation along Clay Cliff Creek between the start of the open channel upstream of Wigram Street and a point 20m downstream of Harris Street. There is an extensive development close to the banks of this section of the creek, and the easement for the creek is only just wide enough to accommodate the existing concrete channel. Therefore widening the creek in this section would not be possible without significant land acquisition and possible property purchases and removal. This option was therefore not considered feasible and so has not been investigated further in this study.

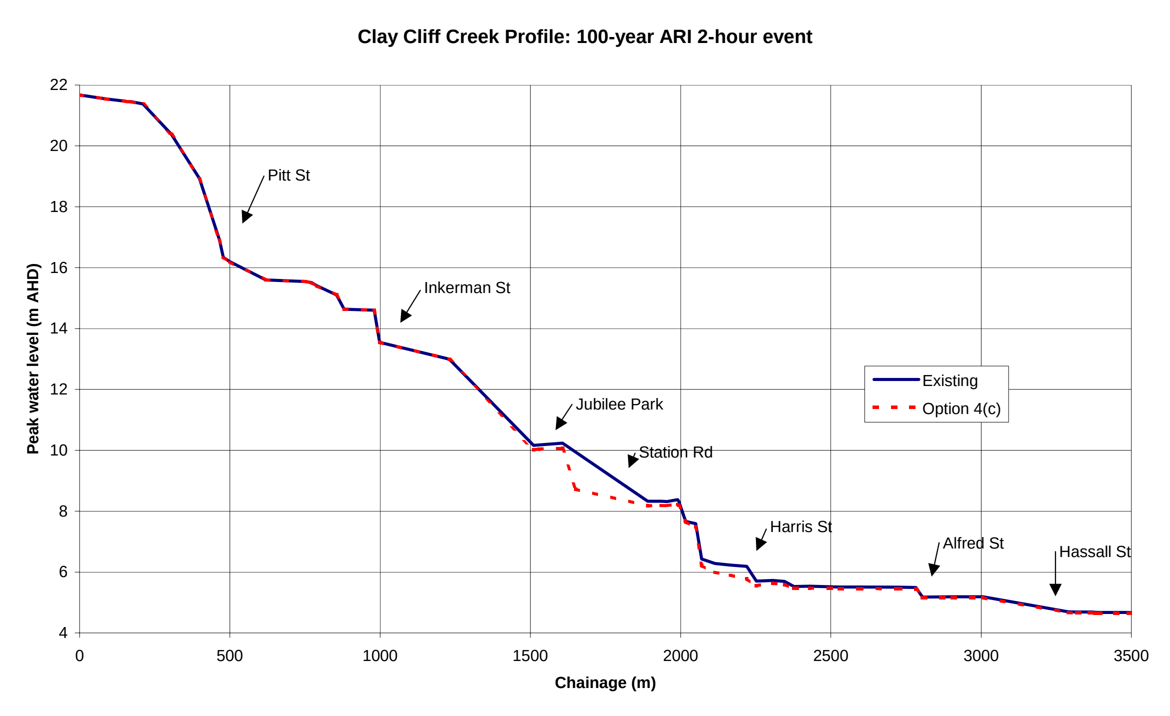
6.1.4 Option 4 – Detention Basin in Jubilee Park

D&L considered constructing a small detention basin in Jubilee Park. Clay Cliff Creek currently flows along the western edge of Jubilee Park in an open concrete channel before going underground at Park Road. The proposed basin would only become operational when the peak flow in this channel reached 24 m^3/s. A weir was proposed along the side of the channel to allow it to spill when the flow reached this rate. Jubilee Park would need to be excavated to provide about 6,000 m^3 of storage. The basin would drain via a one-way flow device linking to the underground culvert at Parkes Street.

Option 4 was added to the MIKE-11 model as it was designed by D&L. The total volume of the basin would be just over 9,000 m^3, achieved by excavating Jubilee Park down to a level of 6.9 m AHD at the upstream end and 6.75 m AHD at the downstream end. The basin inflow would be controlled by a long weir on the side of the existing concrete channel and the basin outflow would be controlled by a 525 mm pipe culvert with a one-way flap valve.

The MIKE-11 model was run for the 100 year ARI 2 hour event and results compared to the existing case. It was found that, on its own, Option 4 would not have a significant effect on flood levels in the 100 year ARI two hour event, with reductions in flood levels limited to the area in the immediate vicinity of Jubilee Park. Results for the 100 year ARI 2 hour event are shown in **Figure 6-3**.

- **Figure 6-3: Peak flood levels for Option 4 in the 100 year ARI 2 hour event**



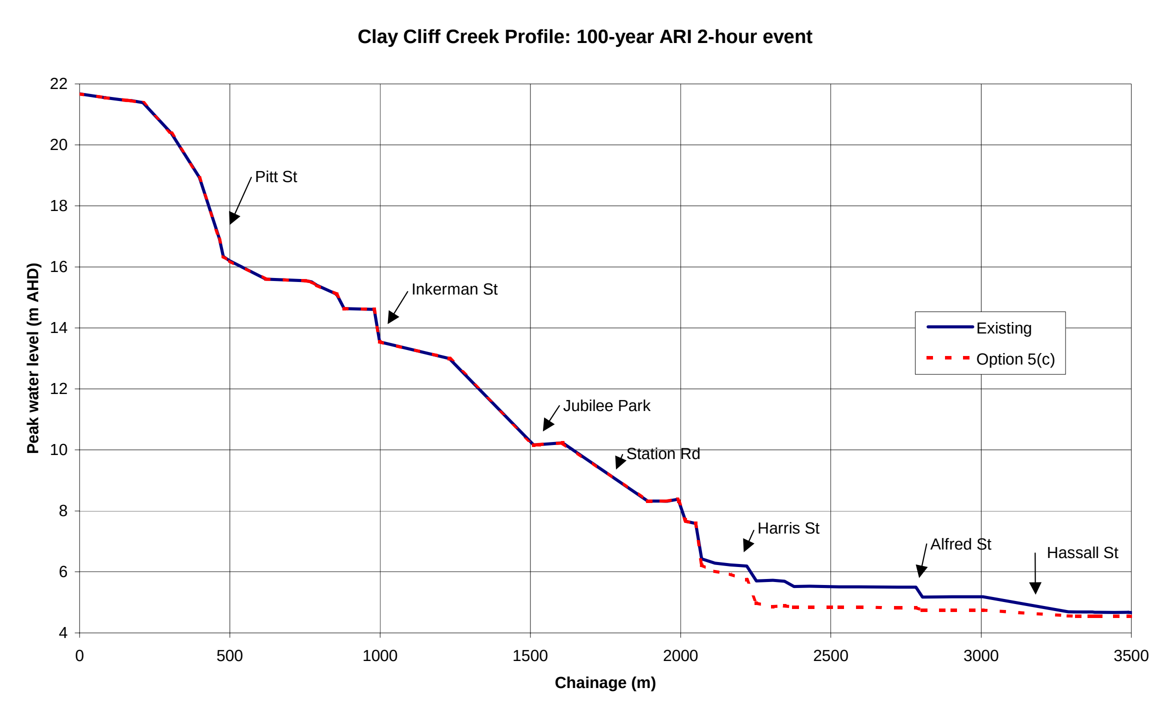
6.1.5 Option 5 – Diversion Channel

Option 5 would involve diverting flow from Harris Street directly to the Parramatta River to the north. D&L proposed that this would be achieved with a culvert through Thomas Reserve, covering a distance of approximately 320 m. The invert of the proposed channel would match that of Clay Cliff Creek but it a weir would be provided in the channel to ensure that Clay Cliff Creek carried the low flows and only flood flows were diverted.

The culvert proposed by Dalland and Lucas was to be 4.5 m wide and 2.4 m high. Preliminary assessment showed that a culvert of this size was appropriate for the flow in Clay Cliff Creek and a culvert of these dimensions was added to the MIKE-11 model. However upon running the model it was found that when there was a flood in the Parramatta River, water could back flow along the culvert and cause flooding in Clay Cliff Creek. The culvert was therefore modified in the MIKE-11 model to only allow one-way flow from Clay Cliff Creek to the Parramatta River.

The model was run for the 100 year ARI event and results compared to the existing case. Peak flood levels for the 100 year ARI 2 hour event are shown in **Figure 6-4**.

■ **Figure 6-4: Peak flood levels for Option 5 in the 100 year ARI 2 hour event**



It can be seen in **Figure 6-4** that Option 5 would be quite successful in reducing peak flood levels downstream of Harris Street. Peak flood levels in the 100 year ARI 2 hour event would reduce by about 0.4 m immediately downstream of the diversion culvert, with the flood level reduction being less at the downstream end of Clay Cliff Creek towards the Parramatta River. The reason for this is that the Parramatta River causes a backwater effect in the lower reaches of Clay Cliff Creek, which impacts flood levels during major storm events.

6.1.6 Combined Options 2, 4 and 5 – Option 6

Options 2, 4 and 5 were all found to have some benefits in terms of flood level decreases. Some of the benefits would be limited to specific areas, however a combination of Options 2, 4 and 5 could be effective in reducing flood impacts along much of the length of Clay Cliff Creek.

The MIKE-11 model was modified to include Options 2, 4 and 5 as a new combined option, called Option 6. The model was run for the 100 year ARI event and results compared to the existing case. Results for the 100 year ARI 2 hour event are shown in **Figure 6-5**.

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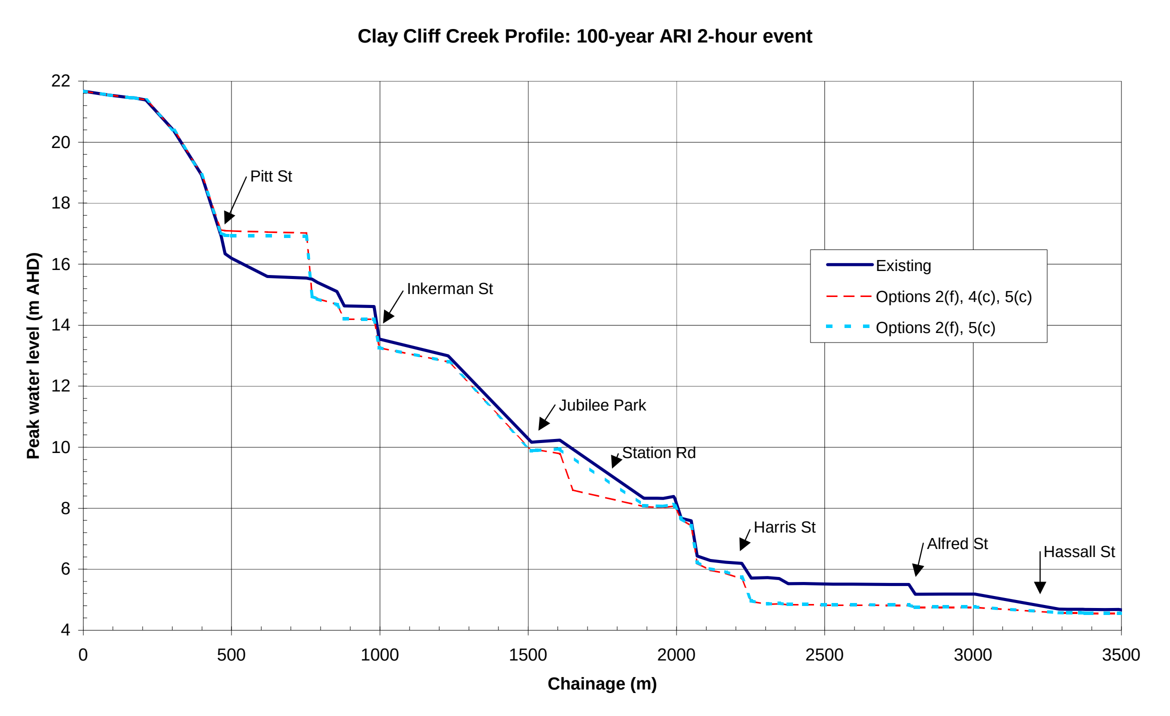
- **Figure 6-5: Peak flood levels for Option 6 (combined Options 2, 4 and 5) and 7 (Option 2 and 5) in the 100 year ARI 2 hour event**



The combination of Options 2, 4 and 5 would have the effect of reducing flood levels along a significant portion of Clay Cliff Creek. The average decrease in flood level downstream of Ollie Webb Reserve would be approximately 0.4 m in the 100 year ARI 2 hour event. This would reduce flood impacts at properties that are currently affected by flooding. Option 4 (Jubilee Park basin) would become more effective when constructed in conjunction with the detention basin in Ollie Webb Reserve.

6.1.7 Combined Options 2 and 5 – Option 7

From review of the results of Option 6, it could be seen that a combination of options, would have a greater benefit than any one option. However, the construction of a retarding basin in Jubilee Park may be difficult to achieve due to considerations such as amenity, heritage, services and community views. Therefore an option combining Options 2 and 5 only was considered. The results are also shown in **Figure 6-5**.

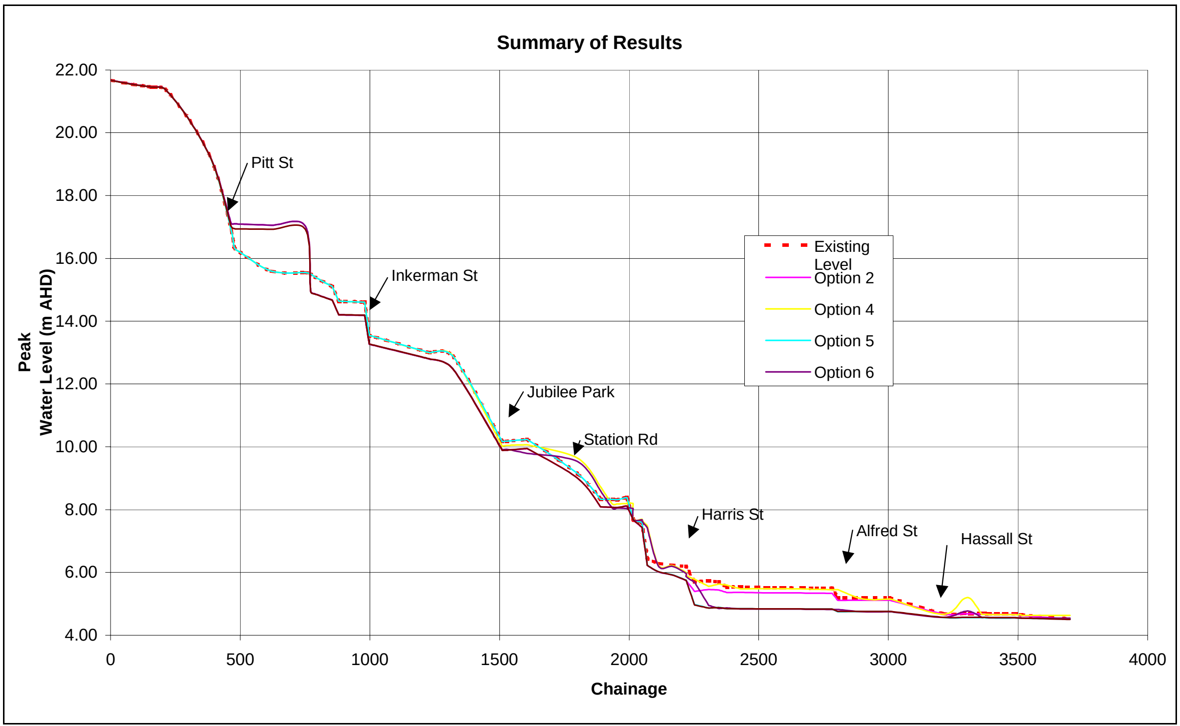
It can be seen that this option produces nearly the same results as Option 6 but with less reduction in level in the vicinity of Jubilee Park.

6.2 Assessment of Effectiveness of Works in Clay Cliff Creek

6.2.1 Changes in Flood Levels for Options considered

The results of the options considered above, has been combined in **Figure 6-6.**

- **Figure 6-6 Summary of Options**



The results of the modelling can also be considered in relation to known locations along the Creek. **Table 6-1** shows the flood levels (100 year ARI 2 hour Event) for the existing case and for the five different options considered at various locations from Burnett St near the top of the catchment down to the Parramatta River just west of James Ruse Drive. The cross section names are those used in the MIKE-11 hydraulic model.

Table 6-2 compares flood levels at the same locations but instead of absolute flood levels, the table shows the reduction in flood level when each option is tested compared to the existing flood level. A negative number indicates that flood levels have reduced for an option while a positive number indicates that flood levels have risen with the option.

The final row in **Table 6-2** shows the average of the flood level changes to provide a simple approximation of the effectiveness of each option.

Table 6-1 Flood Levels at Selected Locations

Location	Cross Section Name	Chainage	Existing Level	Option 2	Option 4	Option 5	Option 6	Option 7
Burnett St	CLAYCLIFF	-	21.67	21.67	21.67	21.67	21.67	21.67
Franklin St	CLAYCLIFF	147	21.47	21.48	21.47	21.47	21.48	21.47
Pitt St	CLAYCLIFF	465	16.91	17.12	16.91	16.91	17.12	17.02
Marsden St	CLAYCLIFF	855	15.11	14.68	15.11	15.11	14.68	14.67
Inkerman St	CLAYCLIFF	980	14.61	14.19	14.61	14.61	14.19	14.19
Church St	Landsdowne_450	1,320	12.89	12.48	12.90	12.89	12.49	12.48
Jubilee Park	CLAYCLIFF	1,511	10.17	9.89	10.02	10.17	9.91	9.89
Pakes St (at Railway)	Church_Parkes_349	1,800	9.15	9.00	9.64	9.15	9.53	9.01
Wigram St	CLAYCLIFF	2,050	7.59	7.43	7.69	7.59	7.68	7.43
Harris St	CLAYCLIFF	2,220	6.19	5.74	6.00	5.75	5.96	5.75
Park St	CLAYCLIFF	2,346	5.69	5.43	5.63	4.89	4.85	4.88
Alfred St	CLAYCLIFF	2,783	5.50	5.34	5.45	4.83	4.82	4.83
Arthur St	CLAYCLIFF	3,006	5.18	5.11	5.16	4.75	4.75	4.76
Hassall St	Hassall_2_524	3,210	4.69	4.68	4.67	4.56	4.57	4.57
Grand Ave North	CLAYCLIFF	3,360	4.69	4.68	4.67	4.56	4.57	4.57
River Road West	CLAYCLIFF	3,490	4.68	4.66	4.65	4.55	4.56	4.56
Parramatta River	CLAYCLIFF	3,701	4.52	4.51	4.63	4.51	4.54	4.50

Table 6-2 Reduction in Flood Level at Selected Locations

Location	Cross Section Name	Chainage	Existing Level	Option 2	Option 4	Option 5	Option 6	Option 7
Burnett St	CLAYCLIFF	0	21.67	0.00	0.00	0.00	0.00	0.00
Franklin St	CLAYCLIFF	147	21.47	0.00	0.00	0.00	0.00	0.00
Pitt St	CLAYCLIFF	465	16.91	0.21	0.00	0.00	0.21	0.11
Marsden St	CLAYCLIFF	855	15.11	-0.43	0.00	0.00	-0.43	-0.43
Inkerman St	CLAYCLIFF	980	14.61	-0.41	0.00	0.00	-0.41	-0.41
Church St	Landsdowne_450	1320	12.89	-0.41	0.01	0.00	-0.40	-0.41
Jubilee Park	CLAYCLIFF	1511	10.17	-0.28	-0.15	0.00	-0.26	-0.28
Pakes St (at Railway)	Church_Parkes_349	1800	9.15	-0.15	0.49	0.00	0.38	-0.15
Wigram St	CLAYCLIFF	2050	7.59	-0.16	0.10	0.00	0.08	-0.16
Harris St	CLAYCLIFF	2220	6.19	-0.45	-0.19	-0.44	-0.23	-0.44
Park St	CLAYCLIFF	2346	5.69	-0.26	-0.07	-0.81	-0.84	-0.81
Alfred St	CLAYCLIFF	2783	5.50	-0.16	-0.05	-0.67	-0.68	-0.67
Arthur St	CLAYCLIFF	3006	5.18	-0.07	-0.03	-0.43	-0.44	-0.43
Hassall St	Hassall_2_524	3210	4.69	-0.01	-0.03	-0.13	-0.13	-0.12
Grand Ave North	CLAYCLIFF	3360	4.69	-0.01	-0.02	-0.13	-0.12	-0.12
River Road West	CLAYCLIFF	3490	4.68	-0.01	-0.02	-0.13	-0.12	-0.12
Parramatta River	CLAYCLIFF	3701	4.52	-0.01	0.11	-0.01	0.02	-0.02
Average Decrease				**-0.15**	**0.01**	**-0.16**	**-0.20**	**-0.26**

6.3 Recommended Works

From **Table 6-2**, it can be seen that Option 7 provides by far the best outcome for most locations and requires less construction work than Option 6. It is therefore the recommended option. However this work could be undertaken as two stages as described below.

6.4 Cost and Benefits for Option 7

6.4.1 Cost and Staging of Option 7

In order to provide flexibility and cost management, it is recommended that works be carried out in two stages as outlined below.

Stage 1 - Detention Basin in Ollie Web Reserve

Provide an embankment around the eastern and southern sides of Ollie Webb Reserve, to a maximum height of 18.0 m AHD to act as a detention basin. No major excavation would be involved. It was assumed that this embankment would have side slopes of 1 (vertical) in 5 (horizontal). The detention basin would have an outlet consisting of a culvert 2.0 m wide by 1.8 m high. The estimated cost is $380,000 as shown in **Appendix D**.

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Stage 2 – Diversion Channel through Thomas Reserve

Divert flood flow from Clay Cliff Creek at Harris Street directly to the Parramatta River to the north with a culvert through Thomas Reserve, covering a distance of approximately 320 m. The culvert proposed is 4.5 m wide and 2.4 m high and is estimated to cost $1,642,000.

6.4.2 Benefit of Option 7

The primary benefit of each option is a reduction in flood levels which reduce the damage costs. For each option the reduction in damages has been assessed and can then be compared to the cost of the works to determine which option has the best rate of return.

The benefits from option 7 are detailed in **Appendix D** and can be summarised as providing $150,000 average annual benefit.

6.4.3 Rate of Return of Option 7

Assuming an internal rate of return of 6%, the future annual benefits of $150,000 equates to a Net Present Value of $1,700,000. This means that the internal rate of return (benefit/cost) of these works is in the order of $1.7 million/$1.975 million = 0.9 which is a very high rate of return for this type of work which also has a high social and environmental benefit.

6.5 Recommendations for Works in Clay Cliff Creek

It is recommended that work proceed on more detailed feasibility and preliminary design **of Stage 1 of Option 7, a detention basin in Ollie Webb Park** followed by Stage 2, a bypass channel from Clay Cliff Creek to the Lower Parramatta River.

6.6 Blockages

A flood management risk that needs to be considered, particularly in an urban area, is whether creeks, channels and culverts can become blocked with debris and if so what effect would this have on flood levels.

The consultant reviewed the risk of blockages for the study area and concluded as follows:

- Blockages are not likely to occur in Parramatta River due to the width of the river and the multiple spans of the bridges

- Partial blockages of tributaries such as Duck Creek could occur and appropriate vegetation management plan needs to be implemented, see **Section 6.7**.
- Blockages in Clay Cliff Creek could occur but the catchment has little vegetation and therefore the risk is more likely to be shopping trolleys, mattresses etc.

Council does have a maintenance program and therefore the risk of blockages anywhere in Clay Cliff Creek is considered slight. However, in order to assess the impact of blockages, the consultant undertook an assessment of the impact of 50% and 100% blockages at three key locations. The three locations were where:

- Clay Cliff Creek passes under Church St,
- The bridge over Park St (Clay Cliff Creek passes under the road in this location)
- Arthur St where Clay Cliff Creek is also in a culvert.

The rise in flood level due to the blockages is shown in **Figure 6-7** to **Figure 6-9**. The top number in each box represents the flood rise due to 50% blockage for the 100 year ARI event while the bottom number represents the effect of 100% blockage. It can be seen that flood rises are in all cases is less than 0.5 metres this is due to the floodwaters redistributing along other floodways.

The location and degree of blockage cannot be confidentially predicted and so it is not possible to specifically protect against a blockage. However the modelling undertaken by the consultant shows that the effect of a blockage will be less than the provision of 0.5 metres freeboard. It is therefore recommended that PCC continue to carry out routine maintenance of the creeks and channels to remove debris but no formal allowance is made for flood rise due to blockage. In the event of new development, it is recommended that the designer be required to provide an alternative overland flowpath or more freeboard if there is any risk of blockage.

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Figure 6-7 Blockage at Church St

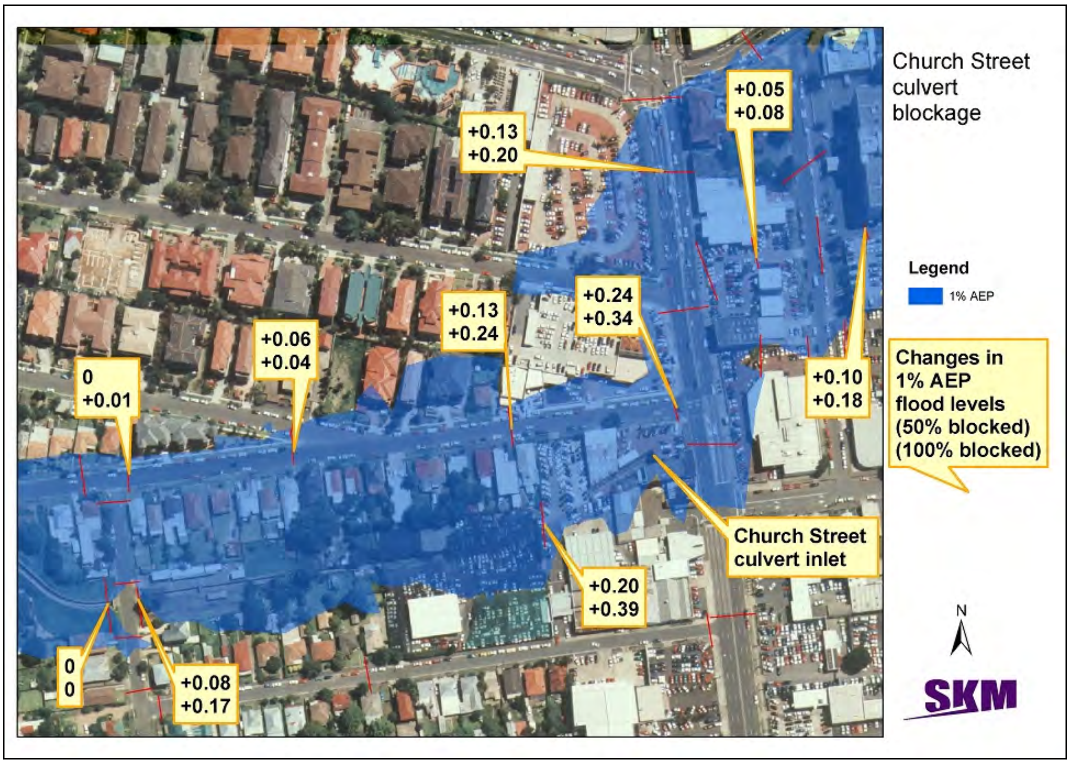
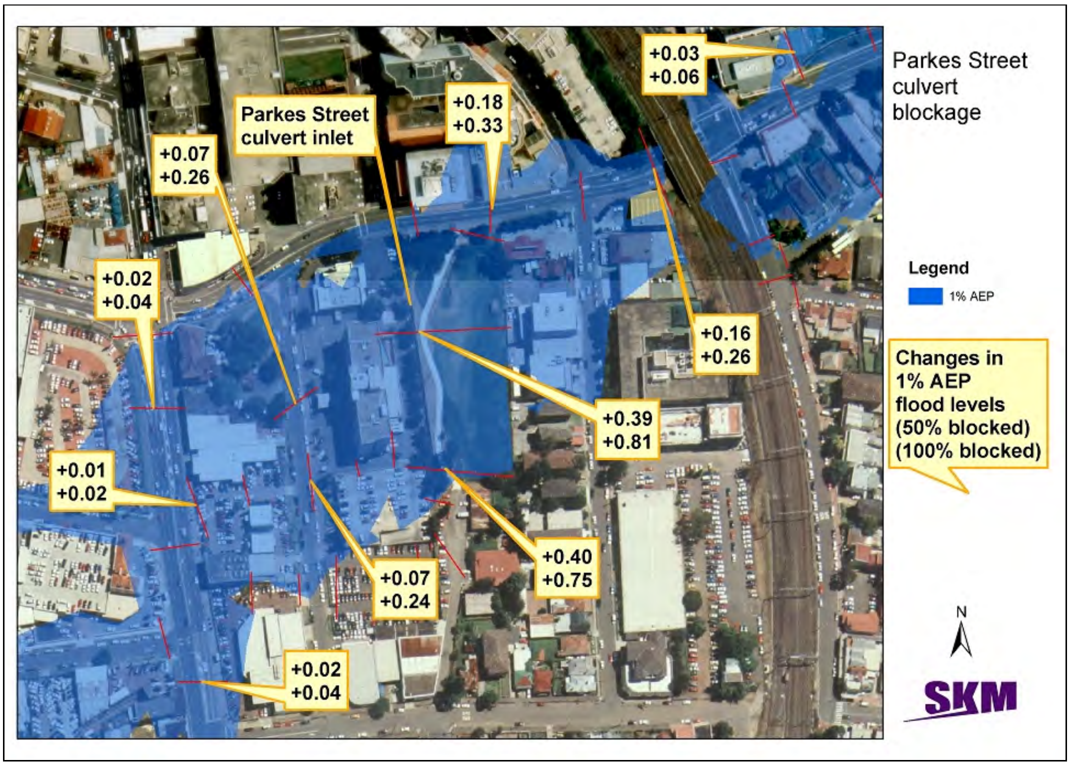
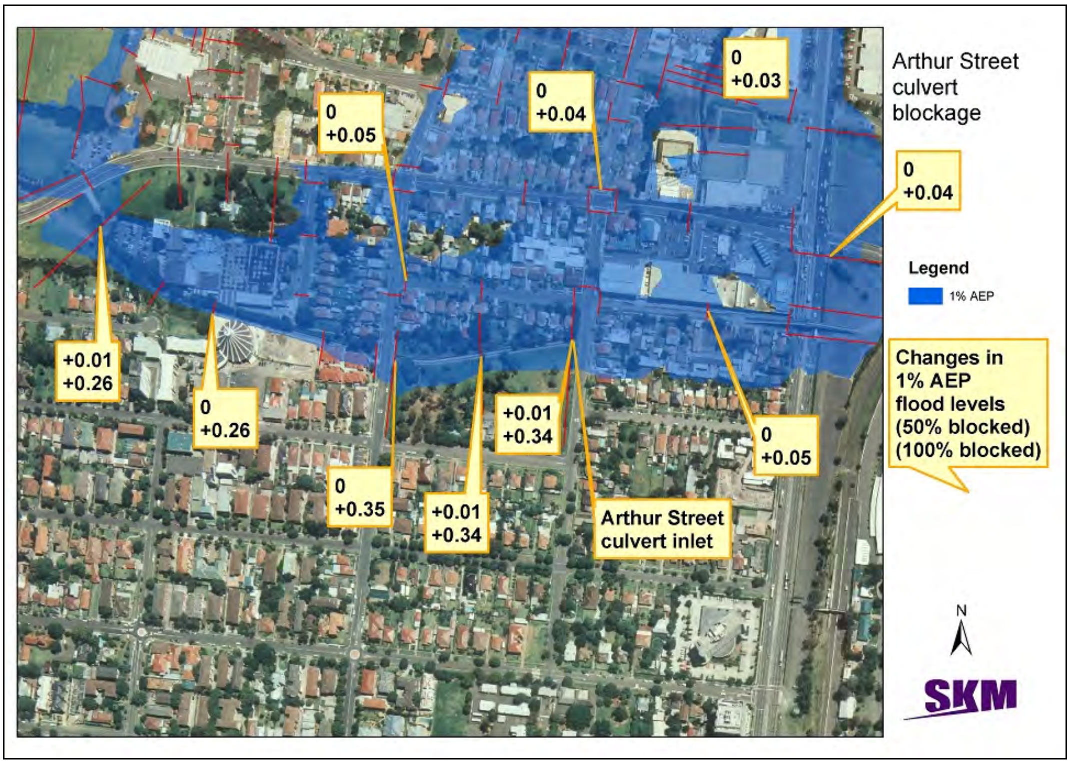


Figure 6-8 Blockage at Park St



■ **Figure 6-9 Blockage at Arthur St**



6.7 Other Flood Modification Measures

In the section above, works have been described which can reduce flood levels in some areas of Clay Cliff Creek. For the entire study area, it is recommended that the PCC will continue to follow UPRCT's On-Site Detention Policy for both new development and re-development.

Excluding the Clay Cliff Creek, other areas within the study area, there is limited opportunity to carry out flood modification measures. However the proposed more detailed studies of each of the tributaries, may identify options such as upstream retarding basins or other flood management options. Within the study area, the options for tributaries are limited to ensuring that the river or creek has sufficient capacity for the major floods (Channel Modification measures). Each of the waterways is discussed below in terms of the options for flood modification measures.

The area of Duck River upstream of the F4 freeway, Duck Creek and A'Becketts Creek were areas that the public identified as being particularly flood prone and a number of residents commented that vegetation in the creeks was to blame for the frequent and high flood levels. For their comments, see **Appendix D.**

This report makes some general comments and suggestions relating to channel maintenance in the tributaries within the study area but it is also recommended that these issues be upgraded and amplified in the individual tributary studies that Council are undertaking.

6.7.1 Parramatta River

Rivers such as the Parramatta River are subject to siltation from upstream land use and development which has the effect of reducing flood capacity and raising flood levels. Similarly excessive vegetation can reduce capacity. However with a regular dredging and maintenance program to keep the Parramatta River deep and wide enough for the River Cats, this is not an issue and no other works can be recommended for the river.

6.7.2 Duck River

The downstream section of Duck River, south of the F4 Freeway, is quite wide and although there are significant areas of vegetation, the centre section of river is clear and it is not considered necessary or desirable to carry out any works, other than routine maintenance.

However for the area upstream of the F4, the river has only limited capacity due to dense vegetation nearly blocking the river. **Figure 6-10** shows a 2003 aerial photograph of the confluence of Duck River and Duck Creek. It can be seen that the upstream section of Duck River and Duck Creek have only limited capacity due to vegetation (mangroves) growing across the watercourses. This vegetation is shown on **Figure 2-4** and the condition of the vegetation is discussed in **Table 2-1**.

6.7.3 Duck Creek

It can be seen from **Figure 6-10** Duck Creek is also quite blocked by vegetation, and a clear width of 20 metres would be desirable. Also routine cleaning of rubbish and dead vegetation would be desirable. In stream snags should be managed to the best practices as promoted by the NSW Department of Primary Industries.

6.7.4 A’Becketts Creek

Flooding has occurred historically in A’Becketts Creek, particularly in the area where the creek cross under James Ruse Drive close to the F4 freeway. However some of these flooding occurrences were due the construction of the road network. Subsequent cleaning and improvements has eliminated this as a cause of flooding but the problems of excessive vegetation and rubbish in the creek remains. It is recommended that routine selective clearing of woody debris and vegetation is carried out to ensure that adequate capacity is maintained. In stream snags should be managed to the best practices as promoted by the NSW Department of Primary Industries.

6.7.5 Subiaco and Vineyard Creeks

These creeks are relatively steep and therefore the length of the creek subject to tidal movement and within the study area is only a few hundred metres. Within this length of creek, the waterway is relatively open and no work is recommended other than routine cleaning.

6.8 Filling of Floodprone Land

An option which can be used in some areas subject to backwater flooding is to allow for filling of either individual blocks or whole precincts. In the floodprone areas of the Lower Parramatta River, there is limited opportunity to consider filling but in order to assess the affects of filling on flood levels, two areas were selected.

6.8.1 Oak Street

Oak Street is flooded in the 20 year ARI event and in the 100 year ARI event, the depth of flooding would exceed one metre. One option is to allow raising of the land to provide a flood free pad for house or unit development. However this type of works reduces the available flood storage on the floodplain and can lead to flood rises in the vicinity of the works or upstream.

In order to assess whether filling in this area was likely to have any adverse effects, the MIKE 11 hydraulic model was modified to represent filling of blocks on the south side of Oak St between Alfred and Arthur Street. The resulting changes to flood levels along Clay Cliff Creek are shown in **Figure 6-11.**

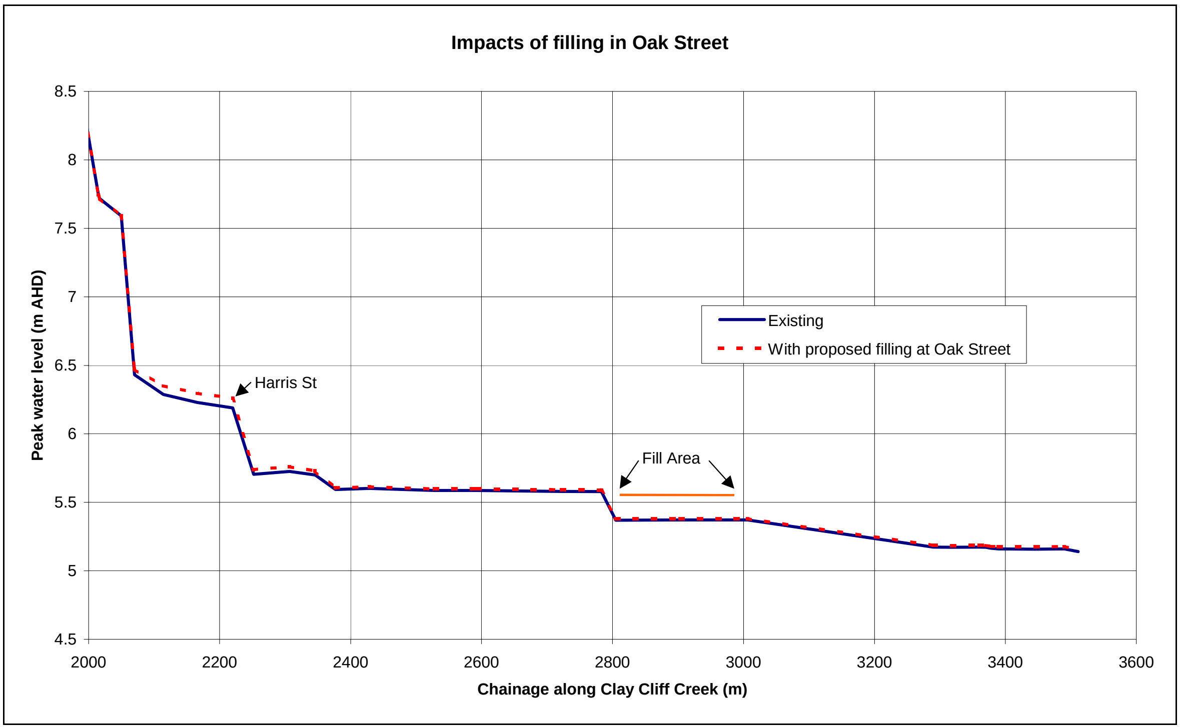
Table 6-3 shows the flood level differences in more detail. It can be seen that the effect of only a small area of filling is quite substantial with flood rises of up to 0.07 m (70 mm), in the area of Harris St. This shows that filling in the Oak Street on a large scale cannot be supported as it will cause significant flood rises elsewhere.

- **Figure 6-10 Duck River Area**

- **Table 6-3 Rise in Flood Level due to Filling – Oak Street[1]**

Location	Existing Water Level (m AHD)	With Filling Flood level (m AHD)	Change in Flood Level (+= rise m)
Parke St (Railway)	9.15	9.15	0.00
Wigram St	7.59	7.59	0.00
Harris St	6.19	6.26	0.07
Park St	5.70	5.73	0.03
Alfred St	5.58	5.59	0.01
Arthur St	5.37	5.38	0.01
Hassall St	5.18	5.19	0.01
Grand Ave North	5.17	5.19	0.01
River Road West	5.16	5.18	0.02
Parramatta River	4.96	4.96	0.01

- **Figure 6-11 Option of Filling in Oak Street**



Based on these results, it is concluded that the area is an important part of the floodplain storage and the loss of the storage would cause flood levels elsewhere to rise by an unacceptable amount.

[1] Flood levels are peak levels for all storm durations and so are higher than the two hour storm.

6.9 Levee Construction

Another option for reducing flood impacts is to protect an area with a levee. Again this reduces the available flood storage but one option of a levee around the Shell refinery site was investigated.

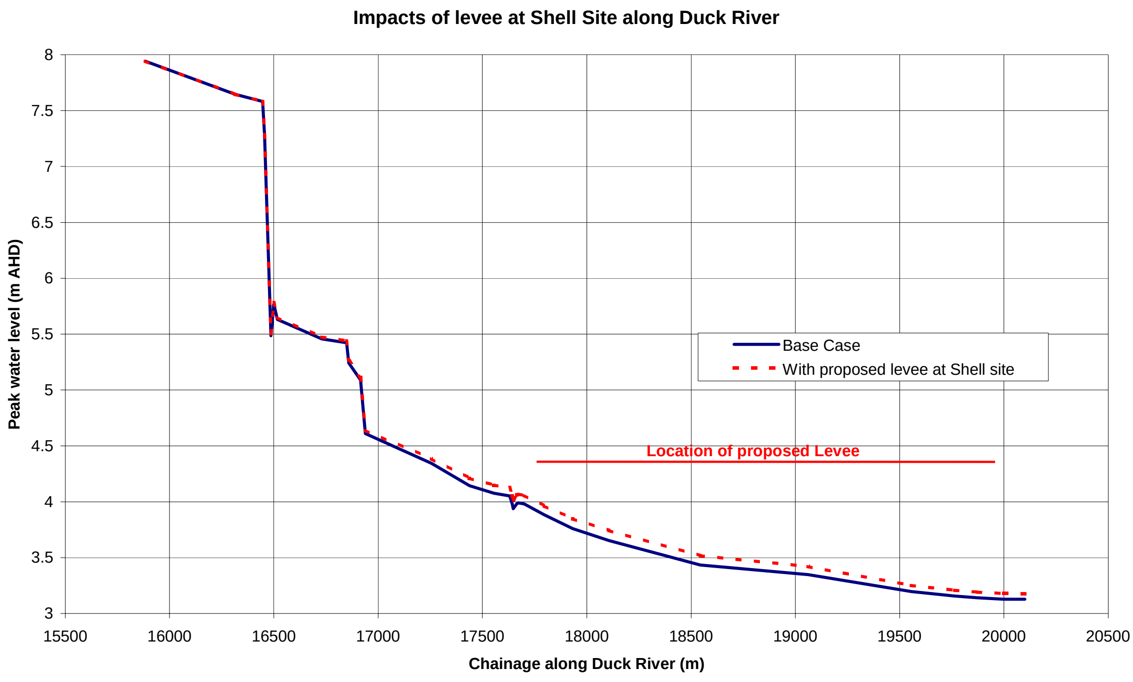
6.9.1 Levees around the Shell Site

A further option that was considered was to allow Shell to provide a levee around the boundary of the oil refinery on the bank of Duck River at Clyde. This levee would have the benefits of reducing flood damage and the risk of oil from the site entering the creek system in times of major floods.

However the proposed levee reduces available flood storage and raises flood levels by about 80 mm over a length of nearly 2 kilometres as shown in **Figure 6-12.**

A rise of this magnitude over such a long distance could not be justified and reinforces the importance of floodplain storage in reducing flood levels.

- **Figure 6-12 Effect of Shell Levee on Duck River**



6.10 Summary of Flood Modification Options

There is limited opportunity for flood modification measures. A summary of the proposed works is shown in **Table 6-4** and described below.

Flood levels along Clay Cliff Creek can be reduced by the construction of one or both of the following works:

- **Stage 1 -** Providing an embankment around the eastern and southern sides of Ollie Webb Reserve, to a maximum height of 18.0 m AHD to act as a detention basin. No excavation would be involved. It was assumed that this embankment would have side slopes of 1 (vertical) in 5 (horizontal). The detention basin would have an outlet consisting of a culvert 2.0 m wide by 1.8 m high.

- **Stage 2 -** Diverting flow from Clay Cliff Creek at Harris Street directly to the Parramatta River to the north with a culvert through Thomas Reserve, covering a distance of approximately 320 m. The culvert proposed by 4.5 m wide and 2.4 m high.

As discussed in **Appendix D**, the cost of these works is estimated at $1,975,000 for an estimated average annual reduction in damages of approximately $150,000. This results in an estimated benefit cost ratio of 0.9.

It is recommended that PCC will continue to follow UPRCT's OSD policy. While no other flood structural work is proposed, the following works need to be undertaken to ensure that flooding does not become worse in the future:

- **Duck River,** ensure that there is adequate waterway area in Duck Creek upstream of the expressway to ensure that flood levels do not rise significantly compared to historical levels and compared to the situation assumed for the modelling.
- **Duck Creek,** is also quite blocked by vegetation, routine clearing of rubbish and dead vegetation would be desirable. In stream snags should be managed as far as practical to the best practices promoted by the NSW Department of Primary Industries.
- **A'Becketts Creek**, particularly in the area where the creek cross under James Ruse Drive close to the F4 freeway needs routine selective clearing of debris and vegetation to ensure that adequate capacity is maintained. In stream snags should be managed as far as practical to the best practices promoted by the NSW Department of Primary Industries.

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Table 6-4 Summary of Recommended Flood Modification Measures

Prior-ty	Location of Works	Description	Cost
1	Ollie Webb Reserve	Construction of a detention basin in Clay Cliff Creek	$380,000
3	Thomas Reserve	Construction of a underground box culvert to divert part of flood flow directly to Parramatta River	$1,640,00
2	A'Becketts Creek	In the tidal zone, carry out de-snagging and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Duck Creek	In the tidal zone, carry out cleaning and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Duck River	In the tidal zone, carry out cleaning and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Whole area	Carry out routine maintenance to remove rubbish from channels and waterways in order to reduce the risk of blockages	$15,000 pa

7. Property Modification Measures

7.1 Floodplain Planning

The following sub-sections of this report outlines both the traditional approach to floodplain planning and a recommended alternate approach which has been adopted by many councils in NSW.

7.1.1 Objectives of Floodplain Planning

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

Risk can be simply defined as a product of frequency and consequence. The frequency (or probability of a flood) is a natural phenomenon which cannot be controlled by structural mitigation works to any substantial degree in the LPRC floodplain. The consequence of a flood varies with the nature of the hazard (depth, velocity, warning time, etc) and what it impacts (property and people). The control and management of land use provides the most effective means of managing the consequences of flood and, hence, minimising flood risks. For example, the consequences of a hospital being subject to increased depths of fast moving floodwaters with no warning could be an unacceptable risk to the community, while shallow backwater flooding of a plant nursery with adequate warning times may be an acceptable risk.

Floodplain risk management traditionally involved defining the flood level (usually for the 100 year ARI event) and then setting the floor level of buildings at the floor level plus an allowance for freeboard. However flood management involves more than setting a floor level, (now termed Flood Planning Level) (FPL). It is about comprehensively managing the risk to people and assets for a range of floods both below and above the 100 year ARI event by applying and integrating a range of available measures.

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

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

- distribution of development within the floodplain in a manner which does not recognise the risks to life or the economic costs of flood damage;

- polarisation of the floodplain into areas that are ‘flood prone’ and perceived ‘flood free’ areas;
- lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there are very few measures in place to manage the consequences of flooding above the FPL);

Accordingly, continuation of the sole reliance on the 100 year ARI FPL is inappropriate if a generic flood risk management approach is to be developed for the Lower Parramatta River area.

7.1.2 Flood Planning Levels (FPL’s)

The flood planning level (FPL) is the level below which a Council places restrictions on development due to the hazard of flooding. FPL is the current preferred terminology in the FDM (2005) replacing ‘flood standard’ or ‘designated flood’, which were used by the previous FDM (1986).

Consistent with the above philosophy, the danger in adopting FPL’s below the PMF is that they are recognised by the community as definitive advice as to whether a flood hazard exists or not. Further, there has traditionally been an approach where a singular FPL (or flood standard) has been chosen which creates significant limitations on a holistic approach to managing the flood risk in the floodplain. The reality is that various land uses are subject to alternate consequences (risks) from the flood hazard. Accordingly, there needs to be a simplistic approach of reflecting the different flood risk to different land uses within the floodplain, while maintaining an understanding that flood risks still occur, regardless that flood controls may not be imposed. The planning matrix approach discussed below is the recommended methodology to address these issues.

PCC has historically used the 100 year ARI flood plus a 0.5m freeboard as the standard flood, or the flood upon which to base the FPL. This is the same risk level that has been adopted by UPRCT and PCC for the Upper Parramatta River and so there will be consistency across the LGA.

7.1.3 The Planning Matrix Approach

Given that some floodplains have an extensive flood range, and given the difficulty in addressing the associated variability in flood risks with simple rules, the use of the planning matrix approach (D. Bewsher and P. Grech, 1997) is recommended.

Using this approach, a matrix of development controls, based on the flood hazard and the land use, can be developed which balances the risk exposure across the floodplain. This approach has been adopted as part of the Hawkesbury–Nepean Flood Management Strategy (1997). After its original application in the Eastern Creek and Tributaries Floodplain Management Plan, this approach has also now been applied within many LGAs and the resulting matrix of planning controls has been pivotal in the new draft DCPs and LEPs recommended for implementation as part of these FRMPs.

7.1.4 Planning Matrix for Lower Parramatta River

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, while the second stage is to divide the floodplains into different areas subject to similar levels of risk.

In regard to the first stage, it is noted that this FRMP relates only to the Lower Parramatta River catchment River (LPR) Floodplain. Notwithstanding, it is our approach that PCC would benefit considerably by having a singular policy document which applies to all floodplains within its LGA.

The approach intended to be adopted to satisfy the above objective, is to prepare singular DCP/Policy controls which have 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.

The second stage in the preparation of the planning matrix is to identify different Flood Risk Precincts (FRPs), reflective of the variable flood risk within each of the separate floodplains. Flood risk precincts (previously referred to as hazard bands) have been identified for LPR.

In regard to this study, the three FRPs shown in **Table 7-1** are proposed:

- **Table 7-1 Definition of Flood Risk Precincts**

Precinct	Description
• **High Flood Risk**	This has been defined as the area within the envelope of land subject to a high hydraulic hazard (in accordance with the provisional criteria outlined in the Floodplain Development Manual, 2005) in a 100 year ARI flood event. 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 significant risk of flood damages or to ensure safe evacuation with reasonable flood related building and planning controls.
• **Medium Flood Risk**	This has been defined as land below the 100 year ARI flood level. In this precinct there would still be a significant risk of flood damage, of evacuation difficulties and risk to life, but these damages or risk to life can be minimised by the application of appropriate development controls.
• **Low Flood Risk**	This has been defined as low hazard (as defined in the 2005 FDM) areas which is all other land within the floodplain (ie. within the extent of the probable maximum flood) but not identified as either within a high flood risk or medium flood risk Flood Risk Precinct. There will be a low cost benefit to compulsorily apply flood related development controls, where risk of damages

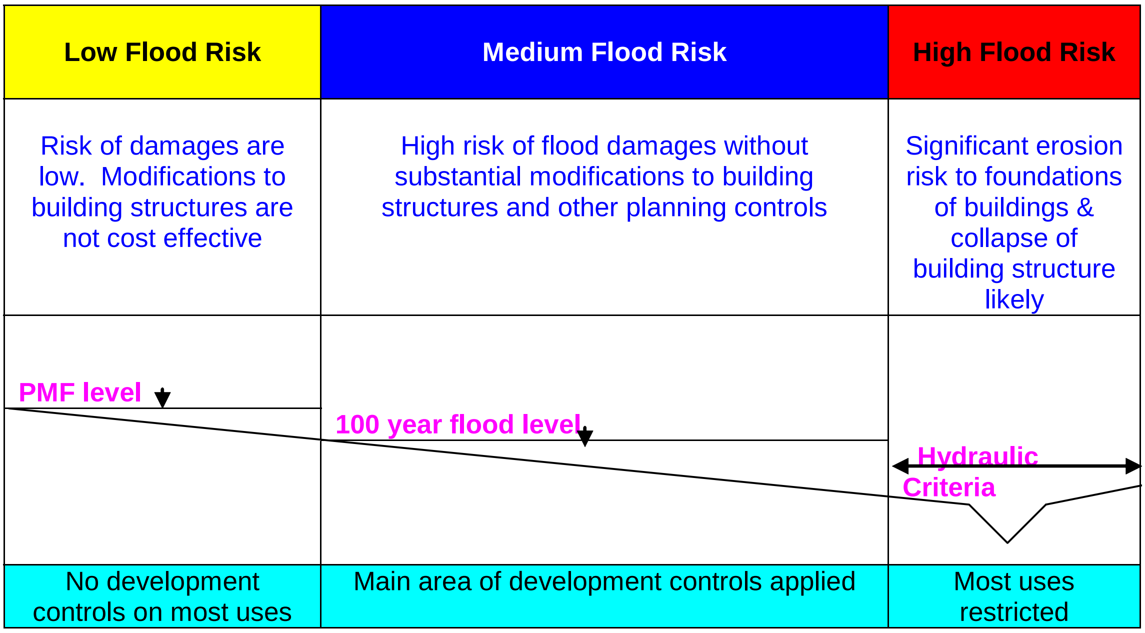
Precinct	Description
	are low for most land uses. The low flood risk precinct is that area above the 100 year ARI flood and most land uses would be permitted within this precinct.

The FRPs delineated above have been formulated to provide a basis for strategic planning and development control having regard to the specific characteristics of the Lower Parramatta River Floodplain.

The Low Flood Risk FRP is that area above the 100 year ARI flood which is potentially subject to flooding, but is not included in any of the other FRPs. This area is still subject to some flood-related risk and those uses which may be considered critical or should be afforded maximum protection against risk from flooding are to be identified as undesirable land uses in this precinct.

The other major purpose for this FRP 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. The diagrammatic definition of the precincts and their implications for planning controls are depicted on **Figure 7-1**.

- **Figure 7-1 Definition of Planning Precincts**



Using the methodology outlined in this section, the Flood Risk Precinct Maps were prepared for the study are and are shown in **Figure 7-2** and **Figure 7-3**.

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■ **Figure 7-2 Western Area Flood Risk Precinct Map**

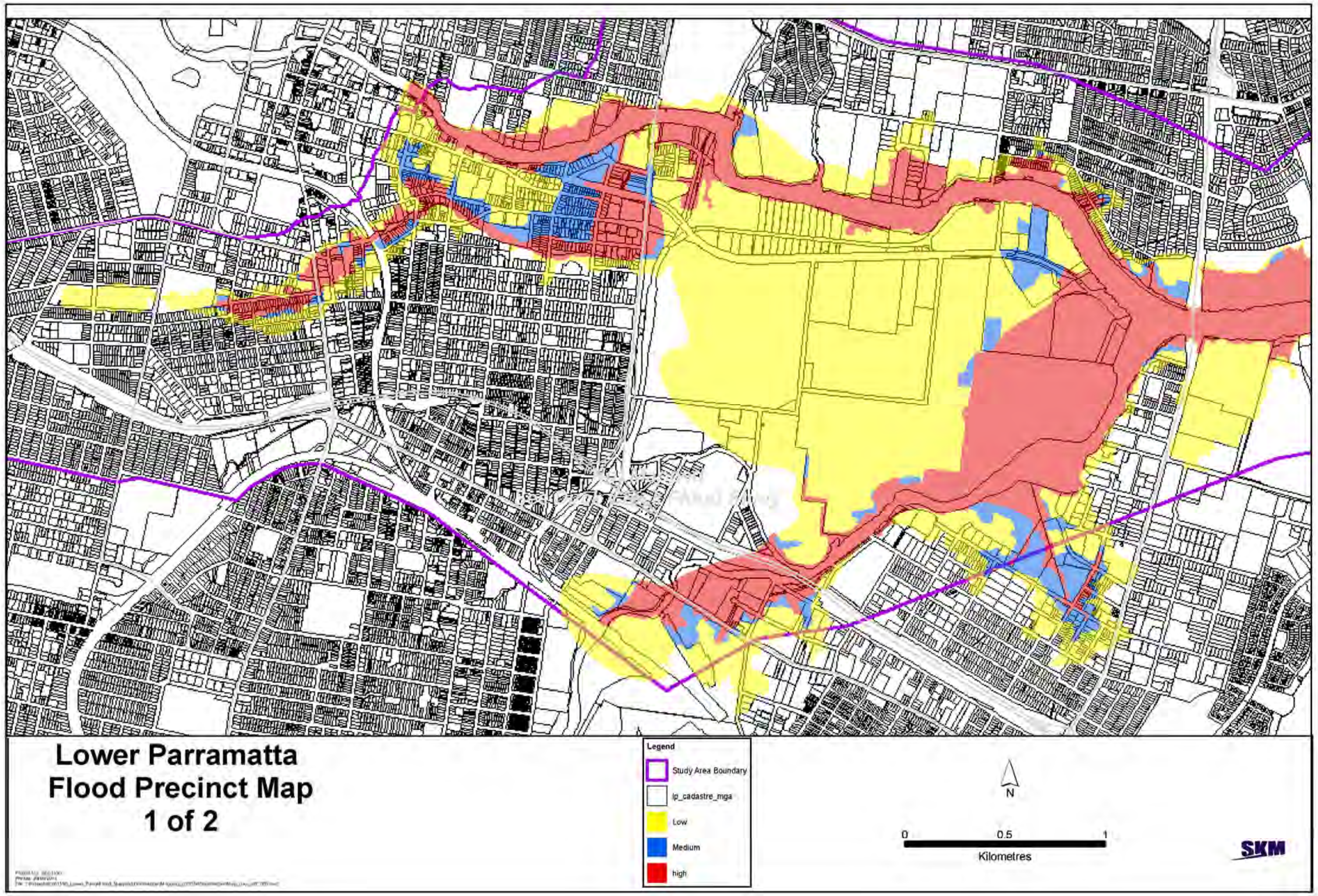
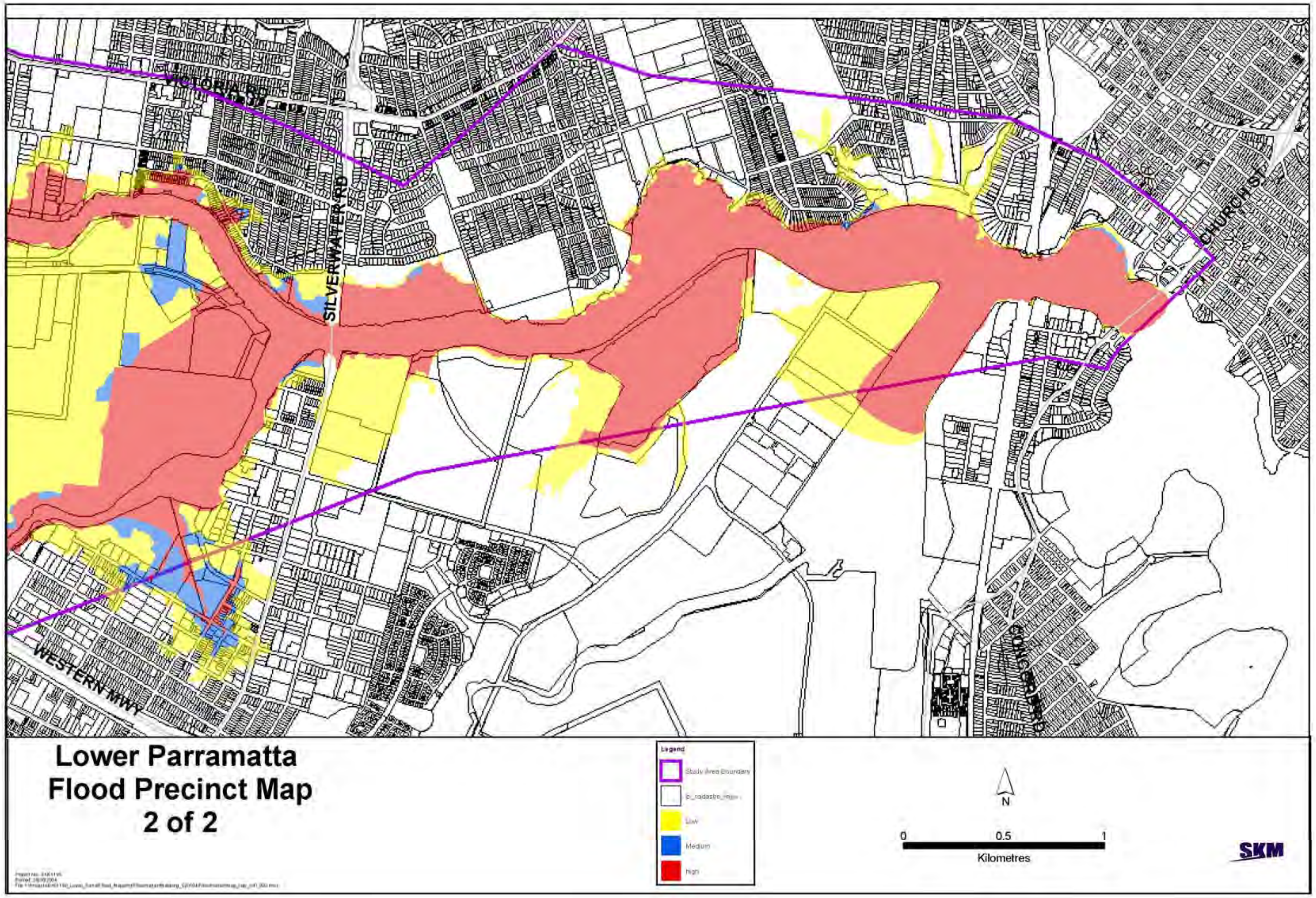


Figure 7-3 Eastern Area Flood Risk Precinct Map



The next component in the preparation of the planning matrix is to prioritise land uses within the floodplain. This is achieved by identifying discreet categories of land uses, of similar levels of sensitivity to the flood hazard.

These categories are subsequently listed under each FRP in the planning matrix dependent upon the level of flood risk which is considerable acceptable. This provides a basis to specifying whether certain categories are unsuitable land uses in different parts of the floodplain or whether they are suitable subject to varying degrees of development control.

The next component in the preparation of the planning matrix is to assign different planning controls to seek to 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.

There should be variance to the stringency of development controls reflecting the attitudes of the community, the sensitivity of the land use category to the flood hazard, and the location of the land use within the floodplain. This has been determined having regard to the characteristics of the study area and with reference to existing research.

7.1.5 Implementation of the Planning Matrix Approach

The most appropriate mechanism for the implementation of the proposed flood policy is its adoption by Council as a DCP or associated Policy documents.

A singular planning matrix has been prepared as a component of this FRMS for the LPRC Floodplain and incorporated into the draft DCP/Policy. It is shown as **Figure 7-4.**

The floodprone areas within the study area have been divided into the three flood risk precincts discussed above. These precincts are based on the flood hazard discussed in **Section 3** but have been modified to reflect other types of risk such as isolation, access and egress.

7.1.6 Freeboard

Figure 7-4 requires development to be constructed above, usually, the 100 year ARI plus an allowance for freeboard. This then provides the Flood Planning Level. Freeboard can be set at what ever value that is considered reasonable given the risk associated with flooding. In the case of PCC, a freeboard allowance of 0.5 metres has historically been applied to all flood levels. This allowance takes into account such risks as inaccuracies in the modelling, changes to the land use, (imperviousness etc), wave action and unexpected restrictions in the channels such as blockages. It is recommended for the Lower Parramatta River area, that the freeboard allowance of 0.5 metres be continued.

Figure 7-5 Floodplain Matrix of the Lower Parramatta River Catchment

Planning & Development Controls

Flood Risk Precincts (FRP's)

Low Flood Risk

Planning Consideration	Sensitive Uses & Facilities	Critical Utilities & Uses	Subdivision	Filling	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level	Unsuitable	3	Not Relevant	Not Relevant	2 5	2 5	2 5	Not Relevant	Not Relevant
Building Components	Unsuitable	2	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant
Structural Soundness	Unsuitable	2	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant
Flood Affectation	Unsuitable	2	2	1	2	2	2	Not Relevant	Not Relevant
Car Parking & Driveway Access	Unsuitable	1 3 5 6	Not Relevant	Not Relevant	1 3 5 6	1 3 5 6	1 3 5 6	2 4 6 7	Not Relevant
Evacuation	Unsuitable	2 4 6	5	Not Relevant	3 4	4	4	Not Relevant	Not Relevant
Management & Design	Unsuitable	2 3 4	1	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant

Medium Flood Risk

Planning Consideration	Sensitive Uses & Facilities	Critical Utilities & Uses	Subdivision	Filling	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level	Unsuitable	Unsuitable	Not Relevant	Unsuitable	2 5	2 5	2 5	1 5	4 5
Building Components	Unsuitable	Unsuitable	Not Relevant	Unsuitable	1	1	1	1	1
Structural Soundness	Unsuitable	Unsuitable	Not Relevant	Unsuitable	1	1	1	1	1
Flood Affectation	Unsuitable	Unsuitable	1	Unsuitable	1	1	1	2	1
Car Parking & Driveway Access	Unsuitable	Unsuitable	Not Relevant	Unsuitable	1 3 5 6 7	1 3 5 6 7	1 3 5 6 7	2 4 6 7	1 5
Evacuation	Unsuitable	Unsuitable	5 3 4	Unsuitable	3 4 6	3 4 6	3 4 6	1 4	3 6
Management & Design	Unsuitable	Unsuitable	1	Unsuitable	2 3 4	2 3 4	2 3 4	2 3 4	2 3 4

High Flood Risk

Planning Consideration	Sensitive Uses & Facilities	Critical Utilities & Uses	Filling	Subdivision	Residential **	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	1 5	4 5
Building Components	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	1	1
Structural Soundness	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	1	1
Flood Affectation	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	1	1
Car Parking & Driveway Access	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	2 4 6 7	1 5
Evacuation	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	1 4	3 4 6
Management & Design	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	2 3 4	2 3 4

Not Relevant   Unsuitable Land Use   ** For redevelopment of an existing dwelling refer also to 'Concessional Development' provisions

NOTES

1. *Freeboard* equals an additional height of 500mm.

2. The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. The above matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.

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

4. Any fencing that forms part of a proposed development is subject to the relevant Flood Affectation and Structural Soundness planning considerations of the applicable land use category.

5. Some developments will need to have regard for the Foreshore Building Line and all its objectives, as per the relevant environmental planning instrument.

6. Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the local government area.

Floor Level

1	All floor levels to be equal to or greater than the 20 year *ARI flood level* plus *freeboard*.
2	Habitable floor levels to be equal to or greater than the 100 year *ARI flood level* plus *freeboard.*
3	All floor levels to be equal to or greater than the *PMF* level plus *freeboard.*
4	Floor levels to be equal to or greater than the 100 year *ARI flood level* plus *freeboard*. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical and, when undertaking alterations or additions, no lower than the existing floor level.
5	A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated above finished ground level, confirming that the subfloor space is not to be used in any form.

Building Components & Method

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

Structural Soundness

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

Flood Affectation

1	Engineers report required to certify that the development will not increase *flood affectation* elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple potential developments in the same catchment.
2	The impact of the development on flooding elsewhere to be considered, having regard to the three factors listed in consideration 1 above.

Car Parking and Driveway Access

1	The minimum surface level of open spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level.
2	The minimum surface level of open parking spaces or carports shall be as high as practical, but no lower than 0.3m above the 20 year ARI flood level.
3	Garages capable of accommodating more than 3 motor vehicles on land zones for urban proposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level.
4	The driveway providing access between the road and parking spaces shall be as high as practical and generally rising in the egress direction.
5	The level of the driveway providing access between the road and parking shall be no lower than 0.2m below the 100 year ARI flood level.
6	Enclosed car parking and car parking areas accommodating more than 3 vehicles, with a floor below the 100 year ARI flood level, shall have adequate warning systems, signage, exits and evacuation routes.
7	Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood.

Evacuation

1	Reliable access for pedestrians required during a 20 year *ARI peak flood.*
2	Reliable access for pedestrians and vehicles required to a publicly accessible location during the *PMF peak flood.*
3	Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the *PMF level*, either on site (eg. second storey) or off site.
4	Applicant to demonstrate the development is consistent with any relevant *flood evacuation strategy* or similar plan.
5	Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development resulting from the subdivision.
6	Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel.

Management and Design

1	Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with the relevant FRMS and FRMP.
2	Site Emergency Flood Response Plan required where the site is affected by the 100 year ARI flood level, (except for single dwelling-houses).
3	Applicant to demonstrate that area is available to store goods above the 100 year *ARI flood level* plus *freeboard.*
4	No storage of materials below the 100 year *ARI flood level.*

7.2 Foreshore Building Alignment

An important part of land use planning is to define the land where it is undesirable to build. PCC have already developed a Foreshore Building Alignment based on a 25 metre set back from the Lower Parramatta River in order to preserve, primarily the scenic qualities of the river. In conjunction with PCC the consultant has now extended this concept to incorporate the following features to incorporate three areas where planning controls are desirable, these being:

- To identify, preserve and enhance important vegetation communities by the restriction of development and consequent clearing within these areas and associated buffer areas. As discussed in **Section 2.6.3**, and shown in **Table 2-2**, a buffer has been provided for each type of vegetation. The areas mapped by the consultant may require refinement during the process of defining the foreshore building line to take into consideration on-site practical difficulties in implementing buffer areas where they extend into areas of existing extensive development.

- To provide an open setback area from the waterway corridors, within which minimal development occurs and a predominance of landscaping prevails, to provide for the preservation and enhancement of the scenic qualities of these corridors. This line is based on the existing PCC Foreshore Building Alignment,

- To identify the areas of high flood risk within the Flood Risk Precinct maps where new development is generally undesirable and redevelopment and alterations and additions to existing buildings must be stringently controlled to minimise potential damages to property and risk to human life. These areas are shown in **Figure 7-2** and **Figure 7-3**.

Further refinement of the flood risk precinct maps may be undertaken by Council to reflect changes to the study area which have occurred since initial mapping was undertaken (such as the filling of land and implementation of flood mitigation works).

It is recognised that the foreshore building line effectively represents a development standard, and Council may from time to time need to exercise appropriate flexibility in varying the setback restrictions of the foreshore building line, through the application of State Environmental Planning Policy No. 1 - Development Standards. The provision of an objective will be important in assessing any objections to the standard.

The three areas defined above have been mapped as an envelope encompassing the which ever of the three areas provides the extremity of the envelope. The resulting Foreshore Building Line is shown in **Figure 7-5** and **Figure 7-6**.

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- **Figure 7-5 Foreshore Building Alignment –West**

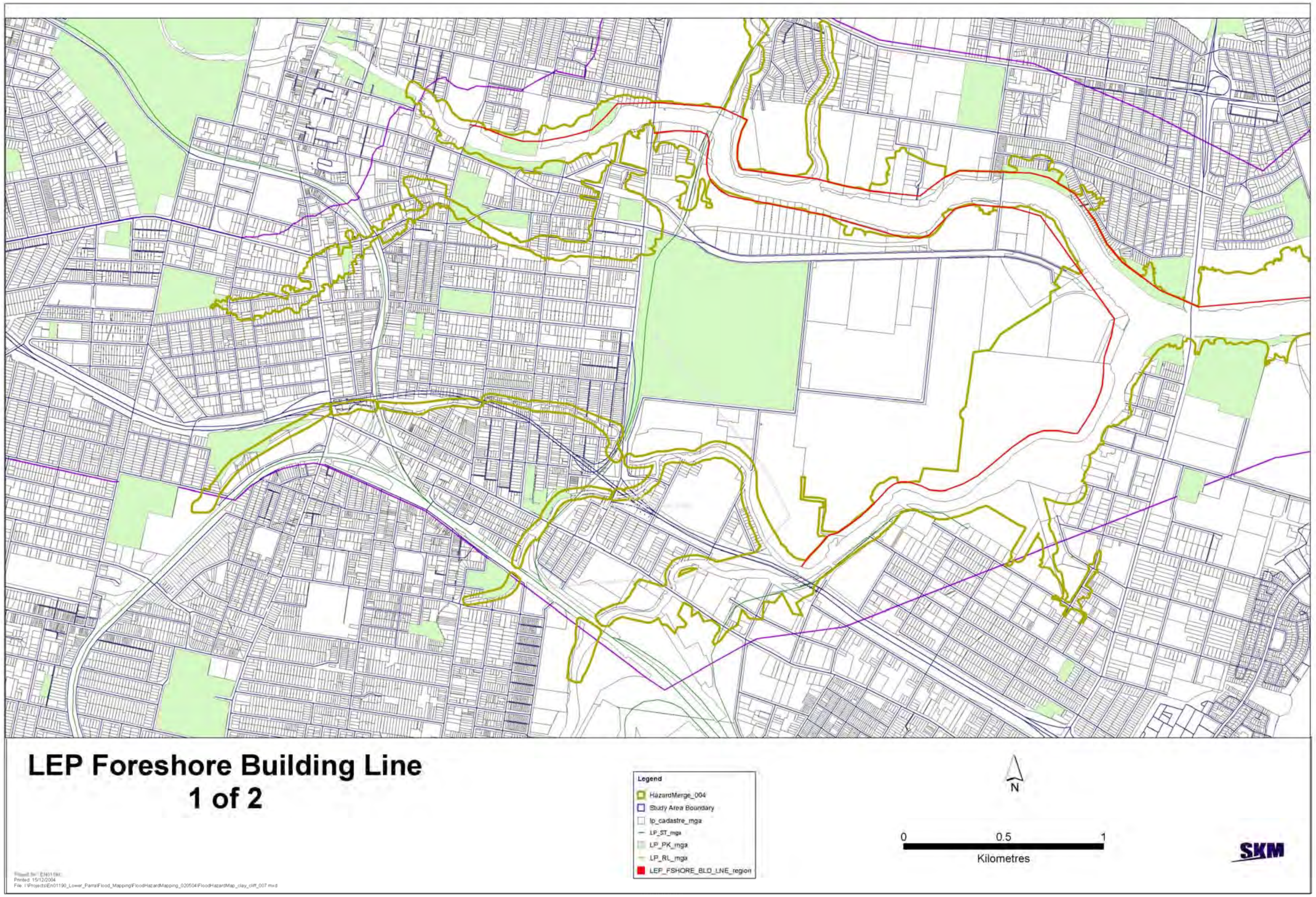
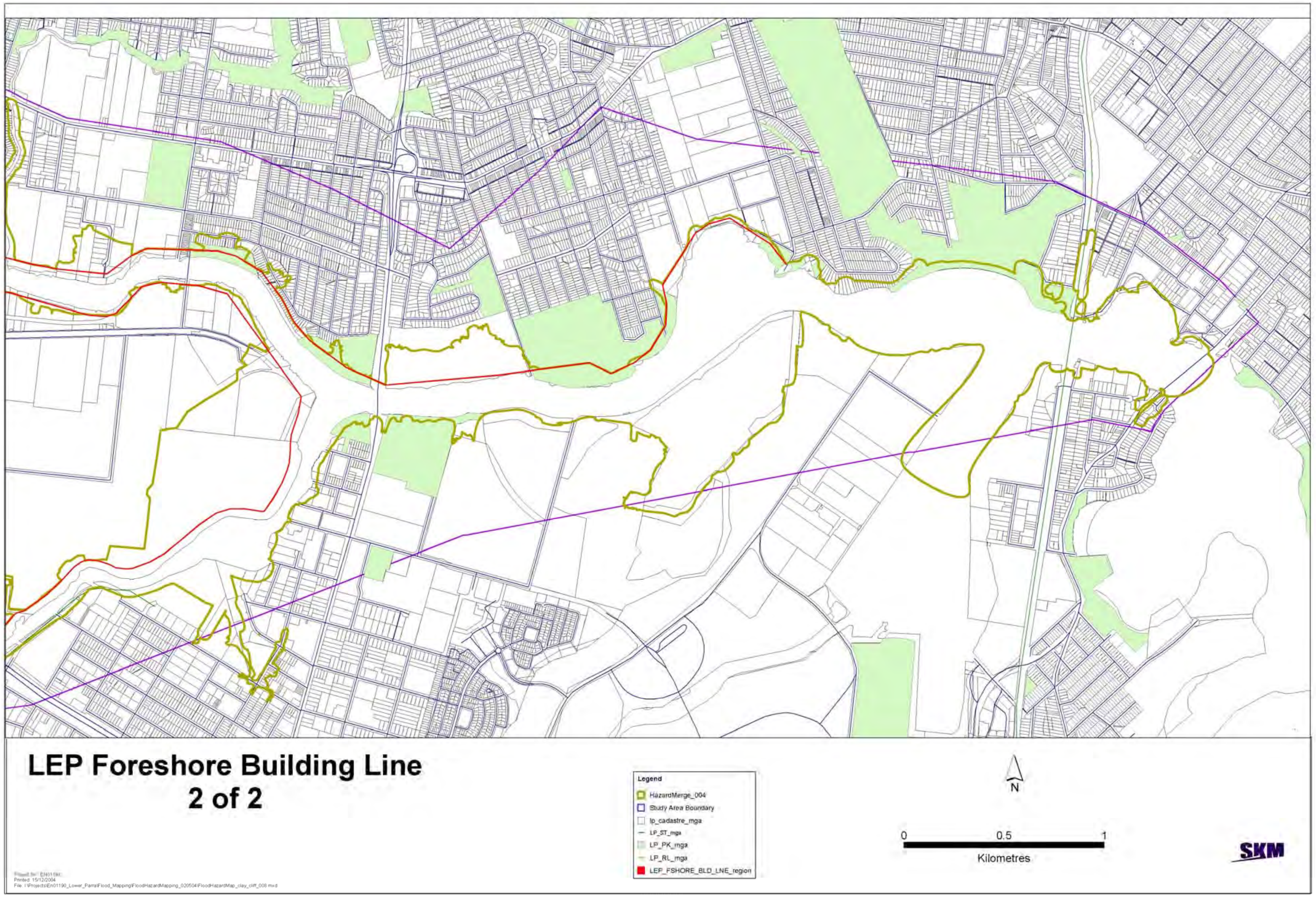


Figure 7-6 Foreshore Building Alignment – East



7.3 Voluntary House Purchase and Voluntary House Raising

In some situations, the Property Modification Measures known as Voluntary House Purchase (VHP) or Voluntary House Raising (VHR) are options which can be considered. VHP can be very expensive and so it is only used infrequently for very severely flooded properties. PCC have a VHP program in place for severely flooded houses in North Wentworthville. VHR involves placing beams under the house and jacking it up so that the floor level is above the 100 year flood event. This has been extensively used in Fairfield LGA with some success and has been recommended by SKM for areas along Blacktown Creek in Blacktown City Council area.

A set of criteria that can be used for assessment of the suitability of houses for raising is as follows:

- The houses have weatherboard, metal or fibrous cement exterior (ie a flexible cladding, double brick or brick veneer houses are very expensive to raise)
- The areas is not planned to be redeveloped or rezoned
- Flooding above the floor occurs quite often (say in a 20 year event)
- There are no plans for any other form of flood mitigation
- Owners are in favour of house raising and may be willing to contribute to the raising
- The depth of flooding is such that the house raising would be not more than 2.4 metres (owners generally opt to raise at least 2.4m so that the subfloor can be used) to ensure that the floor is above the 100 year flood planning level
- Area zoned for single house development (commercial and industrial areas are generally not suitable)

As an example, the photograph below in **Figure 7-7**, shows the house at 21 Cornell St, Seven Hills which had been raised and then had a brick veneer added. It can be seen that raising the house provided opportunities for increased storage and a garage and some views over the surrounding land. However, in some cases, there will be a need to ensure that there is sufficient waterway area at ground level, so in-filling may not be permitted.

The potential benefits of house raising, particularly if the house is subject to frequent over-floor flooding. As can be seen from **Figure 10-1** in **Appendix B**, the cost of damage in each event will often exceed $10,000 and can exceed $30,000 depending upon the size of house and depth of flooding. The one-off cost of the raising can therefore be justified for houses which are frequently flooded.

■ **Figure 7-7 House Raised at 21 Cornell St, Seven Hills**

7.3.1 Cost of House Raising

Discussion with staff at Fairfield City Council who have extensive experience of house raising, say that the cost is approximately $10,000 for the actual jacking but other work[2] increases the overall cost to $40,000 for a fibro/weatherboard house. Allowing for a contingency of $10,000, it would be reasonable to allow $50,000 per house.

7.3.2 Damages after House Raising

House raising will not eliminate all damages, particularly as floods will still inundate garages, under the house and in the PMF event, it would be expected that the flood would still be above the floor. However house raising can significantly reduce flood incidents and severity.

7.3.3 Non Quantifiable Benefits

As part of a separate study, the consultants interviewed a number of residents in Blacktown, NSW who reported that even though flood waters had entered their houses infrequently, there was a constant worry that when ever it rained heavily, it would flood again. As soon as they experienced heavy rain, they started packing up valuables but they have no way of knowing if the water will reach their floor levels. However, once the house is raised residents will not have to move valuables as frequently as they did in the past before the house was raised.

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[2] Work such as temporary service connections, reconstruction of concrete floors, steps, reconstruction of services, preparation of plans for raising and supervision.

7.3.4 Potential Areas for House Raising

An inspection was made of floodprone areas within the study area where house raising could be considered. The review was based on:

- Areas which would be flooded in the 20 year event (ie the areas was subject to frequent flooding)
- A number of houses in the street would be flooded above the floor

The following streets were reviewed:

Lansdowne Street: Landsdowne Street is flooded in the 20 year flood on the south side of the road from Clay Cliff Creek floods, see **Figure 7-8**. Proposed works in Ollie Webb Park would reduce the flooding depth but the houses would still be flooded in a major flood. There are about 14 clad houses which could be considered for a house raising program.

- **Figure 7-8 Lansdowne Street**

Church, Wentworth and Cooper Streets: These streets are flooded in the 20 year ARI event but the two streets are now fully commercial areas and do not contain any clad residences and so would not be considered in any VHR program.

Gregory Place: Gregory Place is a short cul-de-sac on the south side of Hassall Street. It is quite severely flooded in the 20 year ARI event and there are about 6 clad houses on the east side of the street that would be ideal candidates for house raising, see **Figure 7-9**. The area on the west of the street is commercial brick buildings and not suitable or eligible for house raising.

- **Figure 7-9 Gregory Place**

Clay Cliff Creek runs along the southern end of Gregory Place and on the south side (right bank) of the creek, is a villa type development, see **Figure 7-10** which provides an imaginative example of how new development can accommodate flooding from the creek.

- **Figure 7-10 Villa Development on Clay Cliff Creek**

Oak Street and Arthur St: Oak Street runs parallel to Hassall Street and Clay Cliff Creek runs behind the houses on the south side of the road. The houses on the south side are therefore quite flood prone in the 20 year event. In the section of the road between Arthur St and James Ruse Drive, the houses are generally brick but in the section between Arthur and Alfred St there are about 8 clad houses, see **Figure 7-11** that would be suitable for house raising or for a consolidated villa or unit development.

- **Figure 7-11 Oak Street West of Arthur St**

Alfred Street, at the intersection with Oak Street, also has 3 clad houses that could be considered for house raising.

Pike and Antoine Streets: These two streets in Rydalmere are quite floodprone from a 20 year flood in the Parramatta River but the area is industrial and commercial and there are no residential dwellings in the floodprone areas.

Summary of House Raising

Table 7-2 summarises the streets and the number of houses that could be considered for VHR with a recommended priority for investigation and funding based on the perceived degree of flooding in each street.

SKM

Table 7-2 Summary of Streets for House Raising

Prior-ity for work	Street Name	Location	Number of Houses in Street	Estimated Cost of Works[3]
3	Landsdowne St	South side	14	$700,000
2	Gregory Place	East side	6	$300,000
1	Oak St	Between Arthur and Alfred St, south side	8	$400,000
1	Alfred St	Intersection with Oak St	3	$150,000
	Total Houses for VHR		**31**	**$1,550,000**

7.3.5 Voluntary House Purchase

If Council prefers VHP to VHR for these 31 houses, then the cost[4] would be approximately $12 to 15 million. More investigations is needed to justify the additional expense for the purchase.

[3] Based on an average cost of $50,000 per house, see Section 7.2.1. However, these works may be suitable for government subsidy and the cost to PCC reduced to about one third of the above costs.

[4] Based on the average cost per house of $400,000 to $500,000.

8. Response Modification Measures

It is known that residents in floodprone areas can reduce the cost of flood damage if they have sufficient warning and/or know what steps to take when a flood is imminent. This involves a number of actions which can be summarised as follows:

- Flood Education
- Community Flood Readiness
- Flood Prediction and Warning
- Local Flood Plans
- Emergency Management
- Recovery Planning
- Flood Insurance

The implementation of these plans requires a collaborative approach between PCC and other government agencies, particularly SES. PCC should consider implementing a program of public education using similar terms, brochures and procedures as for the Upper Parramatta River area, under the management of the Upper Parramatta River Catchment Trust. This will ensure consistency and avoid confusion in the minds of the public who might read brochures for both areas.

The principle agency, other than PCC involved at a local level is the State Emergency Service (SES) who have a vital role to play in nearly all the above community activities. Their role and recommended actions are outlined in the next section.

Options for community education are then discussed in subsequent sections.

8.1 State Emergency Service

The SES is responsible for dealing with floods in NSW (see web site: www.ses.nsw.gov.au). This includes planning for floods and educating people about how to protect themselves and their property. During floods, SES volunteers are responsible for flood safety advice, evacuation, rescue and the provision of essentials to people cut off by floodwaters.

As part of this study, detailed discussions were held with the SES. The Division Controller (full-time paid position) is located in the SES Sydney Western Division HQ in Seven Hills and his area of responsibility includes the Parramatta River catchment area as well as the Hawkesbury-Nepean River system.

Currently the office is being greatly expanded in order to be able to manage a major flood in the Hawkesbury River when thousands of residents may be flooded and isolated.

Specifically for the Parramatta River area, there is a Regional Controller (Volunteer) based in Parramatta. He has responsibility and financially autonomy, to carry out works in his area and if there was a major flood or other disaster, he could call on the Regional Office for further assistance.

As with most Government Agencies, they are limited by available budget and would like to be able to do more to assist in flood preparedness in the Parramatta area if they had more funds or could obtain grants from the government.

The SES advise that due to the 'flash flood[5]' nature of floods in the Parramatta River and its tributaries, the Bureau of Meteorology (BOM) is unable to provide flood warnings for this river system. However BOM provide warnings of heavy rainfall and hail when they are aware of the event but this does not translate to a flood warning.

SES operations are managed through a Flood Plan. A generic Plan is available for the whole of NSW but in priority catchments, subject to funding, a specific Flood Plan for a river system is prepared. A draft Flood Plan was prepared in 1993 but was not finished or adopted. The SES have advised that they would like to update the Plan and finalise it. However they would need to seek funding from Government for this project.

A Flood Plan provides a clear path of communication, a program of community education and a series of steps to be followed in times of flood. Such a Plan can go a long way to avoid the confusion and duplication of effort that can occur during emergencies. The completion and adoption of a Flood Plan for the study area is highly recommended.

SES make use of GIS maps, using MapInfo and have expressed a desire to have flood inundation maps prepared as part of this project made available to them for incorporation in their database.

In the area of public education, the SES can provide Councils and residents with valuable information to prepare themselves for floods. They prepare a Plan called FloodSafe which advises residents of the steps to be taken before, during and after a flood. A summary brochure, sent to all residence in the Hawkesbury-Nepean floodprone area is shown in **Figure 8-1**.

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[5] Flash floods are defined by the Bureau of Meteorology as having a flood warning time of less than 6 hours.

SKM

- **Figure 8-1 FloodSafe Brochure**

8.2 Flood Education

Flood education makes the community more aware of the risk and impacts of flooding. Some useful flood education activities that need to be included in a Flood Plan are:

8.2.1 Flood Risk Precinct Maps

Flood Risk Precinct Maps need to be prepared which shows all areas subject to flooding up to the PMF. The zones would be colour coded into Low, Medium and High Risk Precincts.

8.2.2 Brochure about Development in Flood Risk Precincts

The Flood Risk Precinct Maps, are tied to the Planning Matrix detailing the works that can be undertaken in each Risk precinct based on land use and zoning. This would be a new concept to most residents and a brochure explaining the process would be necessary.

8.2.3 Flood information Brochure

As discussed above, the SES, in conjunction with PCC can prepare a FloodSafe brochure similar to that shown in **Figure 8-1** to residents in floodprone areas. This will remind them that the area is potentially in a floodprone area.

8.2.4 Specific Flood Risk Advice

In order to avoid owners thinking that a flood brochure does not apply to them, there needs to a letter written specifically to an owner to advise that their property is in a flood risk precinct and what that means.

8.2.5 Section 149 Certificate

At times of sale of a property, a potential purchaser will seek a 149 certificate from council advising if the land is floodprone. If Council's records showed that the property was outside the 100 year ARI line then the property was deemed to be 'flood-free'. This concept has now been modified with consideration of flooding up to the PMF. This has now brought many more properties into the flood-prone category and requires a more complex form or response than simply flood-prone or flood-free. The issue of a 149 Certificate is discussed further in Volume 2 of this report and is covered in some detail in the Upper Parramatta River Catchment – Floodplain Risk Management Study and Plan, April 2003.

8.2.6 Flood Prediction and Warning

Flood prediction services are provided by the Bureau of Meteorology but as outlined above, the Bureau cannot issue a flood warning where the flood warning time is less than 6 hours. In the Lower Parramatta River there would be only limited warning time for most flood events and for the tributaries the floods occur from rainfall with a duration of less than 2 hours.

A flood warning system can only work if there is real-time information from above the area of interest advising of a certain river level or river flow. Without this information it is not possible to provide flood warning. The UPRCT have faced this problem and have not been able to establish a warning system for the area down to the CBD. It may therefore be impractical to establish a warning system for the area downstream.

8.3 Summary of Response Measures

The recommended actions in relation to Response Measures for flood management are summarised in **Table 8-1.**

SKM

■ **Table 8-1 Summary of Response Modification Measures**

Priority	Measure	Description	Cost
1	Flood Planning	Work with SES to develop a specific Flood Plan for the whole of the Parramatta River floodprone areas	$100,000
2	Flood Risk Precinct maps and Brochures	Inform the public and distribute Flood Risk Precinct maps for the whole of the study area	$30,000
1	Section 149 Certificates	Modify the procedure for issuing the Section 149 Certificates to reflect the whole of the floodprone area up to the PMF line	Internal PCC action
3	Flood Prediction and Warning	Initiate discussion with Bureau of Meteorology, SES, PCC, UPRCT to discuss whether any opportunities are available for development of a flood prediction model or to provide some form of warning for floods in the Parramatta River	$10,000

9. Options for Flood Risk Management Plan

9.1 Flood Modification Measures

There are limited opportunities for flood modification measures as discussed in **Section 6**. However the works summarised are recommended works, provided funds are available.

- **Table 9-1 Summary of Recommended Flood Modification Measures**

Priority	Location of Works	Description	Cost
1	Ollie Webb Reserve	Construction of a detention basin in Clay Cliff Creek	$380,000
3	Thomas Reserve	Construction of a underground box culvert to divert part of flood flow directly to Parramatta River	$1,640,00
2	A'Becketts Creek	In the tidal zone, carry out de-snagging and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Duck Creek	In the tidal zone, carry out de-snagging and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Duck River	In the tidal zone, carry out de-snagging and removal of rubbish and excess vegetation to ensure that the capacity of the creek is maintained	$10,000 pa
2	Whole area	Carry out routine maintenance to remove rubbish from channels and waterways in order to reduce the risk of blockages	$15,000 pa

9.2 Property Modification Measures - Planning Options

There are a number of alternate mechanisms by which land use planning may have a role in implementing non-structural measures for the control of development within the floodplain. These measures may vary from a fairly broad strategic overview of future and intended development or detailed building and development controls applicable to various forms of development in different zones. **Table 9-2** shows a summary of planning measures considered appropriate for consideration for the study area.

- **Table 9-2 Summary of Property Modifications Measures**

Priority	Instrument	Description	Cost
3	REP No 28	Amend to provide consistent approach, see **Appendix A** of **Volume 2**	NA
3	LEP	Modify structure to provide greater flexibility, see **Appendix B** of **Volume 2**	NA
1	Residential 2(e) Zoning	Review zoning in the light of current study and other considerations, see **Section 4.4.3** of **Volume 2.**	NA
2	DCP	Amendments to the DCP to incorporate a flood prone lands policy and other controls, see **Section 4.6.4** of **Volume 2**.	NA
2	Section 149 Certificates	Modify certificates to reflect the Flood Risk Precinct and floods up to the Probable Maximum flood, see **Section 4.7**.	NA
3	S94 Contributions	Consider specific S94 contributions for specific developments where applicable, see **Section 2.9.11**.	NA
2	House Raising	Develop a program of house raising for those that are severely flooded, see **Section 7.3** and **Table 7-2.**	$1,550,000

9.3 Response Modification Measures

The recommended action relating to Response Modification Measures are summarised **in Table 9-3.**

■ Table 9-3 Summary of Response Modification Measures

Priority	Measure	Description	Cost
1	Flood Planning	Work with SES to develop a specific Flood Plan for the whole of the Parramatta River floodprone areas	$100,000
2	Flood Risk Precinct maps and Brochures	Inform the public and distribute Flood Risk Precinct maps for the whole of the study area	$30,000
1	Section 149 Certificates	Modify the procedure for issuing the Section 149 Certificates to reflect the whole of the floodprone area up to the PMF line	Internal PCC action
3	Flood Prediction and Warning	Initiate discussion with Bureau of Meteorology, SES, PCC, UPRCT to discuss whether any opportunities are available for development of a flood prediction model or to provide some form of warning for floods in the Parramatta River	$10,000

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Appendix A Typical Floodplain Management Options

A.1 Flood Modification Measures

Flood Mitigation Dams

Flood mitigation dams can reduce downstream flood discharges by storing or attenuating the flood. One flood mitigation dam has been constructed in the Upper Parramatta River Catchment, on Darling Mills Creek. There does not seem to be any other suitable location for any further dams in the catchment.

Retarding Basins

Retarding basins are small dams. They are most suitable in urban areas on small streams that respond quickly to rapidly rising flooding. Retarding basins require a substantial amount of area, although they can be used for other purposes such as sports fields if safety aspects are carefully considered. The risk and consequences of overtopping and failure also need to be considered for all retarding basins.

On-site Detention (OSD)

OSD acts similarly to a series of small retarding basins and is designed to reduce run-off from a development to pre-development (rural) conditions. UPRCT have been instrumental in introducing an OSD policy which has been adopted by PCC for the whole of the LGA. This will over time have a positive effect on the total runoff from a catchment but as the policy only applies to new developments, it will take some time for the effects to be felt in many catchments.

Levees

Levees have traditionally been used to protect properties at risk, and are a common management measure in rural areas of NSW. However, levees reduce the available flood storage on the floodplain and thereby raise flood levels. In addition, they are designed to withstand a particular flood event and, unless this is the PMF, the levee will at some stage be overtopped. The consequences of overtopping in an extreme flood event should be carefully considered when proposing levees.

Bypass Floodways

Bypass floodways can redirect a portion of floodwaters away from areas where flood damages would be high. This can be an effective means of reducing flood levels, however the local topography, environmental considerations and the availability of land may limit opportunities for construction of floodways. Also floodways may disrupt flow patterns, changing the form of the natural channel, and may exacerbate flooding elsewhere.

Channel Modifications

The hydraulic capacity of a river channel can be increased by widening, deepening or realigning the channel, and by clearing the bed and banks of obstructions such as thick vegetation. However, channel modifications are most effective in small creeks with overgrown banks and narrow floodplains. In the study area, channel modifications are impossible in the Parramatta River and are extremely difficult in Clay Cliff Creek (see **Section 6**). Channel modifications also have potential disadvantages including impacts on downstream flood levels, impacts on bank and bed stability and destructive ecological effects.

Floodgates

Floodgates can be used to control flows in bypass floodways or other flood channels and can help protect low-lying urban areas or farmland from flooding. They can be used to prevent mainstream floodwaters from backing up a smaller drain or creek. Floodgates can be designed for manual or automatic operation. Considerations such as fish passage and environmental flow regimes are important when designing floodgates. Review of flooding patterns show that there is no need or opportunity to use floodgates in the study area.

Catchment Treatment

Catchment treatment involves modifying the characteristics of a catchment to reduce runoff contributing to flood events. For urban catchments this involves minimising impervious surfaces, installing porous pavements, providing roofwater tanks etc. For rural areas, runoff can be reduced by limiting deforestation and employing contour ploughing techniques on slopes.

Land Raising

Houses can be made flood-free from say the 100 year ARI flood, by constructing the dwelling on a pad above the flood planning level. However filling in the floodplain can have negative impacts in terms of raising flood levels both at the site of filling and upstream. Filling of areas within the Clay Cliff Creek area, is discussed in Section 7.

A.2 Property Modification Measures

Development Controls

Development controls are the appropriate means of implementing detailed aspects of Council's Floodplain Risk Management Plan. Development controls address future as well as current flood risk through ensuring appropriate development of flood-prone land. Aspects of the Floodplain Risk Management Plan that would typically be dealt with in development controls include:

- Access to and from the site during flood events – both vehicular and pedestrian;
- Fill or excavation in the floodplain – for example limits on the locations, levels and quantities of fill or excavation allowed;
- Freeboard – allows incorporation of a factor of safety into Flood Planning Levels (FPLs);

- Floor levels – for example minimum habitable floor levels;
- Building materials – acceptable flood-proof materials may be identified;
- Services – development controls should consider the impact of floods on infrastructure services such as power, potable water, sewerage and drainage;
- Impacts on flood behaviour within and external to the site including other users of the floodplain. Cumulative impacts should also be considered;
- Land use – different land uses may be appropriate in different areas of the floodplain, and will also require different flood-related development controls;
- Structural soundness when flooded; and
- Fencing – the type, location or height of fencing may be limited.

Rezoning

Zoning is a land-use control, which can be used to ensure that the rate of growth of future flood damage is limited. Flood-prone land should be divided into appropriate zones with related provisions attached, which will ensure an effective and long-term means of limiting flood damage to future developments. When rezoning, flood affectation should be considered along with other factors.

Rezoning flood-prone land to higher density development may be appropriate where the flood hazard is low and access is available, particularly if it encourages people to purchase and demolish flood-liable property and redevelop the area in accordance with the development control provisions of the new Floodplain Risk Management Plan.

Voluntary Purchase

Voluntary purchase of properties in areas subject to hazardous and frequent flooding may be a suitable management measure in areas of the floodplain where it may be impractical or uneconomical to mitigate flooding of existing properties at risk. Areas where properties have been purchased should ultimately be re-zoned to a flood-compatible use.

Voluntary House-Raising

House-raising may allow residents to stay in their homes while reducing the risk of flood damages. House-raising is generally only a suitable measure in low-hazard areas of the floodplain. House-raising is easiest and cheapest for timber-framed houses clad with non-masonry materials. Some brick houses have also been raised; however they are considerably more costly. It is important to consider that raised houses may be isolated during floods, therefore the residents should be capable of self-sufficiency in such a situation. Areas suitable for house raising are discussed in **Section 7.2.**

Flood Proofing

Flood proofing involves preventing water from entering a building through doors, windows etc. and can involve construction using water-resistant materials. Inundation, debris and buoyancy forces should be considered. Flood proofing will minimise structural damage to the building itself and possibly also minimise damage to contents if the building is inundated. Flood proofing should generally only be used as an adjunct to other floodplain management measures, as flood proofing will not reduce the social and economic disruption caused by flooding. Flood-proofing is most effective for commercial and industrial areas where a specific flood plan can be developed for the property taking into account the value and type of goods that require protection.

Flood Access

Flood access is an important consideration in flood risk management. However duration of flooding in the study area will not exceed a few hours and so evacuation will not normally be practical except perhaps in the event of a accident or sudden illness.

A.3 Response Modification Measures

Flood Education

Flood education can improve the community's flood readiness, and therefore modify the community's response to a flood event. Flood education should aim to make the community aware of the risk and impacts of flooding. Some useful flood education activities include:

- Advice to residents such as flood information leaflets on flooding in specific areas;
- Articles in local newspapers;
- Displays of flood photographs and newspaper articles in council chambers or other public places;
- Flood commemorations or signs showing flood levels from previous significant flood events, or the flood planning level for residential floors;
- Signposting of evacuation routes; and
- School projects on floods and flood management.

Community Flood Readiness

Flood readiness can be enhanced through flood awareness, as discussed above. It can also be enhanced by developing local flood plans and making individuals aware of what they should do during a flood event, for example stocking up on food if isolation is likely, avoiding unsafe routes, protecting personal goods and evacuating from their houses.

Flood Prediction and Warning

Flood prediction services are provided by the Bureau of Meteorology but in the Lower Parramatta River there would be less than six hours of effective warning and so the Bureau of Meteorology do not issue flood warnings for the river or its tributaries. The State Emergency Service (SES) has the responsibility to issue flood warnings (if known) to the community, along with local information about the implications of flooding and flood preparedness.

Local Flood Plans

Local Flood Plans are developed by the SES in conjunction with other agencies and the community. The Floodplain Risk Management Committee needs to ensure that the floodplain risk management measures adopted in the Floodplain Risk Management Plan are integrated with the planned development of a local SES Flood Plan.

Recovery Planning

Recovery planning addresses the clean-up activities that will occur after a major flood. Welfare services and support should also be considered. Immediately after a flood is also an ideal time to gather data such as information on the flood behaviour at specific locations and details of damages as well as monitoring the effectiveness of the flood response.

Flood Insurance

Flood insurance does not reduce flood damages, but can reduce the social and economic impact of flooding. Flood insurance is not readily available for houses but insurance companies are considering offering flood insurance for what is often loosely called ‘flash floods’. The community needs to be made aware of the limitations of current flood insurance as part of the flood education programme.

Appendix B Flood Damage Assessment

B.1 Approach

A flood damage assessment was undertaken for the 20 year and 100 year ARI and the PMF events. The assessment identified the properties affected by flooding in each of these events and quantified the costs associated with flooding. The steps undertaken to perform the assessment are outlined in the following subsections, **B.1.1** and **B.1.2**. The results of the assessment are presented in **Sections B.2**, **B.3** and **B.4**.

B.1.1 Properties Affected by Flooding

The 100 year ARI inundation maps were used to identify all of the properties affected by flooding in the 100 year ARI event. Where possible, these properties were identified in the field, in order to determine the type of property and estimate the height of the floor above ground level. Property types were selected from one of the following categories:

- Residential: high, medium or low-value; or
- Commercial and industrial: medium or low value.

Where properties could not be identified in the field, the property type was determined from the aerial photography and the height of the floor above ground level was estimated as 0.3 for residential properties and 0.0 for commercial and industrial properties.

For each of the properties identified, the following steps were undertaken:

- The street number was noted where possible. Most street numbers were estimated from the *Sydway* street directory, which notes selected street numbers;
- At each property, the ground level (m AHD) was estimated from the airborne laser survey data;
- The floor level (in m AHD) was calculated from the ground level plus the height of the floor above ground level;
- The 20 year and 100 year ARI and PMF flood levels at the nearest cross-section to the property were noted;
- The flood levels were compared to the floor levels to determine which properties were affected by above-floor and below-floor flooding in each event; and
- For those properties affected by flooding above floor level, the flood depth above floor level was calculated for each event.

The above assessment was based on properties inundated in the 100 year ARI event. Many of these properties would not be inundated at all, even below floor-level, in the 20 year ARI event. Therefore the 20 year ARI flood level was compared to the ground level at each property. If the ground level was higher than the flood level, it was assumed that no below-floor flooding would occur in the 20 year ARI event.

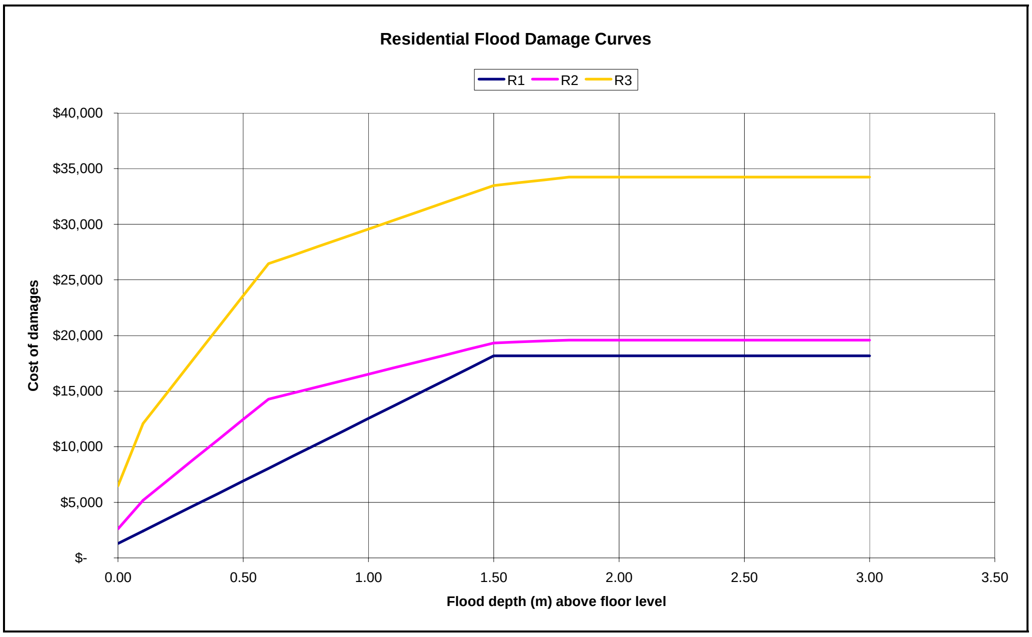
In the PMF, many properties outside the 100 year ARI inundation area would also be affected by flooding. These properties were not included in the above procedure. The properties in this category were identified on the PMF inundation map and the number of properties in this category noted. In order to simplify the assessment, no information about the location, property type or height of the floor above ground level was recorded for these properties.

B.1.2 Cost of Flood Damages

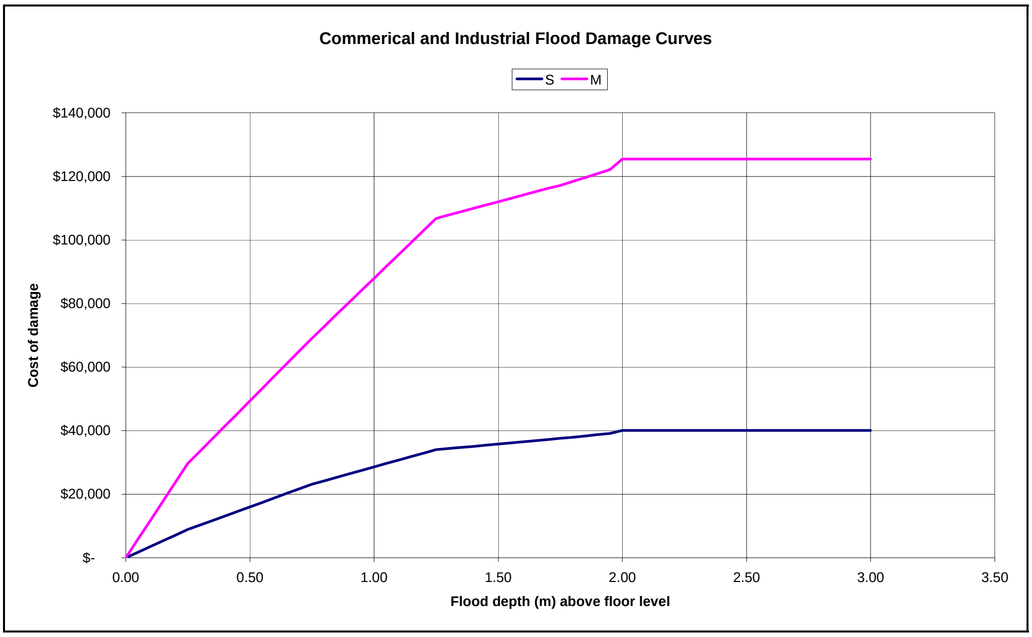
Flood damages were estimated from a series of standard flood damage curves (ANUFLOOD, 1993). The damage curves were updated from 1993 dollars to 2003 dollars based on the consumer price index in 1993 and 2003. The curves for each property category are shown in **Figure 10-1** and **Figure 10-2**. The property categories are:

- R1 = low-value residential;
- R2 = medium-value residential;
- R3 = high-value residential;
- S = small commercial/industrial; and
- M = medium commercial/industrial.

- **Figure 10-1: Residential flood damage curves**



■ **Figure 10-2: Commercial and industrial flood damage curves**



The Shell site was treated as a group of medium-sized commercial/industrial properties. Each building on the site was considered as one medium-sized property.

For the PMF, there were many properties flooded for which no information about the property type or flood depth above floor level was obtained (those outside the 100 year ARI inundation extent). Flood damage costs for these properties were estimated by calculating the average cost of damages per property per event and multiplying this by the number of properties in this category.

B.2 Properties Affected by Flooding

A summary of properties flooded above and below floor level in the 20 year and 100 year ARI events is shown in **Table 10-1**.

■ **Table 10-1: Properties affected by flooding in the 20 year and 100 year ARI events**

Locations (streets)	Properties affected (20 year ARI)		Properties affected (100 year ARI)	
	Above floor	Below Floor	Above floor	Below Floor
Alfred St	7	3	12	21
Anderson St	1	0	1	1
Antoine St	10	0	10	0
Arthur St	7	11	17	7
Brodie St	1	0	2	0
Carnarvon St	1	0	1	0
Charles St	0	0	1	4
Church St	6	0	7	1

Locations (streets)	Properties affected (20 year ARI)		Properties affected (100 year ARI)	
	Above floor	Below Floor	Above floor	Below Floor
Cowper St	8	3	19	4
Crimea St	1	0	1	1
Darcy St	2	0	2	0
Derby St	0	0	3	1
East St	3	0	12	1
Egerton St	1	0	5	1
George St	4	8	24	7
Grand Ave	1	0	1	0
Grand Ave North	0	0	1	0
Gray St	1	0	2	2
Gregory Place	6	2	8	2
Hamilton St	0	1	2	1
Harbord St	4	3	9	3
Harris St	0	0	0	1
Hassall St	3	2	20	29
Holker St	0	0	1	0
Inkerman St	0	0	0	1
James Ruse Drive	4	0	8	6
John St	3	3	7	4
Junction St	1	0	1	1
Kemp St	0	1	1	3
Kendall St	2	0	10	7
Lansdowne St	8	16	20	9
Lennox St	0	1	1	0
Macquarie St	0	0	1	3
Marsden St	0	0	0	3
Marsh St	6	0	6	0
Martha St	5	0	5	0
Millenium Ct	0	0	0	1
Milton St	0	0	0	3
Noller Pde	0	2	3	2
Oak St	9	7	26	6
Off East St	0	0	1	0
Onslow St	1	0	1	3
Park Rd	0	0	1	1
Parkes St	0	0	0	3
Parramatta Road	11	0	14	1
Pemberton St	0	0	0	1
Picken St	1	0	1	0
Pike St	7	0	10	1

Locations (streets)	Properties affected (20 year ARI)		Properties affected (100 year ARI)	
	Above floor	Below Floor	Above floor	Below Floor
River Rd West	1	0	3	2
Shell site	1	0	5	0
Short St	1	0	4	0
Station St East	0	0	1	1
Valentine Ave	0	1	1	0
Vore St	1	0	5	0
Wentworth St	11	0	13	1
Wiblin St	1	0	3	0
Wigram St	1	1	2	3
Total	**142**	**65**	**315**	**153**

In total, it is predicted to be 207 properties affected by flooding in the 20 year ARI event and 468 properties affected by flooding in the 100 year ARI event. The PMF flood affectation for these 468 properties would be:

- 462 of them would be affected by flooding above floor level; and
- The remaining 6 would be affected by flooding below floor-level.

In addition to those properties considered above, 14 other buildings at the Shell site and approximately 720 other properties would be affected by flooding either above or below floor level in the PMF event (ie they lie outside the 100 year inundation area). Therefore in total approximately 1200 properties would be affected by flooding in the PMF event.

B.3 Cost of Damages

A summary of the damage costs in the 20 year and 100 year ARI events is shown in **Table 10-2**.

- **Table 10-2: Cost of damages in the 20 year and 100 year ARI events**

Locations (streets)	Cost of damages in the 20 year ARI event	Cost of damages in the 100 year ARI event
Alfred St	$ 47,489	$ 153,220
Anderson St	$ 11,863	$ 33,602
Antoine St	$ 405,863	$ 790,637
Arthur St	$ 114,128	$ 328,051
Brodie St	$ 65,158	$ 114,864
Carnarvon St	$ 65,158	$ 106,768
Charles St	$ -	$ 41,439
Church St	$ 354,497	$ 553,490
Cowper St	$ 213,907	$ 877,243

Locations (streets)	Cost of damages in the 20 year ARI event	Cost of damages in the 100 year ARI event
Crimea St	$ 4,671	$ 8,218
Darcy St	$ 110,593	$ 133,904
Derby St	$ -	$ 71,148
East St	$ 167,862	$ 441,334
Egerton St	$ 33,602	$ 179,576
George St	$ 134,882	$ 462,739
Grand Ave	$ 41,491	$ 80,402
Grand Ave North	$ -	$ 37,546
Gray St	$ 2,422	$ 14,705
Gregory Place	$ 41,805	$ 109,429
Hamilton St	$ 1,298	$ 9,515
Harbord St	$ 118,600	$ 306,302
Harris St	$ -	$ -
Hassall St	$ 94,02	$ 413,265
Holker St	$ -	$ 29,657
Inkerman St	$ -	$ 1,298
James Ruse Drive	$ 57,180	$ 212,968
John St	$ 18,511	$ 65,525
Junction St	$ 29,657	$ 69,102
Kemp St	$ 2,595	$ 14,792
Kendall St	$ 47,452	$ 188,070
Lansdowne St	$ 59,493	$ 118,313
Lennox St	$ 2,595	$ 8,823
Macquarie St	$ -	$ 33,550
Marsden St	$ -	$ 3,893
Marsh St	$ 507,820	$ 635,548
Martha St	$ 117,599	$ 213,547
Millenium Ct	$ -	$ -
Milton St	$ -	$ 3,893
Noller Pde	$ 2,595	$ 18,857
Oak St	$ 153,957	$ 327,678
Off East St	$ -	$ 45,435
Onslow St	$ 1,781	$ 18,369
Park Rd	$ -	$ 23,726
Parkes St	$ -	$ 3,893
Parramatta Road	$ 373,417	$ 1,041,338
Pemberton St	$ -	$ 1,298
Picken St	$ 65,158	$ 99,235
Pike St	$ 338,837	$ 717,442
River Rd West	$ 5,931	$ 140,858
Shell site	$ 11,863	$ 165,993

Locations (streets)	Cost of damages in the 20 year ARI event	Cost of damages in the 100 year ARI event
Short St	$ 65,158	$ 243,252
Station St East	$ -	$ 11,863
Valentine Ave	$ -	$ 23,726
Vore St	$ 53,324	$ 226,109
Wentworth St	$ 260,926	$ 542,636
Wiblin St	$ 41,491	$ 110,059
Wigram St	$ 10,121	$ 25,821
Total	**$ 4,256,771**	**$10,653,964**

The total costs of damage would be approximately $4.3 million in the 20 year ARI event and $10.7 million in the 100 year ARI event.

The total damage costs for the PMF would be:

- For those properties considered above: $31.4 million;
- For the additional 14 buildings affected at the Shell site: $1.7 million[6]; and
- For the other 720 properties not considered in the above assessment: $22.5 million.

The total cost of damages in the PMF event would therefore be $55.6 million.

B.4 Total Average Annual Flood Damage

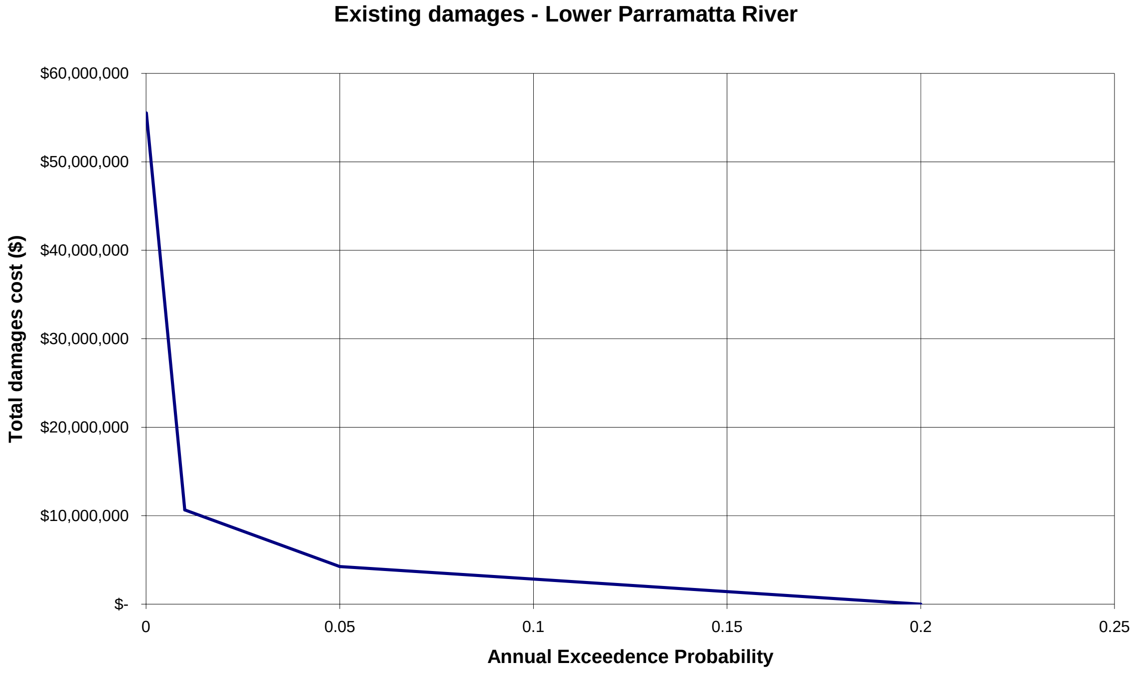
Total damage costs were calculated for a range of storm events, as detailed in **Section B.3** above. These damage costs were summed over the range of event probabilities to come up with an average annual cost of flood damage.

In order to complete this calculation, the point where flood damages would be zero had to be estimated. It was estimated that the cost of damages would be approximately zero in the 5 year ARI event.

The cost of damages for a range of events is presented in **Figure 10-3**.

[6] For large industrial developments, flood damage can only be approximately estimated. For a more accurate assessment, a detailed site specific investigation is required to determine the impact of flooding.

■ **Figure 10-3: Potential flood damages in the Lower Parramatta study area**



Summing the damages over the full range of probabilities, the average annual cost of flood damages would be $948,400 or approximately $1 million per year.

Appendix C Public Consultation

C.1 Public Meeting 9 May 2002

A public meeting was held on 9 May 2002 at Parramatta Masonic Club to discuss issues related to flooding in the Lower Parramatta River and its tributaries within the study area. Officers from PCC and the consultants made brief presentations on LPR-FRMS and sought input from the residents present in the meeting on a range of flooding issues. Information provided by the residents is given below:

Residents' Input – Areas subject to flooding

- Noller Parade
- Arthur Street (north and south end)
- Oak Street:
- Between James Ruse & Arthur: owned the property since '84; in '88 - 3-4 metre high flood; but ever since BP Station was built, hasn't been a flooding since.
- Grand Ave
- Bridge Street:
- Subiaco Creek: '80 & '90 – 2 & a half to 3 mtr high; water moved very quick; because mangrove not cleared @ entrance; ???replanted on bank & to allow water to come up; creek bed need to be cleaned; vines & weeds to be cleaned up.
- Bridge St – Subiaco Ck
    - Car park 1 metre deep through building,
- Mangroves an issue
- Development on opposite side pushed water onto property.
- Kay Street
- Alfred Street
- In 1988 did not get any flooding in Parramatta River
- Flooding was caused by blockage – was cleared after event
- Gone in 1 hour – water up to gutter
- Rosehill car park run off caused blockages
- Future development impacts on flood levels
- Flooding on corner James Ruse / Hassall St
- Tidal impact on flooding severity in Duck River and Clay Cliff Creek
- Improvements from dredging for the River Cat
- Concern over development that has occurred in past
- No Councillors represented at workshop

- Oak St - Brick wall on Oak St caused water to divert – when Bikeplan developed.
- James Rouse/Becketts Creek. Blockages – were cleared after 1988 event.
- 13 houses flooded significantly from Parramatta River.
- Brodie Street
- James Ruse Drive/Hassall Street
- Hassall & Arthur Sts . In 1988 – blockage of easement only; no major flooding; 2001 flooding? No. It was '48 not higher than drain; '1988 was due to blocked drain; Rose Hill car park flooded because it wasn't sealed causing blockage of drains going to Granville.
- River Road: Since the flooding, the site's been fully developed with flats & 4-storey apartments; river's been dredged which seemed to help eliminate flooding.
- A'Beckett Street. Anzac Day flooding in 1974 from channel. Council has widened the creek to alleviate flooding; but silt from swamp & mangrove trees that can't be cut down because of Greenie laws makes flooding worse; water from flooding was running very quick until the mangrove; half metre tide – worst in 1985.
- Boat was required to get around
- Blockage during construction of James Ruse overpass
- Pole in middle of creek.
- Mangroves causing blockage upstream of concrete channel
- Water moving quickly in floods in Duck Creek
- A'Beckett Creek in 2001 had the biggest flooding - about 35 mtr from creek to the house; there was an half hour solid rain that the bridge over the creek was flooded out; concern was expressed by a few residents with calculations of if the rain had lasted longer – what if that happens in the future
- Material gets blocked around pylons – Clyde.
- 85/86 – Flood marker.
- Grand Ave
- Rydalmere (Mary Pde)
- Water on land

General

- All residents criticised the fact that not one Councillor represented
- Funding should be for blockages & clean up of vines, weeds, etc. to prevent flooding
- Rydalmere Railway Station & Subiaco Creek to bridge & Mary Parade –floods rarely
- Some censured the fact that previously Council defined flood prone areas have now been built on

- Some presumed the previously flooded areas now have stopped flooding because of the developments
- Funding for flood management below desirable levels
- Issue of material/litter/overgrown vegetation increasing flooding
- Issue of OSD and impact on new development
- Water over road –Grand Avenue for 12 hours.
- Water escapes from Duck River in times of heavy rain

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C.2 Community Workshop 12 December 2002

Lower Parramatta River Floodplain Risk Management Study

Community Workshop Questionnaire Meeting 12 December 2002

Please Note: These responses will be collated and used in development of general planning controls and the results will be presented at the next Community Workshop

Re-sponse	Question
Tick row if you agree with the response	***A. Due to dangerous flood depths and velocities, development in the High Risk Precinct must be restricted to such land uses as open space, roads, parks and sporting facilities. In your opinion, what other non-habitable land uses should be allowed? (Type of development which might be considered includes swimming pool, fences, garage, sheds, barbecues, car park)***
	Write your comments here:
	B. Would you be willing to accept home units, villas, town houses etc or single dwelling in an established low scale residential street providing they were required to be raised above ground level to address flood risks?
	1. No.
	2. Only if filling of the block was not required or it is proven that no change to the flood risk to other properties would arise
	3. Only if adjoining properties were not subjected to amenity impacts (overlooking, overshadowing, etc)
	4. Only if the height and scale of the development remained consistent with adjoining properties and the streetscape
	5. Only if….(landowner to insert if desired)……………………………………………….
	C Do you think that car which is parked should be protected from flooding?
	1. Only where there is a high, risk of flooding
	2. Only where there is a medium risk of flooding
	3. Only where there is a low risk of flooding
	4. Only where it is Open
	5. Only where it is covered,
	6. Only where it is Open and covered
	D Should residents be able to evacuate in available warning times from flooded areas?
	1. By car
	2. By walking
	3. Be reliant on others to evacuate (eg a nursing home)
	4. Doesn't matter providing have a second storey or floor level above flood
	4. Doesn't matter if they can't evacuate
	E. Nominate those activities that you think should not be allowed in the medium risk precinct (Medium Risk is where flooding is less than one metre depth, but evacuation may be difficult)
	1. Nursing homes
	2. Schools
	3. Retirement units
	4. Hospitals
	5. Standard Industrial
	6. Hazardous industry
	7. Shopping centres
	8. Recreation parks
	9. Critical utilities

▪

	F. What notifications do you consider Council should give about the potential flood affectation of individual properties? (Tick more than one box if required.
	1. Advise every resident and property owner on an annual basis in writing of the known potential flood affectation of your property
	2. Advise prospective purchasers of property or those who inquire of Council's policies on the control of development on land potentially affected by flooding
	3. Provide no notifications
	G. Do you wish to make any other comments on this study or presentation?
	Comments:
	Not Compulsory
	Name:
	Address:
	Telephone Number

Please Note: If you have any specific questions on flood levels for your own particular property, please contact the engineering section of your Council. The consultant is not at liberty to divulge flood levels to individual owners without the approval of Council.

Please send the completed Questionnaire to:

Sinclair Knight Merz
PO Box 164
St Leonards NSW 1590

Attention: Ms Alexa McAuley

T: 9928 2228
Fax: 9928 2504
Email: AMcAuley@skm.com.au

If you need any assistance in completing this questionnaire, please contact Ms Alexa McAuley at the above address

Appendix D Cost and Benefit of Proposed Works in Clay Cliff Creek

D.1 Cost of Recommended Works (Option 7) for Clay Cliff Creek

Option 7 consists of two major items of work:

- Providing an embankment around the eastern and southern sides of Ollie Webb Reserve, to a maximum height of 18.0 m AHD to act as a detention basin. No excavation would be involved. It was assumed that this embankment would have side slopes of 1 (vertical) in 5 (horizontal). The detention basin would have an outlet consisting of a culvert 2.0 m wide by 1.8 m high.

- diverting flow from Clay Cliff Creek at Harris Street directly to the Parramatta River to the north with a culvert through Thomas Reserve, covering a distance of approximately 320 m. The culvert proposed by 4.5 m wide and 2.4 m high.

The cost of these works are shown in **Table 10-3** and **Table 10-4**.

- **Table 10-3 Construction Cost of Detention Basin – Ollie Webb Park**

Item	Description	Quantity	Unit	Rate ($)	Amount ($)
1	Site Establishment		LS		10,000
2	QA		LS		7,500
3	Remove topsoil and stockpile	1,000	m3	5	5,000
4	Excavate cut-off trench	580	m3	15	8,700
5	Import, place fill and compact embankment	5,080	m3	25	127,000
6	Replace topsoil	1,000	m3	15	15,000
7	Construct inlet pit	1	item	4000	4,000
8	Supply culvert 2.1x1.8 m	50	m	790	39,500
9	Excavate, lay and backfill for culvert incl. Base slab	50	m	950	47,500
10	Construct concrete headwall for 2.1x1.8 RCBC	1	item	5000	5,000
11	Outlet protection for the box culvert	1	item	7500	7,500
12	Construct spillway	330	m2	60	19,800
13	Allowance for services relocation (provisional)		LS		20,000
	Cost of works				316,500
	Allow 20% Contingency				63,300
	Total Cost of Works				**379,800**

- **Table 10-4 Cost of Construction of Diversion Channel**

Item	Description	Quantity	Unit	Rate ($)	Amount ($)
1	QA		LS		30,000
2	Remove topsoil and stockpile	500	m3	5	2,500
3	Construct inlet pit	1	item	6000	6,000
4	Supply culvert 2x2.4x2.1 m	320	m	1950	624,000
5	Excavate, lay and backfill for 2x2.4x2.1 RCBC incl. Base slab	320	m	1900	608,000
6	Construct headwall for 2x2.4x2.4 RCBC	1	item	9000	9,000
7	Flood control gates at outlet	1	item	40000	40,000
8	Outlet protection for the box culverts	1	item	10000	10,000
9	Replace topsoil	500	m3	15	7,500
10	Hydromulching - seed and water	2,560	m2	4.5	11,520
11	Allowance for services relocation (provisional)		LS		20,000
	Cost of works				1,368,520
	Allow 20% Contingency				273,704
	Total Cost of Works				**1,642,224**

Total cost of the works is estimated at $2,022,024, say $2,000,000

D.2 Benefits of Options

D.2.1 Option 7

The reduction in flood levels due to Option 7, has the effect of reducing the area inundated in a given flood, reduces the number of properties inundated and reduces the damages for a given flood. **Table 10-5** shows the cost of damage for the 20 year ARI and 100 Year ARI floods for streets in the Clay Cliff Creek area and also the existing damage assessment, taken from **Appendix B**.

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Table 10-5 Flood Damages for Option 7 and Existing Conditions

Street Name	Cost of Damages with Option 7		Existing Damages	
	20 yr ARI	100 Year ARI	20 yr	100 yr
Alfred St	7,785	46,711	47,489	153,220
Anderson St	-	-	11,863	33,602
Arthur St	106,216	246,380	114,128	328,051
Charles St	-	3,893	-	41,439
Church St	313,599	336,910	354,497	553,490
Cowper St	49,274	199,538	213,907	877,243
Crimea St	4,671	8,218	4,671	8,218
George St	10,380	97,339	134,882	462,739
Gregory Place	9,083	11,678	41,805	109,429
Harris St	-	-	-	-
Hassall St	85,495	339,613	94,022	413,265
Inkerman St	-	1,298	-	1,298
James Ruse D	17,646	34,514	57,180	212,968
Kendall St	-	7,938	47,452	188,070
Lansdowne St	48,772	50,034	59,493	118,313
Lennox St	2,595	2,595	2,595	8,823
Macquarie St	-	3,893	-	33,550
Marsden St	-	3,893	-	3,893
Noller Pde	-	1,298	2,595	18,857
Oak St	146,193	243,747	153,957	327,678
Parkes St	-	3,893	-	3,893
Pemberton St	-	1,298	-	1,298
River Rd West	-	113,218	5,931	140,858
Station St East	-	-	-	11,863
Valentine Ave	-	-	-	23,726
Wentworth St	11,863	17,794	41,491	542,636
Wigram St	8,304	21,193	1,298	25,821
Totals	**821,876**	**1,796,881**	**1,389,255**	**4,644,239**
Reduction	**567,379**	**2,847,358**		

As can be seen from the above Table, the reduction in damages is some $567,379 in the 20 year event and $2,847,358 in the 100 year event. These benefits are shown as a probability curve in **Figure 10-4** which equates to an average annual benefit of $150,000.

Figure 10-4 Benefit Curve for Option 7