Prepared for the Georges River Floodplain Management Committee

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY & PLAN

Volume 1 – Main Report

Final Report

May 2004

Bewsher Consulting Pty Ltd

GEORGES RIVER FLOODPLAIN MANAGEMENT COMMITTEE

Comprising Liverpool City Council, Fairfield City Council, Bankstown City Council, Sutherland Shire Council, State Emergency Service, Department of Infrastructure, Planning and Natural Resources, and community representatives.

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FINAL REPORT

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EXECUTIVE SUMMARY

Reasons for the Study and Plan

The Georges River is one of the most populated catchments in Australia. The river and its tributary creeks represent Sydney's most immediate flood problem, both in terms of the number of properties affected by flooding and the potential for increased flood damage due to development pressures within the catchment.

Bewsher Consulting was commissioned by Bankstown City Council and Liverpool City Council in June 2001 to develop a floodplain risk management study and plan for the Georges River. The study was later expanded to incorporate parts of Fairfield City Council and Sutherland Shire Council.

Numerous flood investigations have been undertaken on the Georges River over the years. Most have focused on specific problem areas along the river, and in many cases flood mitigation schemes have been developed to tackle these problems. Many of the schemes have since been implemented, or are in the process of being implemented. Whilst there has been substantial progress in reducing the extent of flooding problems along the river, there remains a significant flood risk to many properties. There has also been no overall strategic floodplain risk management study that considers the broader catchment-wide measures, such as flood warning, emergency management measures, public awareness and consistent planning controls for future development.

The Study report has been produced in two volumes – a main report (Volume 1) and a supplementary report covering planning issues (Volume 2), given the critical importance of the latter to floodplain management on the Georges River.

Responsibilities

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain risk management studies and for the implementation of works identified in any subsequent floodplain risk management plan.

The Georges River Floodplain Management Committee oversaw the Study. This committee includes Councillors and staff from Bankstown, Liverpool, Fairfield and Sutherland Shire Councils. Officers form the Department of Land and Water Conservation (now the Department of Infrastructure, Planning and Natural Resources) and the State Emergency Service were also represented on the committee, along with a number of community representatives.

The Study Area

The Georges River has a catchment area of 960 km^2, and a population of approximately 1 million people. The river itself is about 100km in length and has a number of important tributaries, such as Cabramatta Creek, Prospect Creek, Harris and Williams Creek, Salt Pan Creek and the Woronora River.

The study area includes all the floodplains of the Georges River in the Liverpool, Fairfield and Bankstown Council areas, together with the floodplains upstream of the Woronora River junction in Sutherland Shire.

Consultation

Community consultation has been an important component of the current study. As well as improving the community's awareness of and readiness for flooding, the consultation has aimed to inform the community about the development of the floodplain management study and its likely outcomes.

Key elements of the consultation process have been as follows:

- regular meetings of the Georges River Floodplain Management Committee;
- development of a study web site for the project (www.bewsher.com.au/georges);
- preparation of an SES FloodSafe brochure for the Georges River;
- preparation and distribution of a notification pack for all residents potentially affected by flooding;
- distribution of a short questionnaire to all residents, followed by a more detailed questionnaire;
- organisation of ten public workshops;
- liaison with government agencies and other groups; and
- the intended public exhibition of the recommended floodplain risk management study and plan, prior to formal consideration by each Council.

Modelling of Flood Behaviour

Design flood levels for the Georges River, between East Hills and Liverpool, were determined using a physical model during the 1980s. Flood levels from the physical model were published in the 1991 Georges River Flood Study report, and have been applied by Liverpool, Fairfield and Bankstown Councils since this time.

A computer model of the Georges River, from Botany Bay to upstream of Liverpool, was established as part of the current study. The model was used to verify results from the previous flood study and to test the impact of development and other works that have occurred on the floodplain since the mid 1980s. The computer model also provides additional information on flood behaviour, including flow rates, velocities and flood hazard information.

Whilst some recent floodplain activities are believed to have had a detrimental impact on flood behaviour, the change in flood levels is relatively small (less than 200mm). There may also be some opportunities to redress these problems in the near future. Therefore, no change to the previously adopted design flood levels would appear to be warranted.

The computer model also provides flood information in the lower Georges River, downstream of East Hills, where previously there was no data. Results from the model can therefore be used to define design flood levels in the lower river, principally for use by Sutherland Shire.

The Flood Problem

The April 1988 and August 1986 floods are the largest floods to have occurred on the Georges River over the last 30 years. Over 1,000 residential properties along the Georges River, Prospect Creek and Cabramatta Creek were inundated from the 1988 flood, with a damage bill estimated at $18M (1988 values). Both these floods are estimated to be about a 20 year flood.

The largest flood to have occurred in the 1900s was the February 1956 flood. Whilst some newspaper reports quoted this event as being the "biggest Sydney storm in living memory", much larger floods are reported to have occurred in the late 1800s. The largest flood is thought to have occurred in February 1873. This flood was about 2m higher than the 1956 flood, and about 3m higher than either the 1986 and 1988 floods (at Liverpool).

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

- 5,204 residential homes and 591 commercial buildings would be flooded above floor level in a probable maximum flood (PMF);
- 721 residential homes and 216 commercial buildings would be flooded above floor level in a 100 year flood;
- the predicted flood damage in the 100 year flood is $99M, whilst the average annual flood damage is estimated at $8.2M and the present value of all future flood damages is estimated at $91M.

Flood Risk Mapping & Development Controls

The Georges River floodplain has been divided into three flood risk precincts (high, medium and low). Different development controls are proposed for the catchment, depending on the type of development and the flood risk area that the development is located. It is proposed that the development controls be applied through a Development Control Plan (DCP) in each Local Government Area (LGA). Draft DCPs for each Council have been prepared and are included in the Volume 2 report. The DCPs cover the whole of each LGA and include both river flooding and overland flow issues resulting from stormwater inundation.

Within the three flood risk precincts that are proposed:

- the high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. It is recommended that most development is restricted within this area.
- the medium flood risk area is where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.
- the low flood risk area is that area where the risk of flood damage is low. Most land uses would be permitted within this area (subject to other planning considerations).

The Recommended Floodplain Management Measures

The draft Georges River Floodplain Risk Management Plan is shown on **Figure 10.1**, and summarised in **Table 10.1**. The principal components of the Plan are as follows:

- voluntary acquisition of the remaining 71 properties in the Liverpool Voluntary Purchase Scheme at Moorebank (99 properties have been purchased to date);
- voluntary acquisition of the remaining 4 properties in the Bankstown Voluntary Purchase Scheme at Milperra (21 properties purchased to date);
- minor adjustments to the crest level on the Kelso levee;
- relocation/removal of 7 buildings within the East Hills Flood Mitigation Scheme;
- the preparation of local catchment studies;
- a flood study on Anzac Creek;
- airborne laser scanning to provide improved topographic data;
- compensatory measures to offset the impacts of recent developments;
- adoption of consistent planning and development controls;
- flood warning enhancements to link flood warning predictions with a property database;
- improved emergency management operations; and
- improved public awareness and information on flooding through the issue of flood certificates, S149 notifications and the construction of flood markers to indicate the levels of historic floods.

The recommended measures also include the findings of a review of floodplain management works undertaken within the study area since the early 1980s. In some cases, variations to previous measures have been proposed. Some additional measures are also proposed in other areas. However, the most effective components of the Plan are the catchment-wide measures. These measures are expected to provide significant benefits over the full range of floods that can be anticipated within the catchment, and can be implemented at a relatively low cost.

Several other floodplain management works were also investigated, but have not been recommended due to high capital costs, low economic benefits, and/or significant environmental issues associated with these proposals. Works that were considered, but not recommended include:

- a large flood mitigation dam in the upper catchment;
- dredging of the river; and
- a levee to protect the Milperra Industrial Estate.

Timing and Funding

The total cost of implementing all the recommended measures is approximately $33.6M. This amount is dominated by the $30M that is estimated to be required for the completion of the Liverpool Voluntary Purchase Scheme at Moorebank.

The $30M for the Liverpool Voluntary Purchase Scheme is a high financial burden on both Liverpool Council and the State Government. The investigation of alternative self-funding initiatives, involving private sector development within the voluntary purchase area, has been recommended. If such initiatives are fruitful, then the total cost of the Georges River Floodplain Risk Management Plan will reduce to a much more modest $3.6M.

The timing of the proposed works will depend on the overall budgetary commitments of each Council and the availability of funds from other sources (eg State Government, potential Section 94 contributions, private sector contributions etc).

1. INTRODUCTION

1.1 BACKGROUND

The Georges River catchment is located south west of Sydney. It is the home of approximately one million people, making it one of the most populated catchments in Australia. Not surprisingly, the river and its tributary creeks represent Sydney's most immediate flood problem, both in terms of the number of properties affected by flooding and the potential for increased flood damage due to development pressures within the catchment.

Bewsher Consulting was commissioned by Bankstown City Council and Liverpool City Council in June 2001 to develop a floodplain risk management study and plan for the Georges River. The study was later expanded to also incorporate the Fairfield City Council and the Sutherland Shire areas. These four council areas share the main flood burden within the catchment. Funding for the study was provided jointly by the four councils and the Department of Infrastructure, Planning and Natural Resources (DIPNR), formerly the Department of Land and Water Conservation (DLWC).

Numerous flood investigations (see Section 2.3) have been undertaken on the Georges River and its tributaries over the years. Most of these studies have been focused on the tributary creeks or in specific areas along the main river. In many instances, these studies have recommended various flood mitigation measures to address the flood problems of the area. Many of the schemes have since been implemented, or are in the process of being implemented. Progress over the last 20 years has been substantial, with major levee bank schemes, finger levees, voluntary purchase schemes, house-raising schemes, creek improvement works and other measures being implemented.

Whilst there has been substantial progress on reducing the extent of flooding problems within the catchment, there remains a significant flood risk to many properties. There has also been no overall strategic floodplain risk management study that considers the broader catchment-wide measures, such as flood warning, emergency management measures, public awareness and consistent planning controls for future development.

The objectives of the Georges River Floodplain Risk Management Study have included:

- a review of flood behaviour;
- an assessment of the impact of recent catchment development on flooding;
- quantification of the flood problem;
- review of floodplain management measures undertaken to date;
- consideration of other potential floodplain management measures, particularly the broader catchment-wide measures;
- recommended planning controls to manage the flood risk, which are consistent between the four councils; and

- the preparation of a floodplain risk management plan, which outlines recommended measures to reduce the risk of flooding.

The Georges River Floodplain Management Committee was established to oversee the study. This committee includes representatives from each of the four councils, the Department of Infrastructure, Planning and Natural Resources, the State Emergency Service and a number of community representatives. The committee has met regularly to consider progress reports from the consultant and to provide direction during the progress of the study.

1.2 THE STUDY AREA

The study area includes all the floodplain areas of the Georges River in the Liverpool, Fairfield and Bankstown Council areas, together with the floodplain areas upstream of the Woronora River junction in Sutherland Shire. The study area is further described in **Section 2**, and is also illustrated on **Figure 2.2**.

The floodplain is defined in the Floodplain Management Manual [NSW Government, 2001] as all land that is potentially at risk from flooding up to the probable maximum flood (PMF). This is an important consideration for the current study, as previous flood risk management considerations on the Georges River were limited to land up to the 100 year flood. The broader definition of the floodplain now provides an onus on each Council to consider the flood risk over a larger area of land.

The study area also includes the lower reaches of a number of tributary creeks, where flooding can also occur due to backwater from the Georges River. Specific studies have been undertaken on most of these tributary creeks, and in many cases, floodplain management measures proposed to reduce the risk of flooding. As there is a degree of overlap in flooding on the lower reaches of these creeks with flooding on the Georges River, these lower creeks can also be considered as part of the study area. Measures that may be considered for the Georges River, particularly catchment-wide measures and planning controls, will supplement other measures previously considered for these creeks.

Tributary creeks that fall within the study area include:

- Cabramatta Creek (downstream of the Hume Highway);
- Prospect Creek (downstream of the Hume Highway);
- Milperra Drain;
- Harris and Williams Creeks (downstream of Heathcote Road);
- Deadmans Creek (downstream of Heathcote Road);
- Little Salt Pan Creek; and
- Salt Pan Creek (downstream of Canterbury Road).

The entire Georges River catchment area has also been considered to determine catchment flows, and to assess development and potential floodplain management measures within the catchment that could affect flood behaviour throughout the study area.

1.3 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance with state-wide policy issues and technical support. Financial assistance is also provided to undertake flood behaviour and floodplain management studies, such as the current study, and for the implementation of works identified in these studies.

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

The objectives of the Policy include:

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

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

The implementation of the Flood Prone Lands Policy generally culminates in the preparation and implementation of a Floodplain Management Plan, which is the objective of the current study.

The steps in the floodplain management process are summarised on **Figure 1.1**.

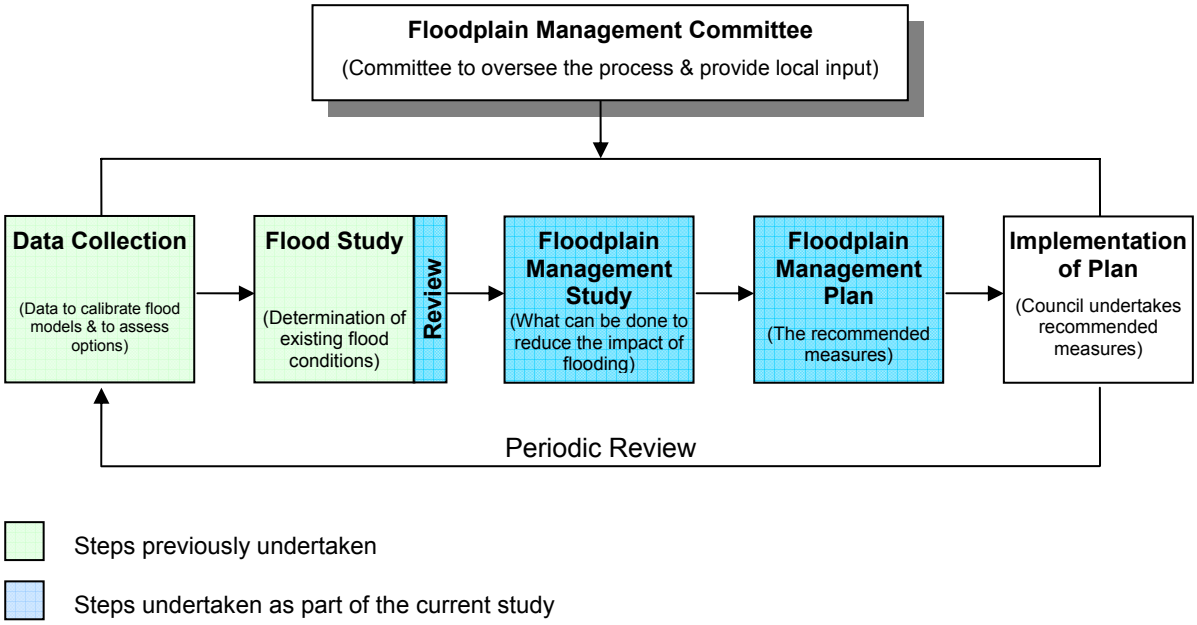


FIGURE 1.1
THE FLOODPLAIN MANAGEMENT PROCESS

1.4 REPORTING

The Georges River Floodplain Risk Management Study is presented as two volumes:

Volume 1 – The Main Study Report (this document); and

Volume 2 – Planning Issues.

Volume 1 provides an assessment of:

- previous flood investigations;
- results of the community consultation program undertaken as part of the study;
- additional flood modelling results;
- a description of flood behaviour, including estimated flood damages;
- floodplain management measures previously undertaken;
- other floodplain management measures that could be considered; and
- recommended measures to reduce the flood risk within the study area.

Volume 2, which was prepared by Don Fox Planning Pty Ltd for Bewsher Consulting, provides an assessment of:

- environmental, social and other planning issues related to the study;
- a review of existing flood-related planning instruments and policies; and
- recommended planning controls for future development, which are consistent across the four council areas and recognise the flood risk of the area and the type of landuse proposed. The controls are to be implemented as new development control plans for each of the four councils.

2. BACKGROUND INFORMATION

2.1 THE GEORGES RIVER CATCHMENT

The Georges River catchment, shown on **Figure 2.1**, has a total catchment area of 960 km^2. The river itself is about 100km long. From its headwaters near Appin, the river flows north towards Campbelltown, through Liverpool and the Chipping Norton Lakes Scheme, and then east through Bankstown to Botany Bay.

The upper catchment area, south of Campbelltown, is largely undisturbed and is still in its natural forested state. Much of the river through this area lies within a deep and narrow gorge. Campbelltown itself, is located on a tributary creek known as the Bunbury Curran Creek, and is not directly affected by flooding from the Georges River.

From Campbelltown to Liverpool the steep river valley gives way to more gently undulating terrain. Development starts to become more prevalent on either side of the river towards Liverpool. The river banks remain relatively high, and all but very large floods are contained in-bank.

The tidal limit of the river is at the Liverpool weir. This structure was constructed in 1836 as a causeway crossing of the river and a source of water for Liverpool. The weir still exists today, with its historical significance recognised by the National Trust and the Australian Heritage Commission.

The next 20 kilometres of the river, between Liverpool and Picnic Point, includes the major floodplain area of the river. This area, being located within the southwest portion of Sydney's metropolitan area, is heavily urbanised and there are significant flood problems. Major tributaries within this reach include Cabramatta Creek, Prospect Creek, Harris and Williams Creek, and Salt Pan Creek. A major feature is also the Chipping Norton Lakes Scheme. This scheme consists of a series of lakes adjoining the river, which were formed in the 1970's and 1980's as part of the rehabilitation of former sand mining activities that had previously been undertaken in this area.

The final 20 kilometres of the lower river, between Picnic Point and Botany Bay, are typical of a deeply incised broad estuary and hence there are numerous bays and small inlets. Intensive development has occurred along both banks of the river, most of which is perched high above river flood levels. Major tributaries in the lower river include Salt Pan Creek and the Woronora River.

In total, about one-third of the catchment is occupied by some form of urban development, particularly in the lower end of the catchment. The remaining two-thirds of the catchment is comprised predominantly of bushland, national parks, reserves or rural lands.

The Georges River catchment is also the home of approximately one million people. The catchment also contains significant areas that have been identified for future urban development under the Sydney Region Urban Development Program. The majority of these areas are located within the Campbelltown, Liverpool, Fairfield and Sutherland Shire council areas. The Metropolitan Strategy [DUAP, 1998] is planned

to accommodate up to 43,000 new dwellings in the catchment over the next 20 to 25 years. A significant component of this future growth is anticipated to occur within the Cabramatta Creek catchment.

The administrative framework for managing the river, the floodplain and the catchment is quite complex. There are 12 different local government authorities within the catchment, namely:

- Wollondilly Shire Council;
- Wollongong City Council;
- Campbelltown City Council;
- Liverpool City Council;
- Fairfield City Council;
- Holroyd City Council;
- Bankstown City Council;
- Canterbury City Council;
- Sutherland Shire Council;
- Hurstville City Council;
- Kogarah Municipal Council; and
- Rockdale City Council.

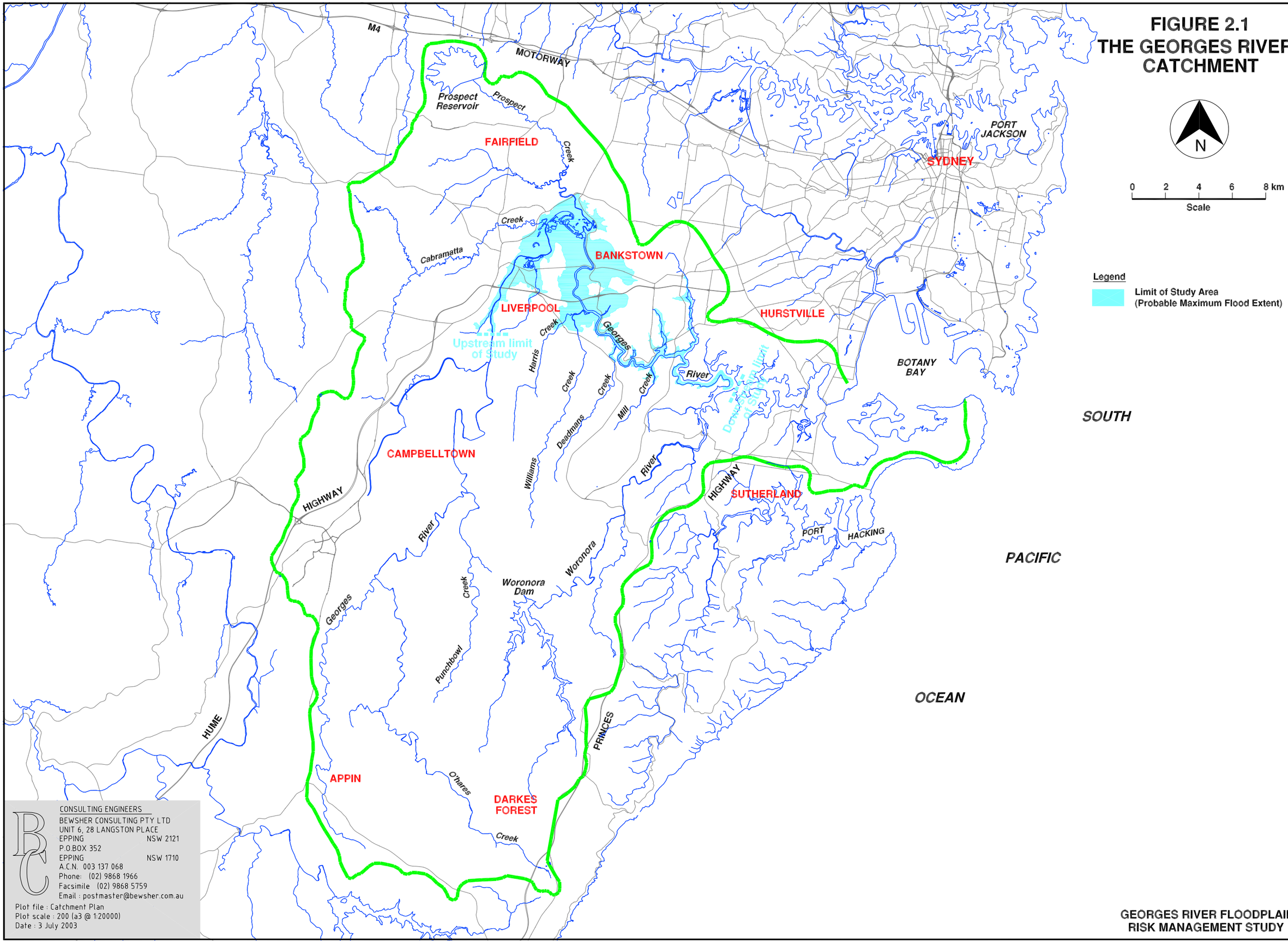
Each Council has their own planning controls to manage the risk of flooding and to safeguard the environmental qualities of the river. There are also many other Government Departments and Agencies with an interest in the river or the catchment, such as the Department of Infrastructure Planning and Natural Resources (DIPNR), Environment Protection Authority (EPA), NSW Fisheries, Georges River Combined Councils and others.

The army also owns approximately 20% of the catchment, including the Holsworthy Barracks, School of Military Engineering at Chatham Village, and other bushland that has been classified as “Military Reserve”.

As previously mentioned, the study area for this floodplain risk management study comprises the floodplain of the lower reaches of the river that is shared between Liverpool, Fairfield, Bankstown and Sutherland Shire Councils. This area is depicted on **Figure 2.2**.

Discussion on the environmental qualities, social aspects and other planning issues within the catchment that are relevant to the current study are presented in **Volume 2** of the Floodplain Management Study.

FIGURE 2.1
THE GEORGES RIVER CATCHMENT



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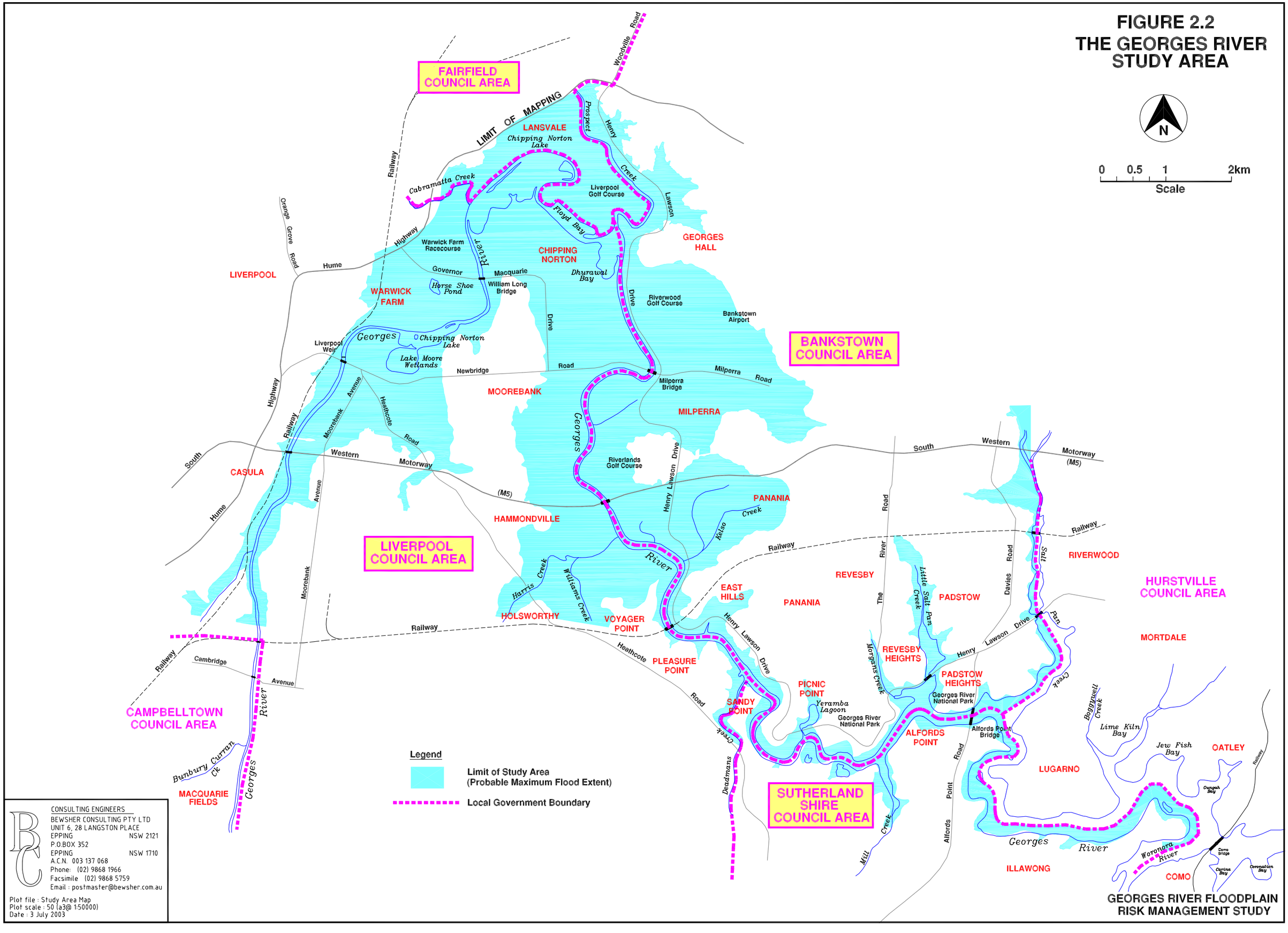
Plot file : Catchment Plan
Plot scale : 200 (a3 @ 1:20000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 2.2
THE GEORGES RIVER STUDY AREA



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Plot file : Study Area Map
Plot scale : 50 (a3@ 1:50000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

2.2 HISTORY OF FLOODING

Many people living near the Georges River will remember the heartache and damage caused by the August 1986 and April 1988 floods. These are the largest floods to have occurred over the last 30 years, and are estimated to be about a 20 year flood [PWD, 1991]. The 1988 flood was estimated to have inundated over 1,000 residential properties along the Georges River, Prospect Creek and Cabramatta Creek, with an estimated damage of over $18M (1988 values).

Fewer people may remember the February 1956 flood. This flood was about 1 metre higher than the 1986 and 1988 floods throughout much of the river, but is still estimated to be less than a 100 year event. The Sydney Morning Herald refers to this flood as the "biggest Sydney storm in living memory". It also refers to properties worth millions of pounds being destroyed, with 8,000 people left homeless.

But much larger floods are believed to have occurred during the 1800's. The largest observed flood is thought to have occurred in February 1873. On the basis of literature searches, this was probably the greatest flood since about 1800.

The 1873 flood level at Liverpool has been estimated to be 2m higher than the 1956 flood, and 3m higher than the 1986 and 1988 floods. It is also estimated as being higher than the 100 year flood.

An extract from the Sydney Morning Herald immediately following the 1873 flood is shown opposite. Whilst the report notes the severity of the flood and property being destroyed, it must be remembered that Liverpool at the time was considered to be a rural outpost of Sydney. The consequences of the flood would have been more far reaching if there had been more development near the river, as there is today.

Sydney Morning Herald, 27th February, 1873

THE FLOODS.

The reports we have received from the country districts show that the floods have been disastrous. A very large amount of private property has been destroyed, and public works also have been injured.

LIVERPOOL.

The highest flood known in the district occurred at Liverpool on Tuesday night. Several houses were swept away. The residence of a farmer near the dam fell into the river. The woolwashing establishment of the Hon. Saul Samuel was partially covered, and the flood has entailed considerable loss.

The Holdsworthy farmers have been washed out, and their hay has been destroyed. A subscription to afford them relief has been already set on foot.

In the town there has been much inconvenience, but no serious damage has been done.

The Paper Company's Works at one time were thought to be in great danger, but they have escaped with the loss only of the pumping-engine, which was carried away.

Some idea of the height of the flood may be obtained by those who know the country, when it is stated that George's River and a creek which runs through Mr. Wooll's farm, met. The rush of water displaced large quantities of soil, and injured the railway.

The river is now falling rapidly.

The late 1800's appears to have been a considerably intense period for floods, both on the Georges River and other nearby catchments, such as the Hawkesbury-Nepean. Other very large floods, similar to the estimated 100 year flood, are also reported to have occurred in 1889, 1887 and 1860.

Historical data on flooding is available from a variety of sources. These include:

- historical references and newspaper articles, such as those mentioned above;
- flood heights that have recorded at key locations throughout the catchment, particularly at the Liverpool weir and some of the older bridges;

- investigation, field survey and documentation of debris levels immediately after a flood, for example reports prepared following the 1986 and 1988 floods;
- data from recent floods, which are now recorded at a number of automatic water level gauges along the river; and
- research undertaken by others that have critically reviewed the available data.

The most complete record of observed flood heights have been recorded at the Liverpool weir, which was built in 1836 and provides a convenient location in which to observe and record flood levels. Today, an automatic water level recorder continually monitors the water level at this location. Flood levels for 30 different flood events have been recorded at the weir, or close to the weir, since the 1873 flood. These results are included in **Table 2.1**.

The Lansdowne Bridge on the Hume Highway crossing of Lower Prospect Creek is another structure of historical significance where a number of flood observations have been recorded. Flood levels for 16 different flood events have been recorded at this bridge, dating back to 1809. These results are also included on **Table 2.1**, along with some more recent results for William Long Bridge (Governor Macquarie Drive), Milperra Bridge and the East Hills Footbridge.

The historical flood records for the Liverpool weir and Lansdowne Bridge have been represented as two different flood histograms on **Figure 2.3**. These two plots effectively show the pattern of flooding over the last 140 years.

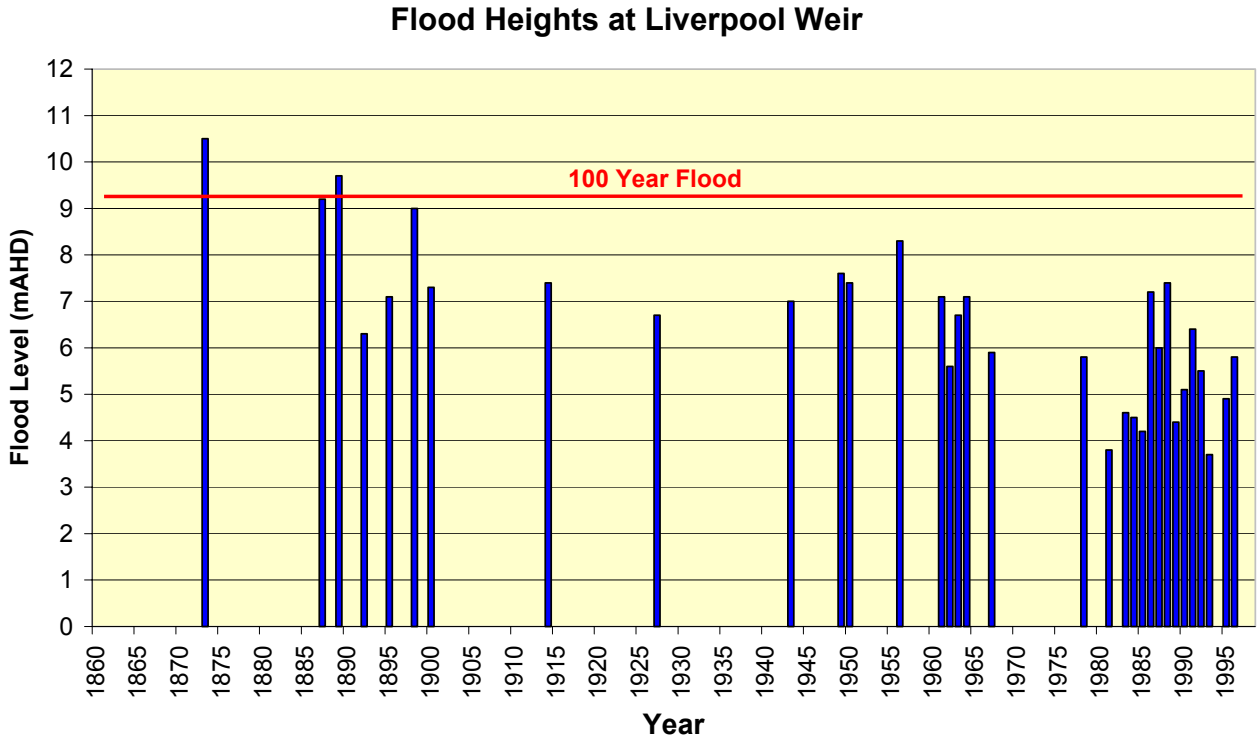
Both histograms indicate that the 1873 flood was the largest flood at both Liverpool and the Lansdowne Bridge, in both cases being at least 2m higher than the estimated 100 year flood level. The 1889 flood also appears to have been a very significant flood event at both locations. It is the second highest flood at Liverpool and the third highest at the Lansdowne Bridge. In both cases it is about 1m higher than the estimated 100 year flood level. A slightly larger flood is also reported to have occurred at the Lansdowne Bridge in 1860, although there are no supporting records from the Liverpool weir.

More importantly, both histograms confirm that floods that occurred in the latter half of the 1800's were significantly larger than floods that occurred during the 1900's. Flooding that has been experienced over the last century on the Georges River has therefore been relatively minor compared to the earlier flood events. Therefore those floods that are remembered by residents, such as those depicted on Photos 1 to 4, are relatively small in comparison to others that are possible, and that have occurred in the past. Consequently, public awareness of the potential magnitude of flooding within the catchment will be very poor.

It is important to note that nothing has happened within the catchment to mitigate major flooding. Some local improvements may have occurred in the vicinity of the Chipping Norton Lakes Scheme, but elsewhere conditions remain the same and possibly exacerbated by increased development that has taken place during the 1900's. It is just fortuitous that we have experienced a century of relatively low floods on the Georges River.

TABLE 2.1
Historical Flood Records
(All levels expressed in meters to Australian Height Datum)

Date	Liverpool Weir	William Long Br	Lansdowne Bridge	Milperra Bridge	East Hills Bridge	Source of Data (Reference)
May 1809			8.2			Sonter
April 1860			7.5			Sonter
Feb 1873	10.5		8.0			Stewart, 1968
April 1887	9.2					Stewart, 1968
May 1889	9.7		7.2			Stewart, 1968
1892	6.3					Scholer, 1966
Jan 1895	7.1					Scholer, 1966
Feb 1898	9.0		5.5			Sonter
July 1900	7.3					Stewart, 1968
Mar 1914	7.4					Stewart, 1968
1927	6.7					Stewart, 1968
1943	7.0					Scholer, 1966
June 1949	7.6					Stewart, 1968
June 1950	7.4		5.3	3.5		Stewart - MHL,1986
Feb 1956	8.3	6.5	5.7	4.8	3.7	PWD,1991
Nov 1961	7.1	5.7	4.6	3.8	2.8	Sonter - MHL,1986
Dec 1962	5.6					Stewart, 1968
Aug 1963	6.7	4.6		3.3		Stewart - MHL,1986
June 1964	7.1	5.2		3.6		Stewart - MHL,1986
April 1967	5.9					Stewart, 1968
Mar 1978	5.8		3.7	2.9	2.1	PWD, 1991
April 1981	3.8				1.2	Auto gauge
Mar 1983	4.6	2.4	1.5	1.2	0.9	MHL,1986
July 1984	4.5				1.3	Auto gauge
May 1985	4.2				1.1	Auto gauge
Aug 1986	7.2	5.7	5.1	4.4	3.2	MHL,1987
Oct 1987	6.0				2.4	Auto gauge
April 1988	7.4	5.9	5.8	4.9	3.6	MHL,1989
April 1989	4.4		1.3	1.2		Auto gauge
Feb 1990	5.1		3.1	2.9		Auto gauge
June 1991	6.6		4.7	3.8		Auto gauge
Aug 1996	5.8		2.4	2.0		Auto gauge



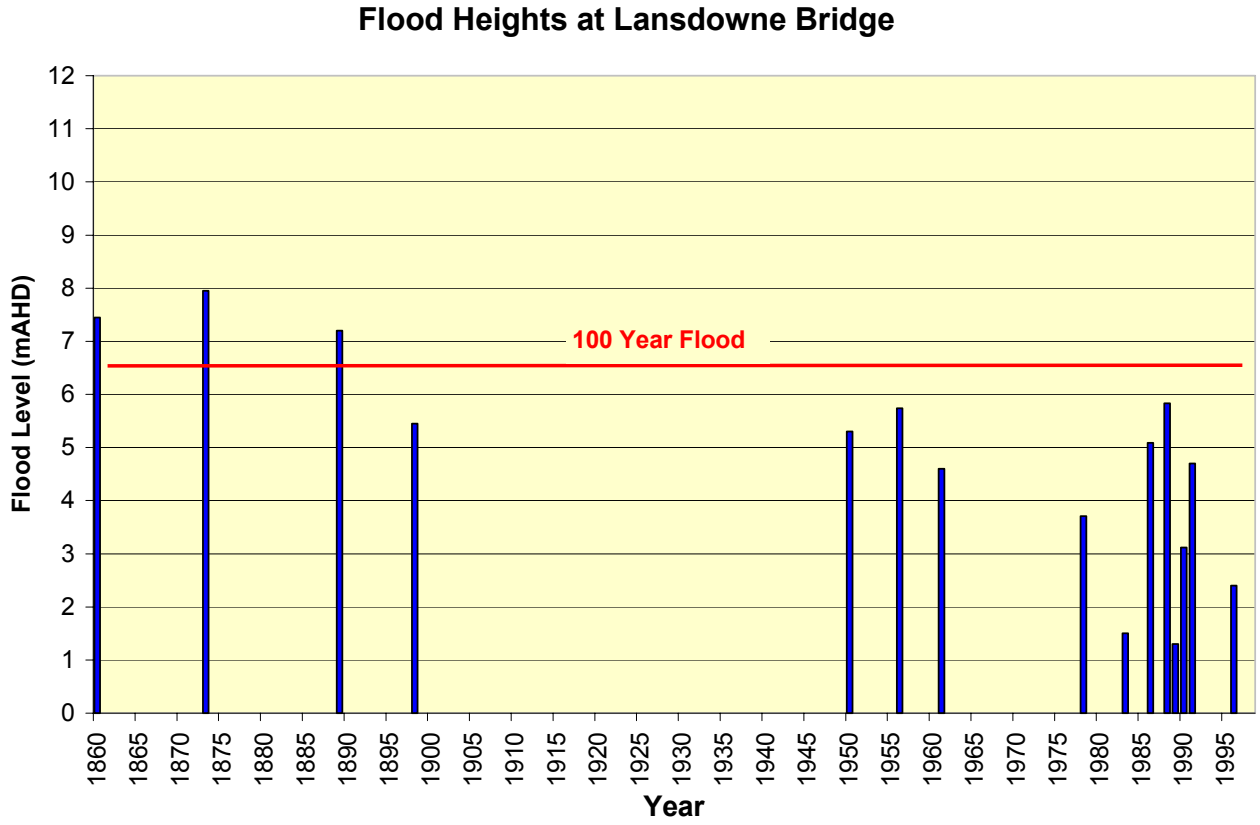


FIGURE 2.3
HISTORICAL FLOOD HEIGHTS AT LIVERPOOL AND LANSDOWNE BRIDGE

Photo 1 – Rescue during 1956 flood, Newbridge Road at Moorebank

Photo 2 – 1964 flood near East Hills Footbridge

Photo 3 – 1986 flood, looking upstream to Milperra Bridge

Photo 4 – 1986 flood, on the lower reaches of Prospect Creek

2.3 PREVIOUS FLOOD INVESTIGATIONS

Flood behaviour on the Georges River has been extensively studied since the mid 1960's. The methods of analysis have varied markedly, including simplified numerical procedures, flood frequency analysis on recorded flood data, physical model studies of the river and floodplain, and more recently, computer modelling.

The more recent flood studies that have been undertaken have defined flood conditions throughout the majority of the study area. The only exception being the Georges River downstream of East Hills. There have also been a number of floodplain management investigations undertaken on specific problem areas (refer Section 2.3.6). One of the main objectives for the current study is to consider the individual studies and to develop a strategic floodplain risk management plan for the wider catchment.

This Section gives a brief summary of some of the studies that have previously been undertaken on the Georges River, starting with the earlier work and concluding with the more recent studies.

2.3.1 Simplified Procedures

The first major investigation of flooding on the Georges River was probably a report prepared in 1966 by the NSW Public Works Department, titled “Georges River Flood Mitigation – Flood Forecasting Scheme for the Lower Georges River” [Scholer, 1966]. The objective of the study was to develop a flood warning procedure that would assist the State Emergency Service during floods.

Flood levels were derived on the assumption that the floodplain between Liverpool and East Hills was comprised of four interconnected ponds. A relationship was then derived between water levels in each pond and the flood height at the Liverpool gauge, based on the analysis of floods that occurred in 1950, 1956, 1961, 1963 and 1964. A flood prediction model, comprising a number of charts, was developed.

2.3.2 Flood Frequency Analyses

Further research on flood behaviour was carried out during the late 1960’s, based on flood frequency analyses of the historical flood records at Liverpool. Investigations were undertaken by various researchers, including Munro, Stewart, and Rowe and Ennis. Unfortunately, the results differed considerably, due largely to different assumptions regarding the accuracy of the early flood records.

In a study titled “The Georges River Hydraulic, Hydrologic and Reclamation Studies” [Munro et al, 1967] a table was produced ranking flood heights recorded at Liverpool from 1873 to 1967. A flood frequency analysis was undertaken on this data to determine flood levels for nominated flood frequencies (eg the 100 year flood). Subsequent investigations in a report titled “Frequency of Floods in the City of Liverpool [Munro et al, 1968] concluded that some of the early flood records were difficult to substantiate, and floods prior to 1890 were excluded from the flood frequency analysis. This eliminated the very large floods that had been reported in 1873, 1887 and 1889 and subsequently lowered flood level estimates by a significant amount. Flood levels determined at Liverpool were also transferred to

other locations on the Georges River, assuming that the flood gradient that was observed during the 1956 flood would be typical for all other floods.

Other studies, such as the "Report on Georges River, with Particular Reference to Levels at Liverpool Bridge" [Stewart, 1968] or "Land at Chipping Norton – Determination of Flood Levels" [Rowe and Ennis, 1970] were based on the analysis of either the full record of flood data or data that was filtered to remove recorded flood heights that could not be substantiated. Whilst the results of the various analyses varied considerably, it is interesting to note that both Munro and Rowe & Ennis arrived at the same dates for the three greatest floods; namely 1873, 1898 and 1956, in that order.

In 1978, the Public Works Department commissioned consultants Sinclair Knight and Partners to investigate flooding between Liverpool and East Hills. The study reviewed earlier flood frequency investigations at Liverpool, and adopted Munro's 1968 analysis. The 1956 flood gradient was then used to transfer the computed flood levels at Liverpool to elsewhere on the Georges River. The results of the study were used to prepare preliminary floodplain maps that defined the extent of flooding for the 20 year, 50 year and 100 year flood.

Limitations with the above approach include:

- it relied on the results of a flood frequency analysis, which had been shown to vary considerably between different researchers;
- it assumed that all floods would behave in a similar manner to the 1956 flood; and
- the extent of flooding shown on the floodplain maps was determined solely on the basis of the 2m contour mapping that was available for the catchment.

2.3.3 Physical Model Studies

Most of the subsequent flood mitigation investigations were carried out by the Public Works Department at their Manly Hydraulics Laboratory (MHL), using physical models. The first investigation was an investigation of flood mitigation options for the Milperra-Moorebank floodway, which ultimately led to the adoption of extensive voluntary purchase schemes for both Liverpool and Bankstown City Councils.

The physical model covered some three kilometres of the river, centred on the Milperra Bridge and had a horizontal scale of 1:200 and a vertical scale of 1:50. This same model was later extended to include the reach downstream to East Hills for investigations of the proposed M5 motorway crossing. It was later extended further downstream to Picnic Point, to allow investigations of flood mitigation works at East Hills and Carinya Road.

A separate physical model was constructed at the Manly Hydraulics Laboratory in 1979/80 to examine various aspects of the tidal hydraulics of the proposed Chipping Norton Lakes Scheme. This model had a horizontal scale of 1:250 and a vertical scale of 1:50, but did not contain overbank floodplain areas. In 1982 the model was modified to include overbank flow paths for the purpose of flood investigations for the Lakes Scheme. The model was later extended to incorporate investigations for both Prospect Creek and Rabaul Road.

A limitation of these physical model studies is that they looked at isolated areas of the river. Boundary conditions, in the form of inflow hydrographs and downstream tailwater levels, were not known to a high degree of confidence, and so a range of flows and tailwater levels were usually investigated.

In 1983, the Public Works Department commissioned the University of New South Wales Water Research Laboratory to undertake the Georges River Flood Study [PWD, 1991]. This study utilised a much larger physical model, which extended between Liverpool and Picnic Point. It had a horizontal scale of 1:500 and a vertical scale of 1:70. Unlike other physical models, this model was capable of operating under both steady-state flood conditions (simulating peak flood conditions only), or dynamic conditions (simulating the complete progress of the flood). The physical model had separate inflow sources to represent floodwater from the Georges River (upstream of Liverpool), Cabramatta Creek, Prospect Creek, Harris & Williams Creek, Deadmans Creek, and other major drainage inflows.

The physical model was calibrated in two phases. The first phase involved calibrating the main river section against data collected from a spring tide that was gauged by the Department in 1977, and minor floods that occurred in 1978 and 1983. The second phase involved calibrating the floodplain section of the river to data collected from larger floods. The 1956 flood was initially used for this purpose. During the course of the study, the 1986 and 1988 floods occurred, providing additional data for calibration.

The Georges River Flood Study report, which was released in 1991, provides design flood level estimates on the Georges River for the 20 year, 50 year and 100 year floods, as well as a PMF flood. These levels have been adopted by the relevant Councils, and are still used today.

There were two limitations with the physical model. Firstly, due to scaling affects, it was not always possible to analyse the impacts of various development scenarios or other changes to the river or floodplain. Secondly, the model occupied a considerable area, and the expense of keeping the model available indefinitely was high. Consequently, the model was dismantled in about 1993.

2.3.4 Computer Modelling

Considerable advances in computer modelling techniques have been made since the 1980's. Consequently, more recent studies have involved the development of computer models to simulate flood behaviour on the Georges River and its tributary creeks.

The Georges River Model Study [PWD, 1992] established a computer model, known as MIKE-11, to simulate the tidal behaviour of the Georges River, between Liverpool and Botany Bay. The model was calibrated to data collected during a spring tide in August 1991, and verified against other tidal data collected in 1989 and 1979.

The model was only intended to analyse tidal behaviour in the river, with cross sections extending only up to the top of bank. As a result, there is no description of the floodplain in the model, and the analysis of floods was not possible.

In 1998 the Department of Land and Water Conservation, in conjunction with Liverpool City Council, commenced the Upper Georges River Flood Study [DLWC, 1998]. These investigations utilised a MIKE-11 computer model to simulate flood conditions upstream of the area covered by the main Georges River physical model (ie upstream of the Liverpool weir).

River cross sections were derived on the basis of photogrammetric analysis of aerial photography and a hydrographic survey of the river that was undertaken in 1997. Boundary conditions for the model were determined from the physical model, to ensure consistency between the two models. The MIKE-11 model was calibrated to flood data that was available for the 1986 and 1988 flood.

Bewsher Consulting was later commissioned by Liverpool Council to convert the MIKE-11 tidal model downstream of Liverpool into a full flood model, by adding overbank sections and additional floodplain flow paths to the original model. This model was than joined to the Upper Georges River MIKE-11 model to provide a single computer model extending between Botany Bay and Cambridge Avenue [Bewsher Consulting, 1999]. This is discussed in more detail in **Section 4**.

2.3.5 Flood Data Collection Reports

In recent years, considerable data has been collected following significant floods. This data consists of records from automatic water level recorders and field survey of debris marks throughout the floodplain. Gauging teams from the then Public Works Department (PWD) have also gauged river flows and levels at various locations, including William Long Bridge, Lansdowne Bridge, Milperra Bridge and East Hills Footbridge.

The data collected has been compiled in separate data collection reports. These reports are available for the March 1983 flood [MHL, 1983], the August 1986 flood [MHL, 1987] and the April-May 1988 flood [MHL, 1989].

2.3.6 Flood Investigations in Specific areas

A number of other studies have been undertaken on specific parts of the study area. These include studies undertaken for the following areas:

Lower Cabramatta Creek

The draft Lower Cabramatta Creek Floodplain Management Study [Bewsher Consulting, 1999] was completed for Liverpool and Fairfield Councils in 1999. This report provides design flood levels in Cabramatta Creek and recommends various floodplain management measures to be implemented in the catchment. Results from the study for the area downstream of the Hume Highway are relevant to the current Georges River Study.

Lower Prospect Creek

The Lower Prospect Creek Floodplain Management Study [Willing & Partners, 1990] provides design flood level estimates and recommended floodplain management measures for Prospect Creek, between its confluence with the Georges River and the Cabramatta-Granville railway line. Results from the study downstream of the Hume Highway are relevant to the current Georges River Study. It is understood that Council has recently commissioned a review of this study, in light of flood mitigation works undertaken to date and the results from a recent flood experienced in the catchment.

Rabaul Road

The Rabaul Floodway Study [PWD, 1985] examined the flood hazard to existing residential development located along Rabaul Road. The study recommended that three properties be included in a voluntary purchase scheme and that specific development controls be applied to the area to reduce the flood hazard as redevelopment occurred.

Moorebank and Milperra Floodways

Studies were undertaken on Moorebank and Milperra Floodways for Liverpool Council and Bankstown Council [PWD, 1983]. The studies concluded that both areas represented extremely hazardous floodways, and recommended voluntary purchase schemes to gradually remove existing development. Both Councils adopted voluntary purchase schemes shortly afterwards, and the schemes continue to operate today. A total of 195 properties are included in the two schemes, with 120 properties purchased to date.

Milperra Drain

Milperra Drain is a tributary of the Georges River that is particularly susceptible to high flood damages, largely due to the type of industrial development located adjacent to the Drain. The Milperra Industrial Area Hydraulic Study [Willing & Partners, 1990] investigated flood conditions in this area for Bankstown Council and investigated options to reduce the level of flooding. Major channel augmentation measures were subsequently adopted by Council, and implementation of these works are now largely completed. A study to review flooding in the Milperra Drain catchment was recently commissioned (July 2003) by Council.

Moorebank

The Moorebank Flood Study [Willing & Partners, 1996] was undertaken for land between the M5 Motorway and Newbridge Road at Moorebank for Liverpool Council. The study evaluated the impacts of previous dredging and land fill activities on this parcel of land and assessed other development proposals.

M5 Motorway Bridge

The F5 Tollroad Bridge Over the Georges River – Verification of Flood Impacts [PWD, 1992] study was undertaken to assess the impact on flooding of the proposed bridge over the Georges River. The assessment was initially undertaken using one

of the smaller Georges River physical models, and later repeated using the broader physical model. The model results were used to determine an appropriate bridge span across the floodplain.

Kelso Levee

A number of investigations have been undertaken concerning the levee at Kelso Park. This includes the original Kelso Park Levee Design Feasibility Study [PWD, 1984] and various studies of the level of internal ponding behind the levee, from local catchment runoff, when the levee gates are closed. These levels were recently reviewed for Bankstown Council as part of the Kelso Creek Floodplain Study [Bewsher Consulting, 2000].

East Hills

The East Hills Floodway Model Investigation [PWD, 1987] report was undertaken for Bankstown Council in 1987 to assess various flood mitigation measures at East Hills. The investigations recommended the construction of a series of 'finger levees' to reduce flood velocities that would be experienced by houses adjacent to the river. The scheme was adopted by Council and the works were recently constructed. The works were recently reviewed as part of the "2D Modelling of East Hills Flood Management Works" study [WBM, 2001] undertaken for Council.

Carinya Road

A similar study, titled "Carinya Road Floodway Investigation" [PWD, 1984] was undertaken for Picnic Point. The recommended measures included the construction of an upstream deflector levee and several 'finger levees' to reduce flood velocities. The scheme was implemented some time ago.

Little Salt Pan Creek

A flood study of Little Salt Pan Creek [MHL, 1995] was carried out using a MIKE-11 hydraulic model. Design flood levels were determined for Little Salt Pan Creek between the East Hills Railway Line and the Georges River. These flood levels are still applicable today.

Salt Pan Creek

A flood study was undertaken to determine design flood levels for Salt Pan Creek [Webb McKeown & Associates, 1991]. The study area included Salt Pan Creek and its major tributaries, between the Georges River, Arab Road, Canterbury Road and Moxon Road. Flood levels were determined using the RUBICON hydraulic model. Flood levels determined from the study are still applicable today.

Deadmans Creek

The Deadmans Creek Flood Study [DLWC, 1997] was undertaken for Sutherland Shire Council. Design flood levels were determined between Heathcote Road and the Georges River using the MIKE-11 hydraulic model. These levels are still applicable today.

3. COMMUNITY CONSULTATION

3.1 CONSULTATION PROCESS

The success of any floodplain management plan hinges on its acceptance by the community, residents within the study area, and other stakeholders. This can only be achieved by involving the local community at all stages of the decision-making process. This includes the collection of their ideas and knowledge on flood behaviour in the study area, together with discussing the issues and outcomes of the study with them.

Community consultation has been an important component of the current study. As well as improving the community's awareness of and readiness for flooding, the consultation has aimed to inform the community about the development of the floodplain management study and its likely outcomes. It has also provided an opportunity to collect feedback and ideas on potential floodplain management measures and other related issues.

The key elements of the consultation process have been as follows:

- regular meetings of the Georges River Floodplain Management Committee;
- development of a study web site for the project;
- preparation of an SES FloodSafe brochure for the Georges River;
- preparation and distribution of a notification pack for all residents potentially affected by flooding;
- distribution of a short questionnaire to all residents, followed up with a more detailed questionnaire;
- organisation of ten public workshops;
- liaison with government agencies Interest Groups; and
- public exhibition of the recommended floodplain risk management study and plan, prior to formal consideration by each Council.

These elements are discussed further below.

3.2 GEORGES RIVER FLOODPLAIN MANAGEMENT COMMITTEE

The study has been overseen by the Georges River Floodplain Management Committee. This committee comprises representatives from:

- Liverpool City Council;
- Fairfield City Council;
- Bankstown City Council;
- Sutherland Shire Council;
- State Emergency Service;
- Department of Infrastructure, Planning and Natural Resources; and
- community members.

The Committee has met regularly to hear progress reports by the consultant, and to provide direction as the study progressed. As many of the representatives on the Committee are themselves members of other associations or groups, the committee has provided a valuable mechanism for the views of many interested parties to be represented.

3.3 PROJECT WEB SITE

A special web site was developed at an early stage of the study. The web site contained information and photographs about the current study and floods that have occurred in the past along the Georges River.

The web site was divided into a number of linked pages, providing details on:

- general information about the study and the web site (home page);
- the history of flooding on the Georges River;
- the current floodplain risk management risk study;
- floodplain management measures likely to be considered;
- publications relevant to the study;
- the detailed study questionnaire;
- a newsletter providing more information about the study; and a
- feedback page.

The site was located at www.bewsher.com.au/georges.htm.

3.4 SES FLOODSAFE BROCHURE

A 'FloodSafe' brochure was prepared for the Georges River, in cooperation with the State Emergency Service (SES), as part of the study.

The brochure was issued under the banner of the Georges River Floodplain Management Committee, and carried the logos of the State Emergency Service and the four participating Councils. The brochure was aimed at raising public awareness of flooding on the Georges River. It included several photographs of past flood events and a map showing the extent of maximum flooding possible (ie the PMF). The brochure also provided advice to the public on what to do in the event of a flood.

The brochure was mailed to residents potentially affected by flooding in October 2002 and was distributed at workshops that were held for the study during November and December.

3.5 COMMUNITY NOTIFICATION PACK

Every property owner potentially affected by flooding from the Georges River received a notification pack in October 2002, advising of the risk of flooding and providing details about the floodplain risk management study.

Approximately 7,000 property owners received:

- an individually addressed letter;
- a copy of the Georges River FloodSafe brochure; and
- a short questionnaire.

The objective of the notification pack was to raise awareness of both the flood risk on the Georges River and the current study. The letter invited residents to visit the study web site for further information about the study, or to contact one of the four Council liaison officers. The letter also invited residents to attend one of a series of planned community workshops to discuss the study.

The short questionnaire provided a mechanism to determine community interest in the study and issues that the community would like the study to address.

3.6 SHORT QUESTIONNAIRE

The short questionnaire asked four questions:

- "would you like to be included on the mailing list for the study?";
- "would you like to be sent a (detailed) questionnaire?";
- "would you like to participate in a workshop?"; and
- "are there any issues that the study should address?".

The response rate for the questionnaire is provided in **Table 3.1**, with results to the four questions summarised in **Table 3.2**.

TABLE 3.1
Short Questionnaire Response Rate

Council Area	Distribution	Response	Percentage
Liverpool	3,019	276	9%
Fairfield	781	49	6%
Bankstown	2,949	331	11%
Sutherland	247	24	10%
TOTAL	6,996	680	10%

TABLE 3.2
Short Questionnaire Results

Question	Council Area	Total 'yes' responses	Rate
Would you like to be included on a mailing list?	Liverpool	268	97%
	Fairfield	44	90%
	Bankstown	298	90%
	Sutherland	24	100%
	TOTAL	634	93%
Would you like to be sent a (detailed) questionnaire?	Liverpool	199	72%
	Fairfield	35	71%
	Bankstown	221	67%
	Sutherland	20	83%
	TOTAL	475	70%
Would you like to participate in a workshop?	Liverpool	112	41%
	Fairfield	16	33%
	Bankstown	111	34%
	Sutherland	16	67%
	TOTAL	255	38%
Are there any issues that the study should address?	Liverpool	80	29%
	Fairfield	16	33%
	Bankstown	88	27%
	Sutherland	8	33%
	TOTAL	192	28%

A complete list of issues, or other comments that were raised, is included in **Appendix A**. The most common issues raised include:

- concern over the impact of recent development (34 responses)
- request for additional flood information (17 responses);
- concern over stormwater issues (17 responses); and
- support for improved emergency management measures (16 responses).

3.7 DETAILED QUESTIONNAIRE

Detailed questionnaires were distributed to all property owners that requested one. Questionnaires were also made available at workshops and through the study web site. A total of 207 questionnaires were completed and returned, representing a response rate of about 43%.

The questionnaire was divided into a number of parts, dealing with flood readiness, flood experience, attitudes to council's controls on development, opinions on floodplain management measures, and other details. Results from the questionnaire are summarised below.

3.7.1 Part A – Flood Readiness

A relatively high proportion of property owners who responded (63%) believe that their property could be flooded some time in the future. This is a particularly high response given that the study area extends up to the PMF, and many property owners are unlikely to have experienced a flood in recent times.

Whilst some property owners (38%) had received information about flooding from Council, most others had learnt about flooding from their own experiences (29%) or from information from neighbours or friends (16%). Others (33%) had received no information from any source.

3.7.2 Part B – Flood Experience

Some 34% of property owners had experienced flooding on their property. The April 1988 flood was the largest flood experienced by 26% of property owners, whilst the August 1986 flood was also experienced by 22% of property owners. Only a very small proportion (5%) had experienced the larger 1956 flood, which suggests that public awareness of large floods is quite low.

A small proportion of owners (8%) had experienced flooding above floor level, mainly from the 1988 and 1986 floods. The average depth of flooding above floor level for these events was 0.8m.

The majority of owners believed there was little warning time available for them to take action to reduce possible flood damage.

3.7.3 Part C – Attitudes to Council's Controls on Development

Property owners were asked to rank development types that were most important to protect them from flooding. These were, in priority order:

i) residential development;

ii) critical utilities;

iii) essential community facilities;

iv) commercial and industrial development;

v) new residential subdivisions;

vi) minor developments and additions; and

vii) recreation or agricultural land.

Some significant number of respondents (34%) believed that Council should place restrictions, such as minimum floor levels, on new development to reduce the potential for flood damage. Slightly more respondents (38%) also believed that new development in hazardous areas should be prohibited.

The majority of property owners (70%) were in favour of every resident and property owner being advised on the potential flood risk of their property on a regular basis. Only a few (15%) believed that such advice should only be given to those who made an enquiry to Council.

3.7.4 Part D – Opinions on Floodplain Management Measures

Property owners were asked to list their five most favoured floodplain management measures that should be considered for the Georges River. The most favoured options are listed in **Table 3.3**. Owners were also asked to list their five least favoured options, which are listed in **Table 3.4**.

TABLE 3.3
Measures Most Favoured by the Community

Measure	Top 5 Priority	Highest Priority
1) Dredge the river	35%	14%
2) Review/Maintain existing flood mitigation works	33%	8%
3) Construct upstream dam(s)	30%	8%
4) Maintenance programs/clear unnecessary vegetation	29%	6%
5) Construct permanent levees	31%	4%

TABLE 3.4
Measures Least Favoured by the Community

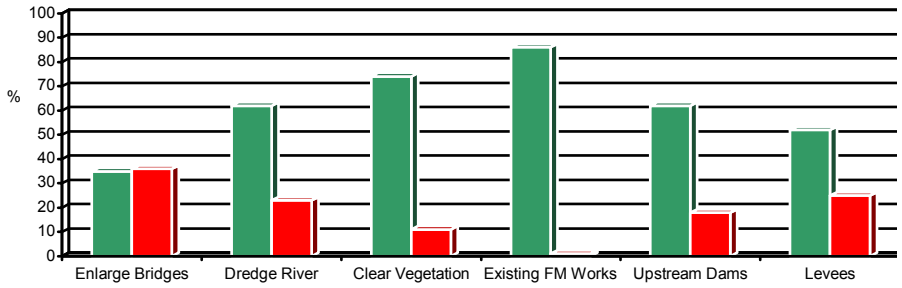
Measure	Least 5 Priority	Least Priority
1) Dredge the river	20%	10%
2) Enlarge bridges	18%	9%
3) Construct permanent levees	16%	6%
4) Flood proofing individual properties	15%	6%
5) Accelerate voluntary purchase scheme	15%	<1%

It is interesting to note that dredging the river was both the most popular floodplain management measure and also the least popular measure. Those favouring dredging possibly saw this measure as one that could potentially lower flood levels. Those that did not favour dredging may have been concerned over the environmental consequences of such action, or believed that there would only be limited flood benefits.

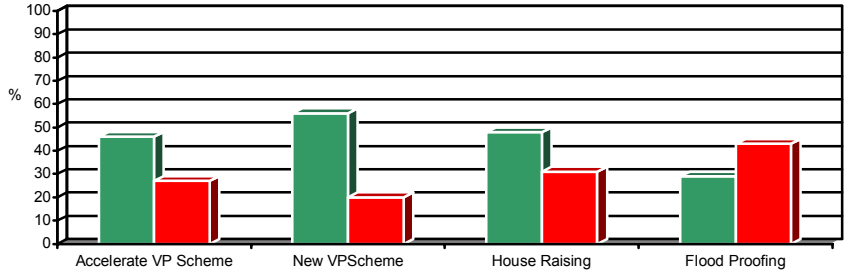
The construction of permanent levees also figured in both the most popular five measures and the least popular five measures.

Other measures that were most popular included the review and maintenance of existing flood mitigation measures, the construction of one or more upstream dams, and maintenance programs to clear the river of unnecessary vegetation.

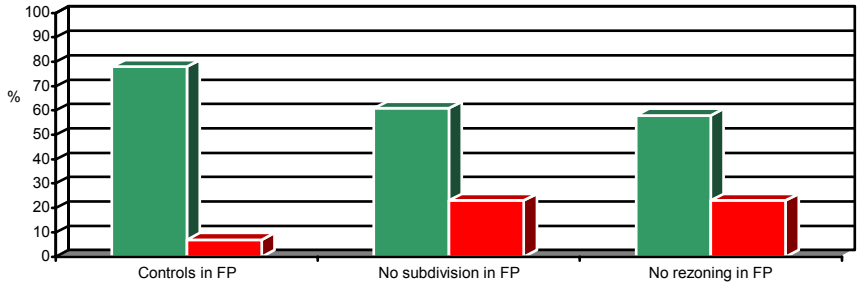
Property owners were also asked to comment on an extensive list of floodplain management measures, results of which are shown in **Figure 3.1**.



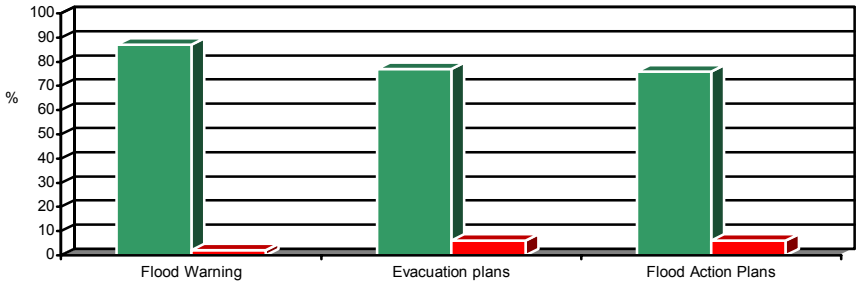
Measures that modify the way a flood behaves



Measures that modify properties



Measures that control building and development



Flood warning and emergency management measures

Flood awareness measures

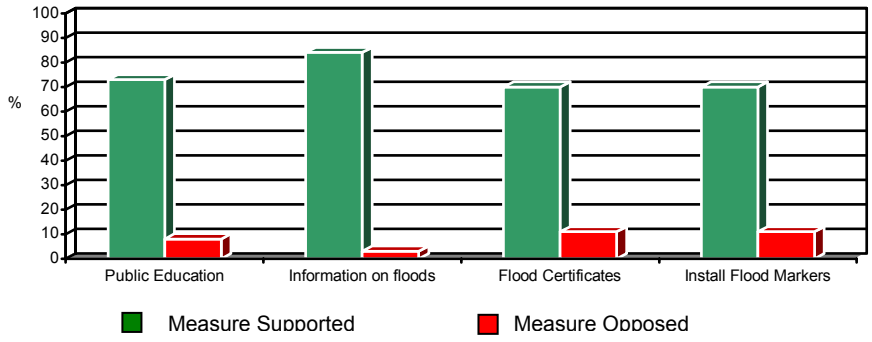


FIGURE 3.1
COMMUNITY VIEWS ON FLOODPLAIN MANAGEMENT MEASURES

The above results generally show that measures that modify the way that a flood behaves were all reasonably well supported (particularly the review and maintenance of existing flood mitigation works and maintenance programs to clear the river of unnecessary vegetation). There was also some opposition to some of these measures (including enlarging bridges, dredging the river, upstream dams and the construction of permanent levees).

Measures that aim to modify property in order to reduce potential flood damage (eg voluntary purchase schemes, house raising schemes and flood proofing) did not attract much community support.

The majority of property owners were in favour of building controls in the floodplain to minimise future flood damage. There was also support for prohibiting subdivisions and rezoning within the floodplain, although there was also some opposition to these latter two measures.

Flood warning and emergency management measures (flood warning, evacuation plans and flood action plans) all ranked very highly, with between 76% to 87% support, and with very little opposition.

All flood awareness measures (public education, providing information on flood risks, flood certificates and the installation of flood markers) also ranked very highly, with little opposition.

3.7.5 Part E – About Your Property

The majority of property owners who responded to the survey (93%) were residential owners with a house in the study area. The average time at this address is 20 years, and the average number of people living in the house is 3.0. The owner has little expectation to subdivide his property (2%), build a dual occupancy (3%), or to build a new dwelling (5%). There was a greater expectation to undertake minor extensions or alterations (26%).

3.7.6 Part F – More Information

Residents were asked to provide additional comments on floodplain management measures, or other issues that the floodplain management plan should consider. Written comments were provided by 46 respondents (22%). These responses have been included in **Appendix B**. The most common issues raised were as follows:

- need for controls on future development to limit runoff;
- stormwater issues, including maintenance of stormwater drains;
- objections to areas of the floodplain being filled, especially at Bankstown Airport;
- more information on flooding being made available; and
- insurance issues.

3.8 PUBLIC WORKSHOPS

A series of workshops were held during November and December 2002 to present details of the study to the community and to get feedback on some of the preliminary results from the study.

Ten workshops were held, including:

- two in the Liverpool Council area;
- three in the Fairfield Council area (two of these were part of related investigations in Prospect Creek);
- four in the Bankstown Council area; and
- one in the Sutherland Shire Council area.

A panel of speakers addressed each workshop, including representatives from the relevant council, the SES, the then DLWC (now DIPNR) and the consultant. Each workshop had two set question periods, and there was an opportunity for individuals to talk informally to members of the panel at the conclusion of each workshop. A series of "frequently asked questions" were also prepared and distributed at each of the workshops.

Preliminary results from the study were presented, including a review of past flood events, results of computer modelling, the proposed flood risk precincts and the likely development controls that would apply to each precinct, and a map showing these different flood risk areas.

The workshops were all relatively well received by the public. The main issues raised included:

- concern over the impact of new development on flood behaviour;
- stormwater flooding problems;
- what it means if you are classified as being in a low flood risk area;
- can anything be done to reduce the flood problems?;
- concern over the impact of the study on insurance and the availability of bank loans; and
- concern on the impact on property values.

Many of these issues had been addressed in the "frequently asked questions" (refer Appendix B), whilst others required some further explanation. The main controversial issues involved local issues that were not part of the current study, such as recent development decisions by the particular council that had not been well supported by the community.

3.9 LIAISON WITH GOVERNMENT AGENCIES AND GROUPS

There are numerous government agencies, authorities and other groups that have assets, interests and/or infrastructure in the Georges River study area. Liaison with these organisations was therefore seen as an important component of the community consultation strategy for the floodplain management plan.

The list of organisations to be consulted was determined with the Committee's assistance. Each organisation was then sent an introductory letter, special questionnaire, and a map of the study area showing the extent of the floodplain. Organisations that were consulted are listed in **Table 3.5**.

A formal response was received from 13 of the 66 organisations contacted (a response rate of 20%). A number of the organisations were also represented on the floodplain management committee, and have had an opportunity to express their views on aspects of the study through the committee. Issues raised by the organisations responding to the questionnaire are summarised below.

3.9.1 Sydney Water Corporation Ltd

Sydney Water advised that they were in the process of preparing an EIS for a proposed water re-use pipeline from the Glenfield and Liverpool sewage treatment plants to Malabar. The project would pipe treated water to Malabar, rather than discharging to the Georges River. Re-use water would be available for watering parks and golf courses along the route of the pipeline.

The re-use pipeline appears to be approximately 1050mm in diameter and will be bored under the Georges River near Cambridge Avenue (upstream of Liverpool) and between Newbridge Road and Governor Macquarie Drive (near Liverpool). The pipeline is also to be bored under Cabramatta Creek and is to cross over Prospect Creek (upstream of the Hume Highway), before turning east and heading towards Malabar. The pipeline is to be trenched from Glenfield to at least Prospect Creek, with sequential excavation and fill to minimise disruption.

Sydney Water requested information on current flood level estimates in the vicinity of the Glenfield and Liverpool sewage treatment plants. Sydney Water also advised that the embankment around the Liverpool plant was at RL 10.36m AHD, which puts it above the estimated 100 year flood level at this location, but just below the estimate for the probable maximum flood.

3.9.2 NSW Fisheries

NSW Fisheries advised that under the *Fisheries Management Act, 1994* approval would be required for any works involving dredging or reclamation of any part of the waterway. This potentially includes stormwater control devices, waterway crossings, sea walls or similar structures. It was noted that NSW Fisheries will not approve the piping or channelling of waterways.

It was also noted that approval from NSW Fisheries was required for any works that:

- potentially harm marine vegetation, macroalgae, seagrasses or mangroves;
- result in any blockage to fish passage;
- could potentially impact any aquatic threatened species;
- involves the removal of snags, including vegetation or boulders.

TABLE 3.5
Consultation with Agencies, Authorities and Groups

Department	Attention	Address		
Main Agencies				
Department of Land and Water Conservation	Environmental Coordinator	PO Box 3935	PARRAMATTA NSW 2124	
Department of Land and Water Conservation	Mr Arthur Low	PO Box 867	WOLLONGONG NSW 2520	
Chipping Norton Lakes Authority	Mr Scott Renwick	PO Box 867	WOLLONGONG NSW 2520	
Public Works Department	Regional Manager	Bankstown Civic Tower	66-72 Rickard Road	BANKSTOWN NSW 2200
Planning NSW	The Manager	GPO Box 3927	SYDNEY NSW 2001	
Planning NSW (Sydney Region West)	The Regional Manager	PO Box 404	PARRAMATTA NSW 2124	
NSW Environment Protection Authority	Policy Advisor	PO Box 668	PARRAMATTA NSW 2124	
NSW Environment Protection Authority	Policy Advisor	PO Box A290	SYDNEY SOUTH NSW 1232	
Sydney Water Corporation Limited	The Manager	PO Box A53	SYDNEY SOUTH NSW 1235	
Sydney Water Corporation Limited	The Manager	PO Box 367	BLACKTOWN NSW 2148	
NSW Fisheries	Lesley Diver	PO Box 21	CRONULLA NSW 2230	
NSW National Parks and Wildlife Service	The Manager	PO Box 1967	HURSTVILLE NSW 2220	
Department of Transport	Strategic Planning Manager	GPO Box 1620	SYDNEY NSW 2001	
Roads and Traffic Authority	Strategic Planning Manager	PO Box 558	BLACKTOWN NSW 2148	
State Rail Authority	Manager, Planning	PO Box K349	HAYMARKET NSW 2000	
Rail Infrastructure Corporation	Manager, Planning	GPO Box 47	SYDNEY NSW 2001	
Rail Estate	Manager, Planning	PO Box K349	HAYMARKET NSW 2000	
State Emergency Service	State Planning Coordinator	Level 4, 6-8 Regent Street	WOLLONGONG NSW 2500	
State Emergency Service	Divisional Controller	PO Box M54	MANAHAN NSW 2200	
Bureau of Meteorology	Gordon MacKay	PO Box 413	DARLINGHURST NSW 1300	
NSW Aboriginal Land Council	Officer in charge	PO Box W125	PARRAMATTA NSW 2150	
Gandangara Aboriginal Land Council	Officer in charge	PO Box 1038	LIVERPOOL BC NSW 1871	
Energy Australia	Network Planner	GPO Box 4009	SYDNEY NSW 2001	
Integral Energy Australia	Network Planner	PO Box 6366	BLACKTOWN NSW 2148	
A.G.L. Gas Company	Manager, Planning	AGL Centre	Locked Bag 944	NORTH SYDNEY NSW 2059
Telstra	Manager, Planning	231 Elizabeth Street	SYDNEY NSW 2000	
Optus	Manager, Planning	101 Miller Street	NORTH SYDNEY NSW 2060	
Vodafone Head Office	Manager, Planning	799 Pacific Highway	CHATSWOOD NSW 2067	
Department of Education and Training	Property Management Division	35 Bridge Street	SYDNEY NSW 2000	
Councils				
Campbelltown City Council	Dick Webb	PO Box 57	CAMPBELLTOWN NSW 2560	
Hurstville City Council	Mick Ward	PO Box 205	HURSTVILLE BC NSW 1481	
Rockdale City Council	The General Manager	PO Box 21	ROCKDALE NSW 2216	
Kogarah Council	The General Manager	Locked Bag 8	KOGARAH NSW 2217	
Wollondilly Council	The General Manager	PO Box 21	PICTON NSW 2571	
Army				
Department of Defence	Captain Stephen Brumby	DCSO Liverpool	Liverpool Military Area	MOOREBANK NSW 2174
Department of Defence	The Environmental Officer	Liverpool Military Area	Moorebank Avenue	MOOREBANK NSW 2174
School of Military Engineering	The Environmental Officer	Moorebank Avenue	MOOREBANK NSW 2174	

TABLE 3.5 (cont)
Consultation with Agencies, Authorities and Groups

Department	Attention	Address		
Committees etc				
Fairfield Five Creeks Committee	The Chairman	C/- Fairfield City Council	PO Box 21	FAIRFIELD NSW 2165
Southern Sydney Catchment Management Board	Jeanne Thuez	PO Box 3935	PARRAMATTA NSW 2124	
The Australian Conservation Foundation	The Secretary	33 George Street	SYDNEY NSW 2000	
Botany Bay and Catchment Alliance	Lynda Newman	PO Box 77	MATRAVILLE NSW 2036	
Georges River Riverkeeper Program	Samantha Rich	PO Box 795	SUTHERLAND NSW 1499	
Chambers of Commerce				
City of Liverpool Chamber of Commerce	Officer in charge	PO Box 167	LIVERPOOL NSW 2170	
Bankstown Chamber of Commerce	Officer in charge	93 Glassop Street	YAGOONA NSW 2199	
Historical Societies				
Liverpool and District Historical Society	Officer in charge	PO Box 90	LIVERPOOL NSW 2170	
Bankstown Historical Society	Officer in charge	4/127 Edgar Street	BANKSTOWN NSW 2200	
Golf Clubs				
Liverpool Colf Club	The General Manager	Hollywood Drive	LANSVALE NSW 2166	
Bankstown Golf Club	The General Manager	PO Box 51	MILPERRA NSW 2214	
Riverwood Golf Club	The General Manager	255 Henry Lawson Drive	GEORGES HALL NSW 2198	
Riverlands Golf Club	The General Manager	56 Prescot Parade	MILPERRA NSW 2214	
New Brighton Golf Club	The General Manager	180 Nuwarra Road	MOOREBANK NSW 2170	
Other Clubs & Associations				
Deepwater Motor Boat Club	The Manager	C/- East Hills RSL Club Ltd	Cnr Marco Ave & Childs St	PANANIA NSW 2213
Bankstown Bushland Society	Ms Patricia Bell	PO Box 210	PANANIA NSW 2213	
Sandy Point Residents Association	David West	C/- 9 Gambier Avenue	SANDY POINT NSW 2171	
Illawong/Alfords Pont Progress Association	Steve Borg	C/- 20 Casuarina Road	ALFORDS POINT NSW 2234	
Picnic Point Progress Association	The secretary	C/- The Scout Association	5 Rogers Avenue	HABERFIELD NSW 2045
Milperra and District Progress Association	The secretary	19 Glencorse Avenue	MILPERRA NSW 2214	
Georges Hall Progress Association	Keith Robey	176 Rex Road	GEORGES HALL NSW 2198	
Save Lansvale Committee	The secretary	121 Hollywood Drive	LANSVALE NSW 2166	
Blue Gum Farm Zoo	The Manager	Maxwell Avenue	MILPERRA NSW 2214	
Industy				
Bankstown Airport Limited	The General Manager	Airport Avenue	Bankstown Airport	BANKSTOWN NSW 2200
Hawker De Havilland	The Manager	361 Milperra Road	MILPERRA NSW 2200	
Goyen Controls Company Pty Ltd	The Manager	268 Milperra Road	MILPERRA NSW 2214	
Pirelli Power Cables & Systems Australia P/L	The Manager	1 Heathcote Road	LIVERPOOL NSW 2170	
Linter Link Roads	John Lindoy	PO Box 700	MOOREBANK, NSW, 1875	
Interlink Roads Pty Ltd	The Manager	Toll Plaza M5 South/West Motorway	HAMONDVILLE NSW 2170	

3.9.3 Department of Transport

Transport NSW advised that the Department administers bus interchanges and commuter car parks across the Greater Metropolitan Area. Their facilities within the study area include:

- bus/rail interchange and multi storey car park at Padstow Railway Station;
- multi-storey car park at Holsworthy Railway Station;
- bus/rail interchange at Liverpool Railway Station; and
- multi-storey commuter car park at Warwick Farm Railway Station.

Other State transport assets are managed by the Roads and Traffic Authority, Rail Infrastructure Corporation and Rail Estate.

3.9.4 Rail Infrastructure Corporation

The Rail Infrastructure Corporation provided details of assets that could be damaged by floodwater. This includes:

- rail bridge at Como (estimated potential damage $20,000);
- rail bridge at East Hills($20,000); and
- track assets at Holsworthy ($500,000).

3.9.5 Bureau of Meteorology

The Bureau of Meteorology provided a list of reference reports applicable to the current study. The Bureau also advised that it holds rain and river records at 3 hourly intervals since 1988.

The Bureau maintains a flood warning scheme for the valley, and questioned the adequacy of flood awareness within the community. It was noted that this lack of flood awareness could diminish the effectiveness of the warning system. It was also noted that people located above the 100 year flood level may believe that they are flood free, and that there was likely economic hardship should an extreme flood (greater than 100 years) occur.

3.9.6 AGL Gas Company

Agility Management Pty Ltd (AGL Gas) advised of potential damage to assets from floods. This includes potential damage to:

- pipes in road corridors (actual damage difficult to quantify);
- district pressures regulators in streets ($50,000 upwards); and
- gas meters in properties ($300 per household);

AGL believed it was desirable to produce flood contour maps showing flood free transport routes for emergency vehicles during flood periods.

3.9.7 Kogarah Council

Kogarah Council returned the questionnaire, but provided little detail or issues for the study to address.

3.9.8 Southern Sydney Catchment Management Board

A community representative responded on behalf of the Southern Sydney Catchment Board.

Reference was made to potential damage to parks, reserves and boardwalks during flood events.

It was also noted that there were a number of relevant studies on the Georges River, which were held in the Georges River Environmental Education Centre.

A number of issues were suggested for the current study, including:

- reference to the Georges River REP and the Southern Sydney Catchment Board Blueprint;
- the principle of no net loss of riparian vegetation and instream habitats (eg saltmarsh, mangrove and seagrasses) as criteria for any works; and
- any works should not impact negatively in terms of biodiversity or aesthetics on rivers or creek lines.

3.9.9 Bankstown Bushland Society

The Bankstown Bushland Society raised a number of concerns, mainly related to activities at Bankstown Airport.

There was concern that fill had been placed on flood prone land on the airport site, and that the impact of this fill on flood behaviour had not been quantified. There was also concern that flooding from the “Airport Creek” drain would impact on endangered bushland at Deverall Park. There was also concern over the potential impact to the Milperra Wetlands (corner Milperra Road and Henry Lawson Drive), which contains a number of plants that are regionally rare.

3.9.10 Sandy Point Residents Association

The Sandy Point Progress Association provided comments regarding the effect of flooding on sewerage and other infrastructure at Sandy Point. It was noted that the main pumping station at the river end of St George Crescent and two other intermediate pumping stations serve over 250 homes. There was some concern that unofficial connections may overload the system in relatively minor floods, resulting in sewerage overflows prior to the design cut-off flood level of the system.

The vulnerability of telephones, water and electricity supply was also noted.

Road access issues were also raised. Heathcote Road was cut by floodwater in both the 1986 and 1988 floods on the Liverpool side of Deadmans Creek Bridge. The road was closed for some time, which could be a problem for school buses trying to return to Sandy Point in the afternoon. Heathcote Road was also likely to be cut at the Williams and Harris Creek bridges, which would affect people at Pleasure Point and Voyager Point. It was noted that Heathcote Road is a major arterial road serving Sydney's South West, and any closure along this road had a major impact on traffic over a large area.

3.9.11 Save Lansvale Committee

The Save Lansvale Committee is a group of residents whose main aim is to stop undesirable development of flood prone land. The committee recommended that all flood affected property should be rezoned to prohibit any filling on flood prone land, as per Zone 6B. It was noted that where there needed to be an exception to this rule, it should be put to the wider community, not just a couple of surrounding properties.

There was concern that a major development involving 2m of fill at the corner of the Hume Highway and Knight Street had been permitted by Council, whilst at the same time minor development by residents in Knight Street had been refused.

3.9.12 Pirelli Power Cables

Pirelli Power Cables is a manufacturing organisation located on the eastern bank of the Georges River at Liverpool, which employs approximately 500 personnel. Potential flood damage to electrical systems was estimated to be as high as $5M in a major flood.

The organisation would like the current study to focus on methods to reduce the impact of future flooding.

3.9.13 Interlink Roads Pty Ltd

Interlink Roads have responsibility for managing the M5 motorway, including bridges over the Georges River at Hammondville and at Casula.

The road pavement and bridge piers could potentially sustain flood damage. The amount of damage would be dependent on the depth of inundation, duration of flooding and flood velocity. It was noted that potential flood damage costs were difficult to estimate, but could be as high as $2M/km of damaged road pavement and $40M for bridge repairs should piers be damaged through flood scour.

It was recommended that the impact of vegetation on the floodplain be considered as part of the current study.

3.10 PUBLIC EXHIBITION OF DRAFT REPORTS

A draft copy of the Georges River Floodplain Risk Management Study and Plan was placed on public exhibition from 21st January to 5th March, 2004.

Copies of Volume 1 (Main Report) and Volume 2 (Planning Issues) were exhibited at Liverpool, Fairfield, Bankstown and Sutherland Councils. The proposed flood risk precinct maps and other details were also exhibited, along with an executive summary that was available for people to take away. The reports were also published on the Internet and made available on CD to anyone requesting a full copy of the reports.

The exhibition did not generate a large response from the community. Whilst there were a number of general enquiries concerning the study, only 9 formal submissions were received (4 from Liverpool, 1 from Fairfield and 4 from Bankstown). A summary of these submissions is included in **Appendix C**.

4. MODELLING OF FLOOD BEHAVIOUR

4.1 PURPOSE

Design flood levels on the Georges River are available from the Georges River Flood Study [PWD, 1991]. This study used a physical scale model of the Georges River to simulate flood conditions between Picnic Point and Liverpool. Flood level contours from this report are included in **Appendix D**.

A number of other studies have also been undertaken to define flood conditions upstream of Liverpool and for the main tributary creeks of the Georges River. These studies include:

- Upper Georges River Flood Study [DLWC, 1999];
- Draft Cabramatta Creek Floodplain Management Study [Bewsher Consulting, 1999];
- Lower Prospect Creek Floodplain Management Study [Willing & Partners, 1990];
- Milperra Industrial Area Hydraulic Study [Willing & Partners, 1990];
- Little Salt Pan Creek Flood Study [Manly Hydraulics Laboratory, 1995];
- Salt Pan Creek Flood Study [PWD, 1991];
- Deadmans Creek Flood Study [DLWC, 1997].

A single computer model of the Georges River study area was recently developed by Bewsher Consulting for Liverpool Council. This model has been used as part of further flood investigations for the current floodplain management study. The purpose of the new modelling was to:

- verify flood levels from previous studies;
- consolidate the results of various models into a single computer model;
- provide additional information on flood behaviour, including velocities and other hazard indicators that were unavailable from the physical model; and
- verify whether or not recent development within the catchment has had any significant impact on design flood levels, and whether a revision of the design flood levels is warranted;
- test the impact of potential flood mitigation works in lowering flood levels; and
- provide flood level estimates in areas where these were previously unavailable (ie downstream of East Hills, through the Sutherland Shire part of the study area).

4.2 GEORGES RIVER MIKE-11 MODEL

The computer model used to simulate flood conditions in the Georges River is known as MIKE-11. This is a commercially available program that is used extensively throughout Australia and overseas, and is supported by the Danish Hydraulics Institute. It is a one-dimensional branch network model that simulates flood behaviour over the full duration of a flood, not just at the peak of the flood.

The Georges River MIKE-11 model was developed from various sources. The origin of the model was a MIKE-11 in-bank tidal model, which was first developed by the Public Works Department to study tidal behaviour between Liverpool and Botany Bay [PWD, 1992]. The tidal model was subsequently extended by Bewsher Consulting to incorporate the floodplain, by extending model cross sections and inserting additional overbank flow paths. A separate MIKE-11 model, developed as part of the Upper Georges River Flood Study [DLWC, 1998], was also added to the main model to extend it upstream of Liverpool.

The model extends over a distance of some 46km, from above Cambridge Avenue to Botany Bay. There are over 278 cross sections and a number of separate overland flow paths. A schematic diagram showing the location of model cross sections is provided on **Figures 4.1** and **4.2**.

The overbank topography was based on the 1:4000 scale orthophotomaps with 2m contours for the area downstream of Picnic Point. This is considered to be of a suitable accuracy due to the steeply sloping river banks and relatively wide river bed. Between Picnic Point and Liverpool the overbank topography was based on the same survey data used to construct the physical model of the Georges River in the 1980's. This consisted of orthophotomaps with 2m contours and overlays to these maps with additional survey data that had been assembled from various sources. The topography upstream of Liverpool was based on photogrammetric and ground survey undertaken as part of the Upper Georges River Flood Study.

Inflow boundary conditions for the model were the same as those adopted from the Georges River Flood Study [PWD, 1991]. However, due to the model's greater extent, additional inflows were required to account for Little Salt Pan Creek, Salt Pan Creek, Woronora River and other local catchment areas.

The adopted tailwater boundary condition for the model was a typical spring tide in Botany Bay. The timing of the tide was adjusted so that the peak discharge in the river coincided with the peak tidal level (ie RL 0.6m AHD). Whilst these tailwater level conditions were appropriate for use in the model, higher levels in Botany Bay and the Lower Georges River estuary, due to astronomic and other storm tide conditions, were adopted as design levels (as shown on Figure 4.3).

4.3 MODEL CALIBRATION

It is usual practise to calibrate a model to data collected from one or more historical flood events. This principally involves adjusting model roughness coefficients for the river and floodplain so that computed flood levels match observed or expected flood levels. Calibration of the MIKE-11 model has been considered over three separate reaches.

The reach of the model upstream of Liverpool, which was originally developed as part of the Upper Georges River Flood Study, had already been calibrated to flood data available from the 1986 and 1988 floods. Further calibration of this part of the model was therefore unnecessary.

GEORGES RIVER FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 4.1
MIKE-11 MODEL
CROSS SECTION LOCATIONS
(SHEET 1 OF 2)

N

0 0.5 1 2km
Scale

LEGEND

- 22835 — Cross section location and chainage
- MIKE 11 flowpath
- MIKE 11 link channel

FAIRFIELD CITY COUNCIL
LIVERPOOL CITY COUNCIL
BANKSTOWN CITY COUNCIL

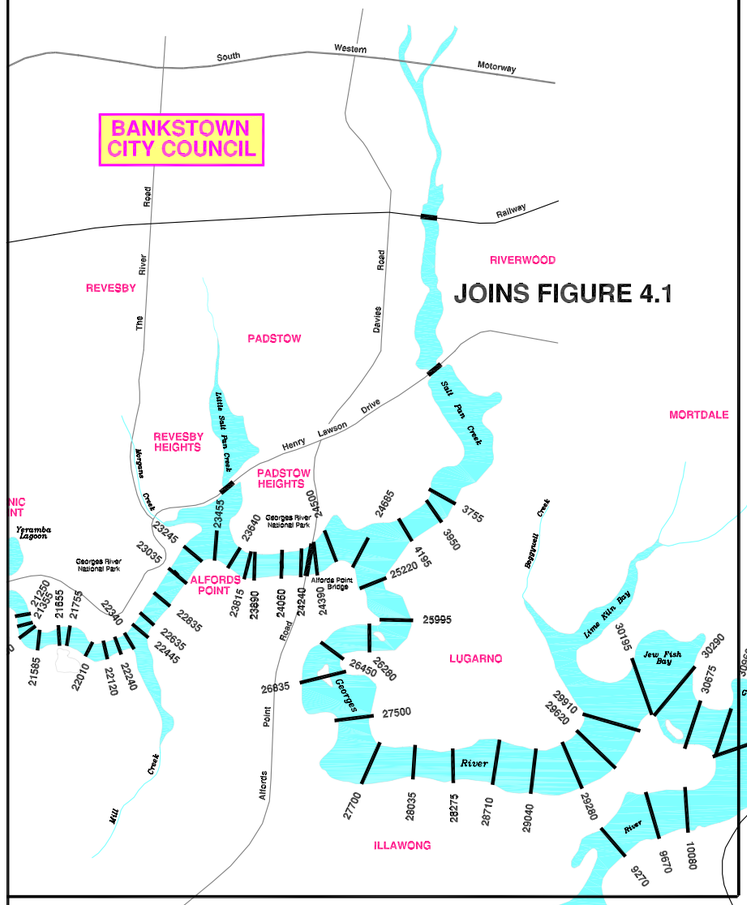
LANSVALE
GEORGES HALL
CHIPPING NORTON
LIVERPOOL
WARWICK FARM
MOOREBANK
MILPERRA
CASULA
HAMMONDVILLE
HOLSWORTHY
VOYAGER POINT
EAST HILLS
PLEASURE POINT
SANDY POINT
PICNIC POINT
MACQUARIE FIELDS
REVESBY
PADSTOW
REVESBY HEIGHTS
PADSTOW HEIGHTS
ALFORDS POINT
RIVERWOOD
MORTDALE
LUGARNO
ILLAWONG

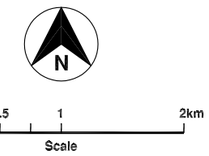
JOINS FIGURE 4.2

CONSULTING ENGINEERS
BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
EPPING NSW 2121
P.O.BOX 352
EPPING NSW 1710
A.C.N. 003 137 068
Phone: (02) 9868 1966
Facsimile (02) 9868 5759
Email : postmaster@bewsher.com.au

Plot file : Model-Cross-sections
Plot scale : 50 (a3 @ 1:50000)
Date : 3 July 2003

FIGURE 4.2
MIKE-11 MODEL
CROSS SECTION LOCATIONS
(SHEET 2 OF 2)





LEGEND

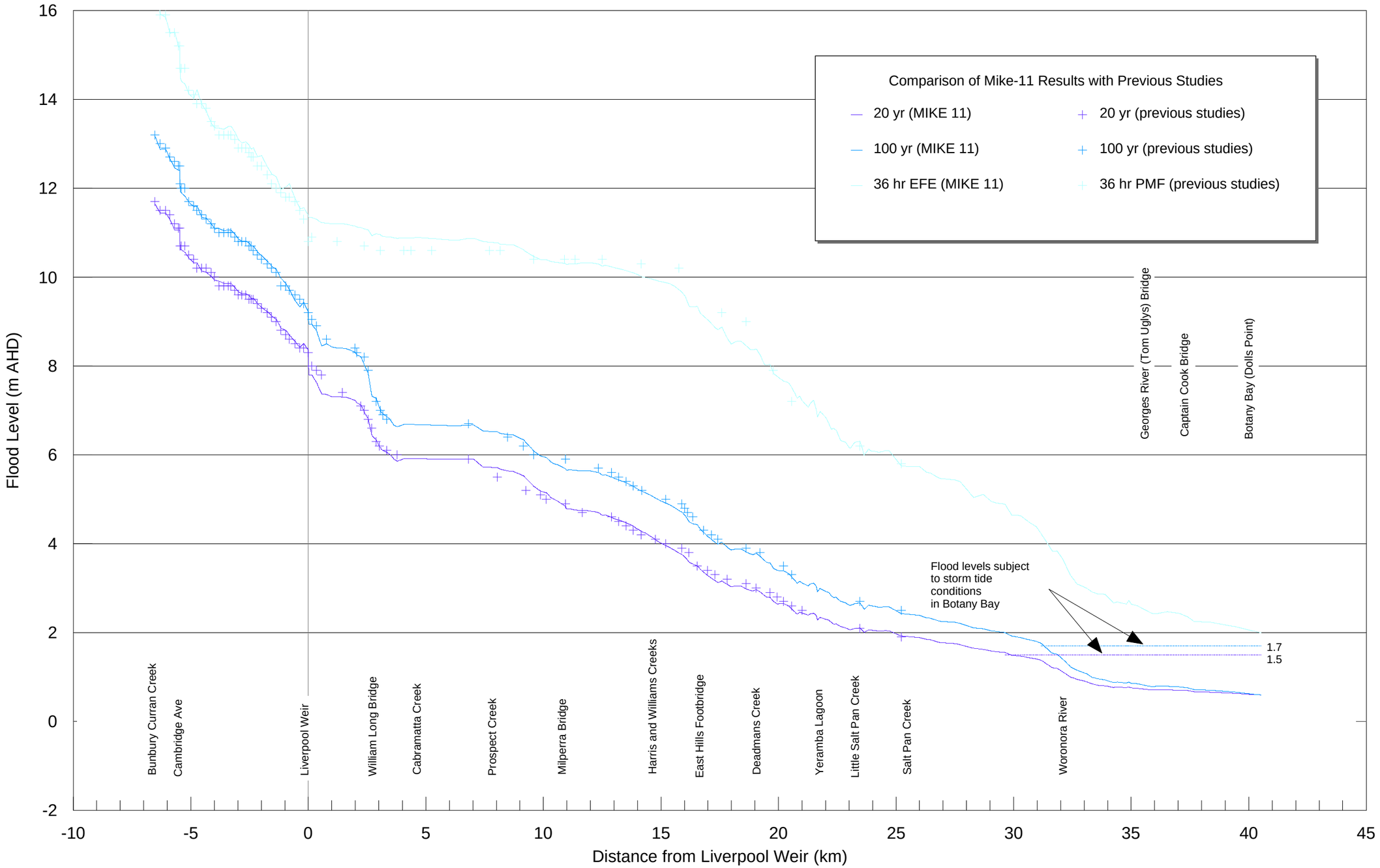
22835 Cross section location and chainage

CONSULTING ENGINEERS
BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
EPPING NSW 2121
P.O.BOX 352
EPPING NSW 1710
A.C.N. 003 137 068
Phone: (02) 9868 1966
Facsimile (02) 9868 5759
Email : postmaster@bewsher.com.au

Plot file : Model-Cross-sections
Plot scale : 50 (a3 @ 1:50000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 4.3
VERIFICATION OF THE GEORGES RIVER MIKE-11 MODEL



The mid section of the model, between Liverpool and Picnic Point, effectively represents the area covered by the previous Georges River physical model. This model had been extensively calibrated over a number of years to floods that occurred in 1956, 1978, 1986 and 1988. Consequently there is a high degree of confidence in the results from the physical model in this part of the study area. Also, as the main purpose of the model in this reach was to test the impact of recent development and potential floodplain management measures, it was considered appropriate to calibrate the MIKE-11 model to results from the physical model (particularly the 100 year flood).

The downstream part of the model, from Picnic Point to Botany Bay, represents a new area for flood modelling. There is no documented information on historic flood levels within this reach of the river. Roughness coefficients determined from the MIKE-11 tidal model, which had been calibrated to data collected during two spring tides, were therefore maintained in the current model. Floodplain coefficients were estimated on the basis of aerial photography. Comparison was also possible with some previous flood level estimates that were determined by the Public Works Department at the confluence of Little Salt Pan Creek, Salt Pan Creek and the Woronora River.

A comparison of the computed MIKE-11 flood profiles with other previous flood level estimates is shown on **Figure 4.3**. Results indicate good agreement for the 20 year and 100 year floods, with most points lying within ±0.1m of previous results. There is more variability with the PMF estimates with most points lying within about ±0.3m. Given the magnitude of this extreme flood, the new estimates are still considered to be relatively consistent with the previous results.

The floodplain represented in the MIKE-11 model has matched, as closely as possible, conditions that were represented in the former physical model. These conditions coincide approximately to 1986 floodplain conditions. The model has subsequently been used to assess changes in the floodplain that have occurred since this date, which could potentially have an impact on design flood levels. Results of this assessment are discussed below.

4.4 IMPACTS OF RECENT DEVELOPMENT

The short questionnaire that was distributed to all residents in the study area invited people to suggest issues of concern that the current study should address. By far the most common issue raised was concern over the impact of recent development on flood behaviour. This issue was raised by 34 different people, representing 18% of those people who made written submissions in response to the questionnaire.

A number of changes have occurred throughout the catchment and study area since 1986. Aerial photography of the catchment that was flown in 1986, 1996, and 2001 has assisted in identifying some of these changes. The main changes that are evident include:

- upstream catchment development;
- the Chipping Norton Lakes Scheme;
- filling on Bankstown Airport;

- Moorebank/Milperra floodway scheme;
- sand extraction and stockpiling activities at Moorebank;
- the M5 Motorway Bridge over the Georges River;
- Kelso Park levee;
- flood mitigation works constructed at East Hills; and
- flood mitigation works constructed at Carinya Road.

4.4.1 Upstream Catchment Development

Much of the development that has occurred in the Georges River catchment over the last 10 years has been in new development areas located in the upper reaches of the catchment. Areas in upper Prospect Creek and Cabramatta Creek have been developed, or are in the process of being developed. There has also been substantial growth in the Campbelltown area.

New development usually leads to an increase in impervious catchment area, leading to increased runoff, with the potential to increase downstream flooding. Fairfield, Liverpool and Campbelltown Councils have developed drainage strategies in these new developing areas to ensure that the impacts of increased catchment runoff are mitigated by appropriate compensating measures. The three Councils have adopted schemes with a number of detention basins to ensure that post-developed flows do not exceed pre-developed flows.

Given the scale of the development that has taken place over the last 15 years in relation to the total catchment area, coupled with the drainage strategies adopted by the Councils concerned, the impact on flood levels in the Georges River should be very small.

4.4.2 Chipping Norton Lake Scheme

The Chipping Norton Lakes scheme involves the rehabilitation of former sand mining sites adjacent to the river by the creation of a series of inter-connected lakes and other recreational areas. The scheme commenced in 1977 and is largely complete today.

Both the former physical model and the current MIKE-11 model incorporate the scheme as it existed in 1986. Comparison of aerial photography between 1986 and 1996 indicates only marginal changes to the extent of the lake scheme. Only minor changes have occurred to the extent of Chipping Norton Lake and Dhurawal Bay as dredging operations have come to an end.

Flood behaviour through the Lakes scheme is largely influenced by channel constrictions at Long Point, Coot Island, and also the reach of the Georges River downstream of Dhurawal Bay. As these do not appear to have changed since 1986, it is expected that minor changes to the Lakes area will have negligible impact on flood behaviour.

4.4.3 Filling on Bankstown Airport

Of the residents that raised concerns over the impact of recent development on flood behaviour, many specifically referred to filling that had recently taken place, and continued to occur, on Bankstown airport. Many members of the Georges River Floodplain Management Committee also raised this as a major concern.

The airport site is on land that is owned by the Commonwealth of Australia. The airport and its facilities are operated by Bankstown Airport Limited, an independent public company wholly owned by the Commonwealth of Australia. Being Commonwealth land, there are no obligatory requirements for Bankstown Airport Limited to seek approval from Bankstown Council for activities undertaken on the site, including the filling of land.

The airport runways and main tarmac appear to be located on land that is at or above the 100 year flood. Other areas to the south, near Milperra Road and Henry Lawson Drive, are lower and have previously been affected by both the 1986 and 1988 floods (see Photo 3). These floods are estimated to be approximately 20 year flood events and more widespread flooding can be expected in larger events. This low-lying land has been filled, or is in the process of being filled, to a level similar to the 100 year flood level.

Filling of this site will result in a loss in floodplain storage and also a loss in flood conveyance in larger floods. Given the scale of the earthworks undertaken to date, it was considered that this activity was likely to lead to an increase in flood levels, both at the site and elsewhere along the river and floodplain. These works were therefore included in the MIKE-11 model to assess their potential impact on flood behaviour. Results from the assessment are summarised in **Table 4.1**.

TABLE 4.1
Impact of Filling at Airport on Georges River Flood Levels

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	+13
Cabramatta Creek	4360	CNWEIR 4360	+18
Prospect Creek	8720	MILCN 8720	+23
Rabaul Road	9880	MILCN 9880	+34
Moorebank VP area	N/A	ARTHUR 180	+47
Airport Site	N/A	MIL DRAIN 7670	+65
Milperra Road	10930	MILCN 10930	+37
Milperra Drain	12620	SPMIL 12620	+37
M5 Motorway	14150	SPMIL 14150	+37
Williams Creek	14760	SPMIL 14760	+32
Kelso Creek	15880	SPMIL 15880	+31
East Hills Railway	16970	SPMIL 16970	+30
Deadmans Creek	18610	SPMIL 18610	+28
Salt Pan Creek	25220	SPMIL 25220	+19
Como Bridge	31635	GEORGES 31635	+1

As can be seen from the above results, the filling of the airport site is estimated to lead to an increase in the 100 year flood level of 30 to 40mm over a distance of some 8km along the river. Larger increases are also evident at and adjacent to the airport site.

The floodplain management committee is concerned about the impact of this activity, and has pursued the matter on several occasions either through letters issued by Bankstown Council or the Committee. However, neither Bankstown Council nor the Committee have any jurisdiction over the airport site, and a course of corrective action is yet to be agreed to.

4.4.4 Moorebank/Milperra Floodway Scheme

Liverpool and Bankstown Councils adopted voluntary purchase plans in the early 1980s for the gradual removal of development from the Moorebank-Milperra floodway. A total of 170 properties are included in the scheme on the Liverpool side of the river and 24 properties on the Bankstown side. To date, just over half of the Liverpool properties and most of the Bankstown properties have been acquired and removed from the floodway.

The removal of houses from the floodway results in less obstruction to floodwaters, and consequently a slight change in flood behaviour can be anticipated. This change was assessed by reducing the MIKE-11 model roughness coefficients in locations where buildings have been removed. This is a somewhat subjective change, but nevertheless provides an indication of the potential change in flood levels. A summary of model results for this activity is provided in **Table 4.2**.

TABLE 4.2
Impact of Removal of Buildings from the Moorebank/Milperra Floodway

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	-7
Cabramatta Creek	4360	CNWEIR 4360	-8
Prospect Creek	8720	MILCN 8720	-10
Rabaul Road	9880	MILCN 9880	-14
Milperra Road	10930	MILCN 10930	-9
Milperra Drain	12620	SPMIL 12620	+5
M5 Motorway	14150	SPMIL 14150	+6
Williams Creek	14760	SPMIL 14760	+6
Kelso Creek	15880	SPMIL 15880	+5
East Hills Railway	16970	SPMIL 16970	+5
Deadmans Creek	18610	SPMIL 18610	+4
Salt Pan Creek	25220	SPMIL 25220	+4
Como Bridge	31635	GEORGES 31635	0

Results from the assessment indicate that there will be a small reduction in flood levels upstream of the floodway of up to 14mm, as the floodway becomes more efficient. However, downstream of the floodway, levels increase marginally by up to 6mm.

4.4.5 Activities at Moorebank

There have been various sand extraction and stockpiling activities on land at Moorebank, located between Newbridge Road and the M5 Motorway, since the early

1970s. This has resulted in the alteration of the natural floodplain, with consequential loss in flood storage and flood conveyance since this time.

Much of these activities occurred prior to 1986, and therefore the topography represented in both the physical model and the new MIKE-11 model already incorporate the majority of these changes.

A separate study on the impact of past activities at this location was undertaken for Liverpool Council, titled "Moorebank Flood Study" [Willing & Partners, 1996]. This study assessed flood behaviour using a fairly detailed computer model that represented a small reach of the river and floodplain upstream of the M5 motorway. The findings of that report indicate that activities undertaken to that time had possibly increased the 100 year flood level by as much as 120mm in the 100 year flood at Newbridge Road.

It is understood that the conditions of consent in relation to the activities undertaken on in this area include a requirement that the site be rehabilitated to "natural" floodplain conditions on completion of the operations. This would then negate the impact of the former activities on flood behaviour. As these operations draw to a conclusion, it is important that this requirement is not overlooked.

As most of the changes in topography are largely incorporated in both the physical model and MIKE-11 model, these impacts are already factored into the design flood levels that have been determined for the Georges River. However, there is an opportunity to improve flood conditions when rehabilitation takes place.

4.4.6 M5 Motorway Bridge

In 1991 the Roads and Traffic Authority entered into an agreement with Interlink Roads Pty Ltd to build and manage the M5 Motorway between King Georges Road and Moorebank Avenue. The project included the construction of a 540m bridge across the Georges River and its western floodplain at Hammondville. The size of the bridge was chosen to limit the impact on flood behaviour, based on an assessment using the previous physical model.

A temporary access track was formed beside the bridge alignment in order to assist with the construction of the bridge. It is understood that approval for this temporary access track was conditional on its removal within 12 months of the completion of the bridge. This was largely due to concerns that the access track, in combination with the bridge, may have a more significant impact on flood behaviour.

A catchment inspection undertaken by the Georges River Floodplain Management Committee in December 2001 revealed that the temporary access track had not been removed. The access track was observed to be 1-2m above natural floodplain levels immediately downstream of the bridge. This prompted further assessment of the impacts of the bridge and access track in the MIKE-11 computer model. The results of the assessment are summarised in **Table 4.3**.

Results from the assessment indicate that the access track and bridge result in a maximum increase in the 100 year flood of 74mm on the upstream side of the bridge. The majority of this increase is considered to be attributable to the access track, rather than the Motorway Bridge. The constriction does, however, provide a smaller reduction

in flood levels on the downstream side of the bridge of up to 51mm. Given the properties potentially affected by flooding on the upstream side of the bridge, the net result of the constriction is considered to be undesirable.

TABLE 4.3
Impact of M5 Motorway Bridge and Access Track

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	+3
Cabramatta Creek	4360	CNWEIR 4360	+4
Prospect Creek	8720	MILCN 8720	+9
Rabaul Road	9880	MILCN 9880	+25
Milperra Road	10930	MILCN 10930	+42
Milperra Drain	12620	SPMIL 12620	+52
M5 Motorway	14150	SPMIL 14150	+74
Williams Creek	14760	SPMIL 14760	-51
Kelso Creek	15880	SPMIL 15880	-50
East Hills Railway	16970	SPMIL 16970	-47
Deadmans Creek	18610	SPMIL 18610	-41
Salt Pan Creek	25220	SPMIL 25220	-3
Como Bridge	31635	GEORGES 31635	-1

The Committee has been liaising with Interlink Roads in relation to the matter, and it is understood that Interlink Roads have agreed to remove the access track.

4.4.7 Kelso Park Levee

The Kelso levee was constructed by Bankstown Council in 1986 to provide protection to an estimated 148 houses at Panania in a 100 year flood. As the levee reduces the available floodplain storage for floodwater from the Georges River to pond, some increase in flood levels can be expected.

The levee was under consideration at the time of the physical model tests, and was included in all model design runs. It was also included in the current MIKE-11 model. Therefore, whilst a slight increase in flood levels is anticipated as a result of the levee, all model runs have already incorporated this increase in the current estimates.

The feasibility study undertaken for the levee in 1984 [PWD, 1984] estimated that the levee would reduce the available floodplain storage by 300,000m^3. At the time, this was not considered to result in a significant impact on flood behaviour, and that the benefits of the scheme far outweighed any small adverse impacts.

As the levee was approved many years ago, and already factored into current flood level estimates, further assessments do not appear to be warranted.

4.4.8 Flood Mitigation Works at East Hills

Flood mitigation works have recently been completed by Bankstown Council at East Hills. The scheme consists of the construction of an upstream deflector levee and five 'finger levees' that were to be constructed along property boundaries, perpendicular to the direction of river flows. The objective of the scheme is not to prevent flood

inundation, but to reduce flood velocities, thereby reducing the flood hazard for existing buildings in this area (which is dependent on both flood depths and flood velocities).

The scheme was first investigated as part of the East Hills Floodway Model Investigation [PWD, 1987], with construction first commencing in 1995. The scheme has now essentially been completed, except for one of the proposed finger levees where agreement with property owners could not be reached.

The levees reduce the flow of water across the floodplain and consequently some change in flood behaviour can be expected. The scheme was therefore included in the MIKE-11 model, by increasing roughness coefficients on the floodplain to reduce its capacity to convey floodwaters at this location. Results of the assessment are shown in **Table 4.4**.

TABLE 4.4
Impact of East Hills Flood Mitigation Works

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	+1
Cabramatta Creek	4360	CNWEIR 4360	+2
Prospect Creek	8720	MILCN 8720	+2
Rabaul Road	9880	MILCN 9880	+3
Milperra Road	10930	MILCN 10930	+3
Milperra Drain	12620	SPMIL 12620	+3
M5 Motorway	14150	SPMIL 14150	+5
Williams Creek	14760	SPMIL 14760	+6
Kelso Creek	15880	SPMIL 15880	+7
East Hills Railway	16970	SPMIL 16970	0
Deadmans Creek	18610	SPMIL 18610	-1
Salt Pan Creek	25220	SPMIL 25220	0
Como Bridge	31635	GEORGES 31635	0

The change in flood levels from the scheme are small, and limited to about 7mm. It should be noted however, that local increases in flood level immediately adjacent to individual levee walls could be substantially higher, though confined to a relatively small area.

4.4.9 Flood Mitigation Works at Carinya Road

A finger levee scheme, similar to that described above for East Hills, was also implemented at Carinya Road several years earlier.

The impact of the Carinya Road flood mitigation scheme was also assessed using the MIKE-11 model. Results of the assessment are provided in **Table 4.5**.

The maximum increase in the 100 year flood due to the scheme is estimated to be 21mm. This is a larger impact than that for the East Hills Flood Mitigation Works, but is still relatively small and dissipates quickly upstream of the works. Local increases in flood levels adjacent to individual levee walls could occur.

TABLE 4.5
Impact of Carinya Road Flood Mitigation Works

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	0
Cabramatta Creek	4360	CNWEIR 4360	+1
Prospect Creek	8720	MILCN 8720	+2
Rabaul Road	9880	MILCN 9880	+4
Milperra Road	10930	MILCN 10930	+6
Milperra Drain	12620	SPMIL 12620	+6
M5 Motorway	14150	SPMIL 14150	+9
Williams Creek	14760	SPMIL 14760	+9
Kelso Creek	15880	SPMIL 15880	+12
East Hills Railway	16970	SPMIL 16970	+17
Deadmans Creek	18610	SPMIL 18610	+21
Salt Pan Creek	25220	SPMIL 25220	-1
Como Bridge	31635	GEORGES 31635	-1

4.4.10 Deepwater Motor Boat Club

The Deepwater Motor Boat Club is located on the eastern bank of the Georges River at Milperra, downstream of the M5 Motorway bridge. Part of the car park for the Club was filled in 1998 by former owners of the Club.

Whilst the filling that occurred on this site has not been included in the current MIKE-11 model, it was assessed as part of a previous study requested by Bankstown Council. That investigation indicated that the fill could result in an increase in upstream flood levels of up to 10mm in the 100 year flood.

4.4.11 Conclusions

The cumulative impact of all of the measures that were assessed using the MIKE-11 model has been computed and is summarised in **Table 4.6** for the 100 year flood. It should be noted that in some instances, development or works have resulted in an increase in flood levels in some locations, and a reduction in flood levels at other locations.

The maximum cumulative impact of all works modelled is estimated to be 146mm, which is estimated to occur immediately upstream of the M5 Motorway Bridge. The increase in flood levels gradually reduces to 100mm at Milperra Road, 33mm at the Prospect Creek confluence, and 15mm at William Long Bridge. The cumulative impact downstream of the M5 Motorway Bridge is substantially lower, with a maximum increase of less than 27mm.

The two main contributors to the increase in flood levels are the access track beside the M5 Motorway Bridge and the filling of the airport site. The Georges River Floodplain Management Committee has pursued both issues with the organisations responsible for these works, and is hopeful that the works will be removed or other compensatory measures provided.

TABLE 4.6
Cumulative Impact of Development (measures assessed in the MIKE-11 model)

Location	River Chainage (Km)	Section No. (Refer Fig. 4.1)	Change in 100 year Flood Level (mm)
Liverpool Weir	0	UPPERGEORGES 106530	0
William Long Bridge	3060	CNWEIR 3060	+15
Cabramatta Creek	4360	CNWEIR 4360	+23
Prospect Creek	8720	MILCN 8720	+33
Rabaul Road	9880	MILCN 9880	+63
Milperra Road	10930	MILCN 10930	+100
Milperra Drain	12620	SPMIL 12620	+117
M5 Motorway	14150	SPMIL 14150	+146
Williams Creek	14760	SPMIL 14760	+14
Kelso Creek	15880	SPMIL 15880	+18
East Hills Railway	16970	SPMIL 16970	+18
Deadmans Creek	18610	SPMIL 18610	+23
Salt Pan Creek	25220	SPMIL 25220	+27
Como Bridge	31635	GEORGES 31635	+2

Given that flood level increases are generally less than 100mm and within the existing freeboard allowance, and that these increases may be further reduced in the near future, the Committee decided that no change in design flood level estimates previously adopted by the four councils would appear to be warranted. That is, results from the previous flood studies on the Georges River and its tributary creeks would appear to be still valid, and should continue to be used.

Flood level contours determined from the Georges River Flood Study [PWD, 1991] are included in **Appendix D**.

4.5 DESIGN FLOOD LEVELS IN THE LOWER GEORGES RIVER

There have been no previous studies to define design flood levels on the Georges River for the area downstream of Picnic Point, in the Sutherland Shire part of the study area. Results from the current MIKE-11 modelling therefore provides Sutherland Shire Council with flood level estimates for this purpose.

Flooding in the lower reaches of the Georges River can be caused by high river flows or by elevated water levels in Botany Bay arising from storm tide conditions. Modelling of flood conditions in the lower river have assumed that both the 100 year river flows and 20 year river flows coincide with a mean high water level in Botany Bay. The PMF assessment, which represent a more extreme flood event, has assumed that PMF river flows coincide with an extreme storm tide level.

The mean high water level in Botany Bay is about RL 0.6m AHD. The highest tides, that are typically experienced twice a year, usually reach about RL1.1m AHD. Tide levels can be further elevated by two other storm processes. These include:

- storm surge, due to low pressure systems and wind stress across a body of water; and
- wave set-up, due to the action of large waves that break across the inlet of a bay or river entrance.

Advice received from the Coastal Branch and Flood Branch of the former Department of Land and Water Conservation is that there have been no formal investigations on storm tide levels conducted in Botany Bay. However, on the basis of investigations undertaken in Sydney Harbour, and elsewhere, the levels provided in **Table 4.7** have been recommended for Botany Bay.

Design flood levels for the Lower Georges River are shown on **Figures 4.4**, **4.5** and **4.6** for the 20 year, 100 year and PMF events. These flood levels are based on the higher level from either the modelling of river flood flows, or the estimated storm tide levels from Botany Bay.

TABLE 4.7
Recommended Storm Tide Levels in Botany Bay
(Source: personal communications with Department of Land & Water Conservation, 2002)

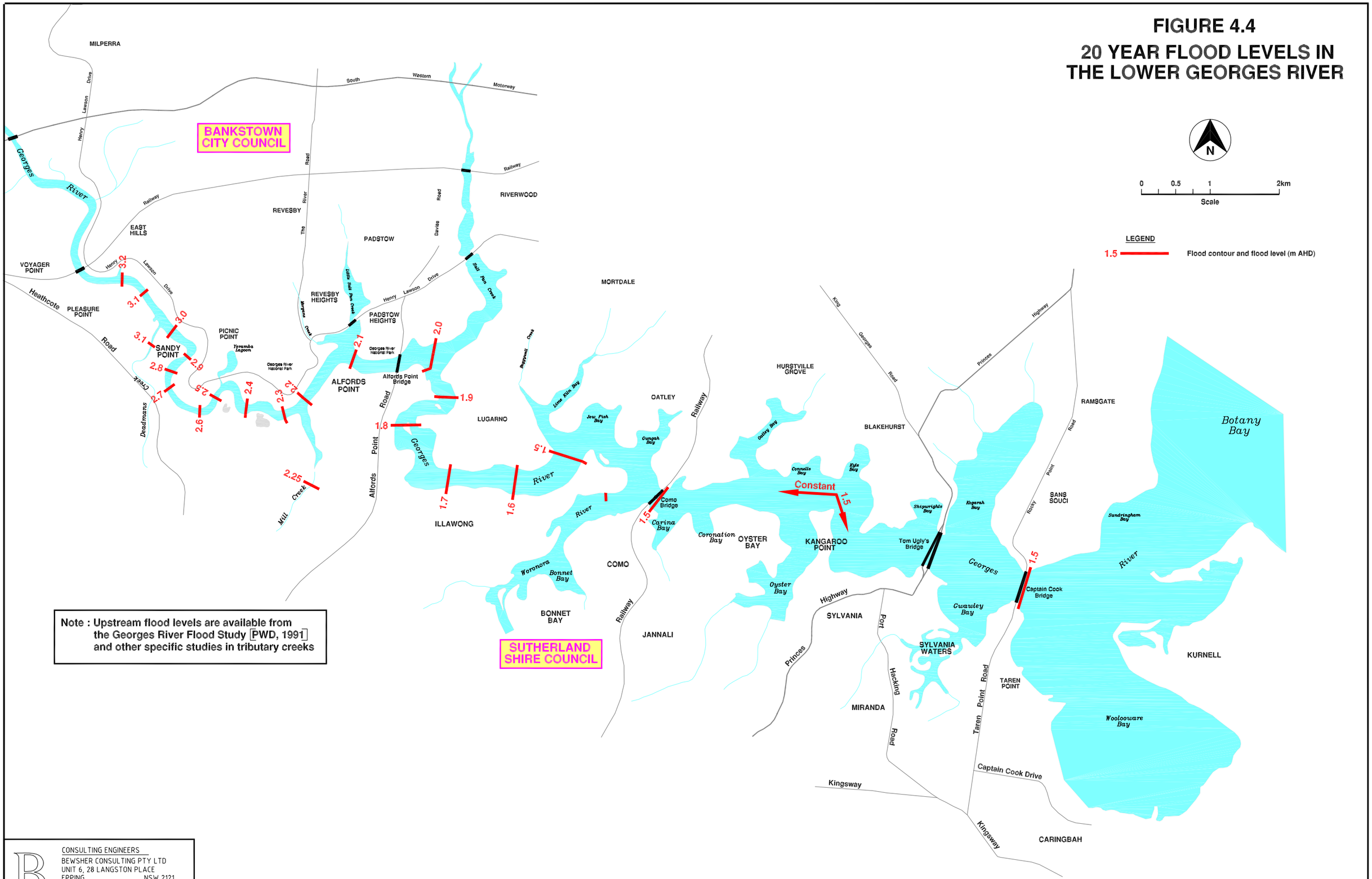
Type of Tide	Peak Water Level (m AHD)
Normal High Tide	0.6
High Spring Tide	1.1
20 year Storm Tide	1.5
100 year Storm Tide	1.7
Extreme Storm Tide	2.0

The results of the assessment are also consistent with tailwater levels that were assumed for the Georges River as part of other major studies undertaken on the Woronora River, Deadmans Creek, Salt Pan Creek and Little Salt Pan Creek.

The Georges River is tidal up to the Liverpool weir. High tide levels for Liverpool will be similar to high tide levels at Botany Bay, but will occur some 2-3 hours later. However, the influence of the tide on flooding becomes relatively insignificant upstream of the Woronora River in all but minor flood events.

FIGURE 4.4

20 YEAR FLOOD LEVELS IN THE LOWER GEORGES RIVER



Note : Upstream flood levels are available from the Georges River Flood Study [PWD, 1991] and other specific studies in tributary creeks

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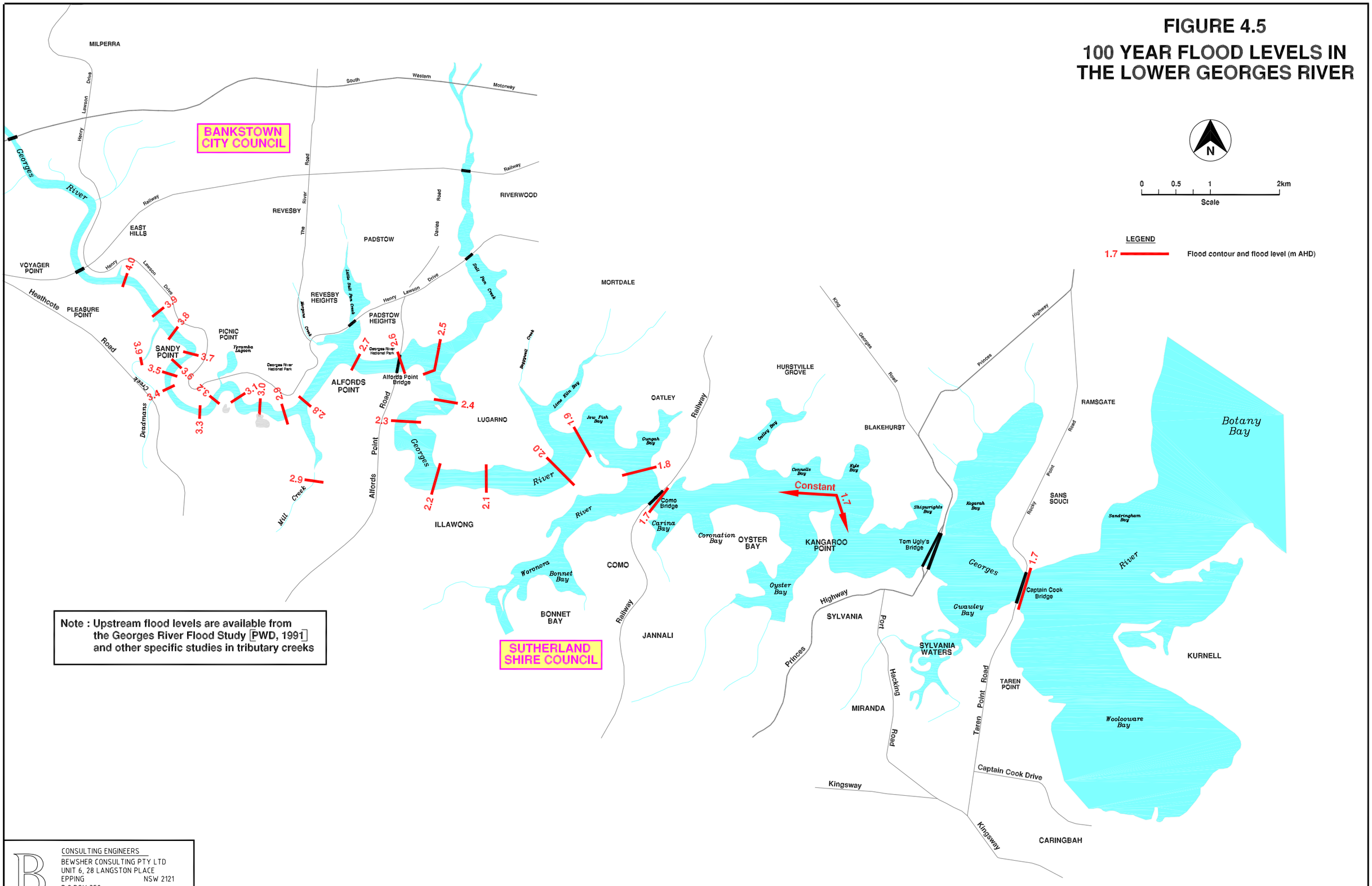
Plot file : Sutherland-flood-levels
Plot scale : 50 (a3 @ 1:50000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

FIGURE 4.5
100 YEAR FLOOD LEVELS IN THE LOWER GEORGES RIVER



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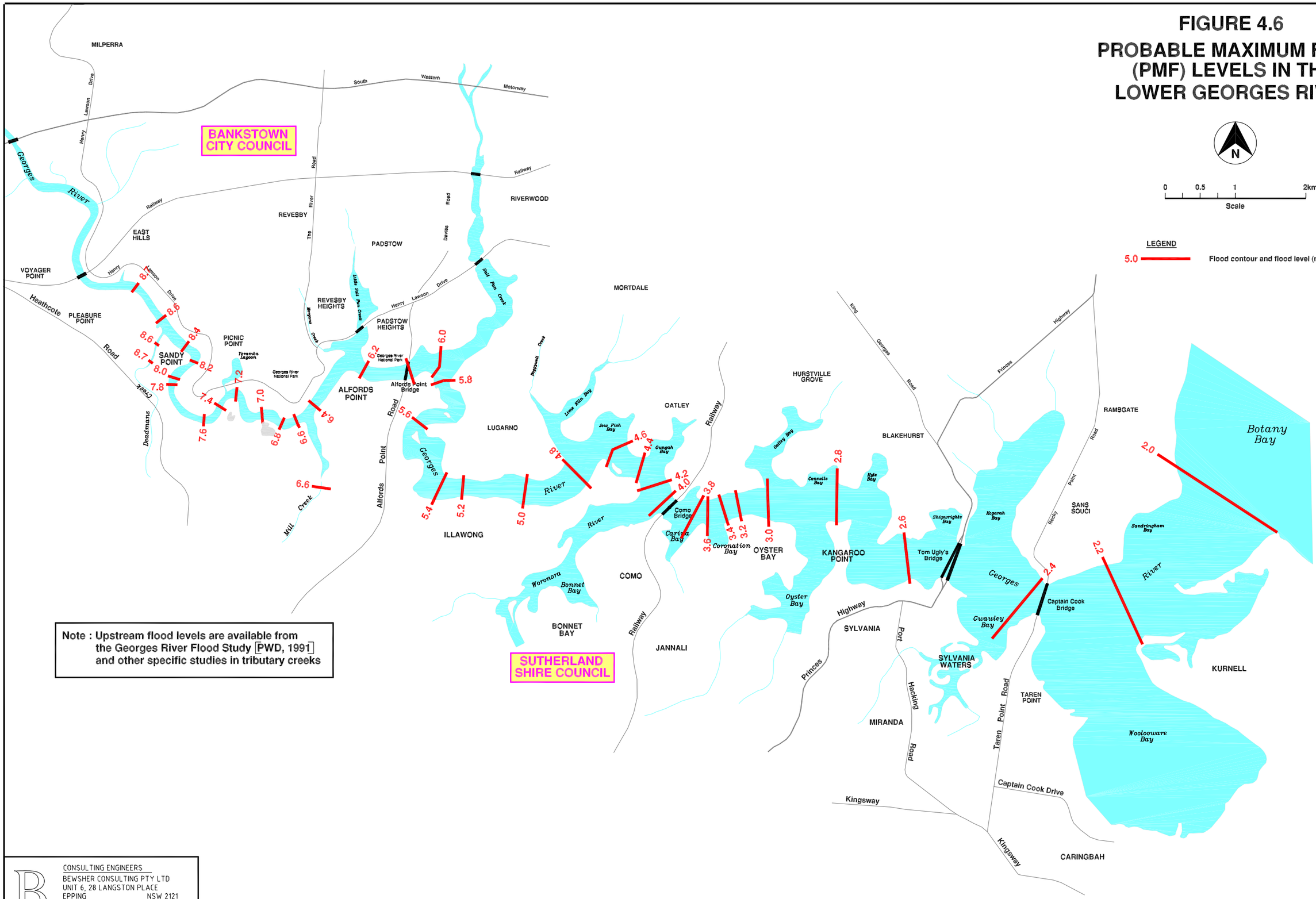
GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

FIGURE 4.6

PROBABLE MAXIMUM FLOOD (PMF) LEVELS IN THE LOWER GEORGES RIVER



Note : Upstream flood levels are available from the Georges River Flood Study [PWD, 1991] and other specific studies in tributary creeks

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GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

5. DESCRIPTION OF FLOOD BEHAVIOUR

5.1 SOURCE OF FLOOD DATA

Information on design flood levels throughout the study area is available from the Upper Georges River Flood Study [DLWC, 1999], the Georges River Flood Study [PWD, 1991] and other flood studies undertaken on tributary creeks. The current Georges River MIKE-11 model provides similar estimates (generally within ±0.2m) of the design flood levels published in these studies.

No flood studies have been undertaken on the Lower Georges River, below Picnic Point, hence levels provided in the current modelling can be used for design flood levels in this part of the river. Flood contours for the Lower Georges River were presented on **Figures 4.4**, **4.5** and **4.6**.

Results from the current modelling also provides additional information that was previously unavailable, including information on flood depths, velocities, flood hazard and the extent of inundation.

5.2 SUMMARY OF PROPERTY INUNDATION

A flood damages database of potentially flood affected buildings has been prepared for the study area. The database, which is discussed in more detail in **Section 6**, provides details of those properties likely to be inundated in different sized floods.

The number of residential, and commercial/industrial properties that are potentially affected by flooding in the Georges River study area is shown in **Tables 5.1** and **5.2**.

Results from **Tables 5.1** and **5.2** show that:

- In the **probable maximum flood** it is estimated that:
  5,697 residential properties (containing a house) would be flooded
  5,204 residential homes would be flooded above floor level
  617 commercial or industrial properties (containing buildings) would be flooded
  591 commercial and industrial buildings would be flooded above floor level;
- In the **100 year flood** it is estimated that:
  1,363 residential properties (containing a house) would be flooded
  721 residential homes would be flooded above floor level
  261 commercial or industrial properties (containing buildings) would be flooded
  216 commercial and industrial buildings would be flooded above floor level;
- There are substantially more residential properties affected by flooding than there are commercial or industrial properties affected;
- The number of homes that would be flooded in the 100 year flood for the four council areas are as follows:-

Liverpool City Council	308
Fairfield City Council	239
Bankstown City Council	156
Sutherland Shire Council	18
TOTAL	721

TABLE 5.1
Residential Property (Containing a Home) Affected by Flooding

Location	20 Year Flood		100 Year Flood		PMF	
	Property	Homes	Property	Homes	Property	Homes
Liverpool City Council Area						
Upstream of Newbridge Road at Liverpool	131	61	264	168	587	547
Newbridge Road to Governor Macquarie Dr	9	5	97	23	333	285
Governor Macquarie Drive to M5 Bridge	70	40	319	81	1296	1251
Downstream of M5 Bridge	21	12	52	36	421	380
TOTAL	*231*	*118*	*732*	*308*	*2,637*	*2,463*
Fairfield City Council						
TOTAL	*227*	*136*	*326*	*239*	*656*	*645*
Bankstown City Council Area						
North of Milperra Road	11	10	22	17	344	304
South of Milperra Road	98	35	179	122	1335	1118
Kelso Levee area	17	0	60	17	642	602
TOTAL	*126*	*45*	*261*	*156*	*2321*	*2024*
Sutherland Shire Council Area						
Sandy Point Area	14	5	20	11	36	35
Illawong Area	18	6	24	7	47	37
TOTAL	*32*	*11*	*44*	*18*	*83*	*72*
TOTAL	**616**	**310**	**1,363**	**721**	**5,697**	**5,204**

TABLE 5.2
Commercial/Industrial Property (Containing a Building) Affected by Flooding

Location	20 Year Flood		100 Year Flood		PMF	
	Property	Building	Property	Building	Property	Building
Liverpool City Council Area						
Upstream of Newbridge Road at Liverpool	25	4	107	88	168	167
Newbridge Road to Governor Macquarie Dr	0	0	10	4	19	19
Governor Macquarie Drive to M5 Bridge	24	17	45	30	77	77
Downstream of M5 Bridge	0	0	0	0	2	2
TOTAL	*49*	*21*	*162*	*122*	*266*	*265*
Fairfield City Council						
TOTAL	*23*	*15*	*34*	*30*	*85*	*84*
Bankstown City Council Area						
North of Milperra Road	10	9	11	13	42	43
South of Milperra Road	32	27	52	51	*217*	*192*
Kelso Levee area	0	0	2	0	7	7
TOTAL	*42*	*36*	*65*	*64*	*266*	*242*
Sutherland Shire Council Area						
Sandy Point Area	0	0	0	0	0	0
Illawong Area	0	0	0	0	0	0
TOTAL	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	**114**	**72**	**261**	**216**	**617**	**591**

The **depth of flooding** experienced by residential homes affected by the 100 year ARI flood is indicated in **Table 5.3**. The depth of flooding experienced by other buildings is indicated in **Table 5.4**. The main points to note are:

Liverpool City Council Area

- the majority of homes in the Liverpool Council area (62%) would be inundated by more than 0.5m above floor level in a 100 year flood;
- the majority of industrial and commercial properties (57%) would be inundated by less than 0.5m above floor level in a 100 year flood;
- most of these homes and commercial/industrial buildings that are affected by the 100 year flood are located upstream of Newbridge Road at Liverpool.

Fairfield City Council Area (Lansvale)

- properties in the Fairfield Council area generally experience the greatest inundation depths in a 100 year flood, when compared with the other three council areas;
- almost one half of the homes in the Lansvale area (48%) would be inundated by more than 1.0m above floor level in a 100 year flood;
- commercial/industrial buildings are similarly affected (40%) by more than 1.0m in a 100 year flood.

Bankstown City Council Area

- the majority of homes in the Bankstown area (54%) would be inundated by less than 0.5m above floor level in a 100 year flood;
- the majority of the commercial, industrial or public sector buildings in the study area (78%) would be inundated by more than 0.5m above floor level in a 100 year flood;
- the Kelso levee area provides reasonable protection for floods up to the 100 year event (only 17 homes estimated to be inundated above floor level) but little protection in larger floods (602 homes inundated above floor level in the PMF).

Sutherland Shire Council Area

- only 18 homes are estimated to be affected by flooding above floor level in the 100 year flood. No industrial/commercial properties would appear to be affected.
- both the Sandy Point and Illawong areas would be equally affected in a 100 year flood, with problems occurring in isolated areas.

TABLE 5.3
Inundation Depths for Homes in the 100 Year Flood

Location	Below Floor (No. Houses)		Above Floor Flooding (Number of Houses)				
	-.5 to -.2	-.2 to 0	0 to 0.2	.2 to.5	.5 to 1	> 1.0m	TOTAL
Liverpool City Council Area							
Upstream of Newbridge Road at Liverpool	56	40	28	30	45	65	168
Newbridge Road to Governor Macquarie Dr	40	34	6	8	4	5	23
Governor Macquarie Drive to M5 Bridge	201	39	21	11	15	34	81
Downstream of M5 Bridge	5	11	6	8	12	10	36
TOTAL	*302*	*124*	*61*	*57*	*76*	*114*	*308*
Fairfield City Council							
TOTAL	*46*	*29*	*18*	*32*	*75*	*114*	*239*
Bankstown City Council Area							
North of Milperra Road	6	1	4	0	5	8	17
South of Milperra Road	31	17	20	43	29	30	122
Kelso Levee area	30	13	11	6	0	0	17
TOTAL	*67*	*31*	*35*	*49*	*34*	*38*	*156*
Sutherland Shire Council Area							
Sandy Point Area	3	0	2	1	4	4	11
Illawong Area	4	3	0	2	5	0	7
TOTAL	*7*	*3*	*2*	*3*	*9*	*4*	*18*
TOTAL	**422**	**187**	**116**	**141**	**194**	**270**	**721**

TABLE 5.4
Inundation Depths for Commercial Buildings in the 100 Year Flood

Location	Below Floor (No. Buildings)		Above Floor Flooding (Number of Buildings)				
	-.5 to -.2	-.2 to 0	0 to 0.2	.2 to .5	.5 to 1	> 1.0m	TOTAL
Liverpool City Council Area							
Upstream of Newbridge Road at Liverpool	11	8	19	38	28	3	88
Newbridge Road to Governor Macquarie Dr	3	3	0	4	0	0	4
Governor Macquarie Drive to M5 Bridge	7	8	4	4	5	17	30
Downstream of M5 Bridge	0	0	0	0	0	0	0
TOTAL	*21*	*19*	*23*	*46*	*33*	*20*	*122*
Fairfield City Council							
TOTAL	*2*	*2*	*4*	*5*	*9*	*12*	*30*
Bankstown City Council Area							
North of Milperra Road	0	0	0	1	3	9	13
South of Milperra Road	13	6	4	9	15	23	51
Kelso Levee area	2	0	0	0	0	0	0
TOTAL	*15*	*6*	*4*	*10*	*18*	*32*	*64*
Sutherland Shire Council Area							
Sandy Point Area	0	0	0	0	0	0	0
Illawong Area	0	0	0	0	0	0	0
TOTAL	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	***38***	***27***	***31***	***61***	***60***	***64***	***216***

Each property in the flood damages database has been classified within one of three different **flood risk areas** (high, medium and low). The hazard classification is based on the depth and velocity of floodwater over the floodplain and consideration of evacuation issues. This flood risk categorisation is further discussed in the following Section.

Where properties are located within different flood risk areas, the higher flood risk area has generally been adopted. The number of properties within the different flood risk areas is indicated in **Table 5.5**.

The distribution of properties within the three flood risk areas are as follows:

- 2,648 are classified as High Risk (31%);
- 1,342 are classified as Medium Risk (16%); and
- 4,440 are classified as Low Risk (53%);

It is important to note that many of the properties identified as being in a high flood risk area may only be partially affected by this risk category. Other parts of the property, including the location of existing buildings, may be subject to a lower flood risk category.

TABLE 5.5
Number of Properties in Each Flood Risk Area

Location	Flood Risk Area			
	High Risk	**Medium Risk**	**Low Risk**	**Total**
Liverpool City Council Area				
Upstream of Newbridge Road at Liverpool	269	91	552	912
Newbridge Road to Governor Macquarie Dr	42	182	237	461
Governor Macquarie Drive to M5 Bridge	243	96	1261	1600
Downstream of M5 Bridge	54	53	463	570
TOTAL	*608*	*422*	*2513*	*3543*
Fairfield City Council				
TOTAL	*389*	*148*	*288*	*825*
Bankstown City Council Area				
North of Milperra Road	354	130	378	862
South of Milperra Road	1176	292	875	2343
Kelso Levee area	99	298	368	765
TOTAL	*1629*	*720*	*1621*	*3970*
Sutherland Shire Council Area[1]				
Sandy Point Area	22	15	0	37
Illawong Area	0	37	18	55
TOTAL	*22*	*52*	*18*	*92*
TOTAL	**2648**	**1342**	**4440**	**8430**

[1] Additional property in Sutherland Shire Council area with existing buildings above the PMF are not included.

5.3 FLOOD RISK MAPPING

Different parts of the floodplain are subject to different degrees of hazard, or flood risk. The Georges River Floodplain Management Committee agreed that the study area should be categorised into three different grades of flood risk, namely high, medium and low. This approach is similar to the categorisation of other natural risks, such as bush fire risk.

The committee also recognised that it would be unreasonable to apply the same types of development controls to properties that have a low risk of flooding as those that may have a high risk. Therefore, development controls that are considered later in this study have recognised both the type of development and the flood risk of the area where the development is located. Further discussion on the approach to floodplain planning is provided in **Volume 2** of the floodplain risk management study.

The three flood risk areas, which are defined below, are shown on **Figure 5.1**.

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

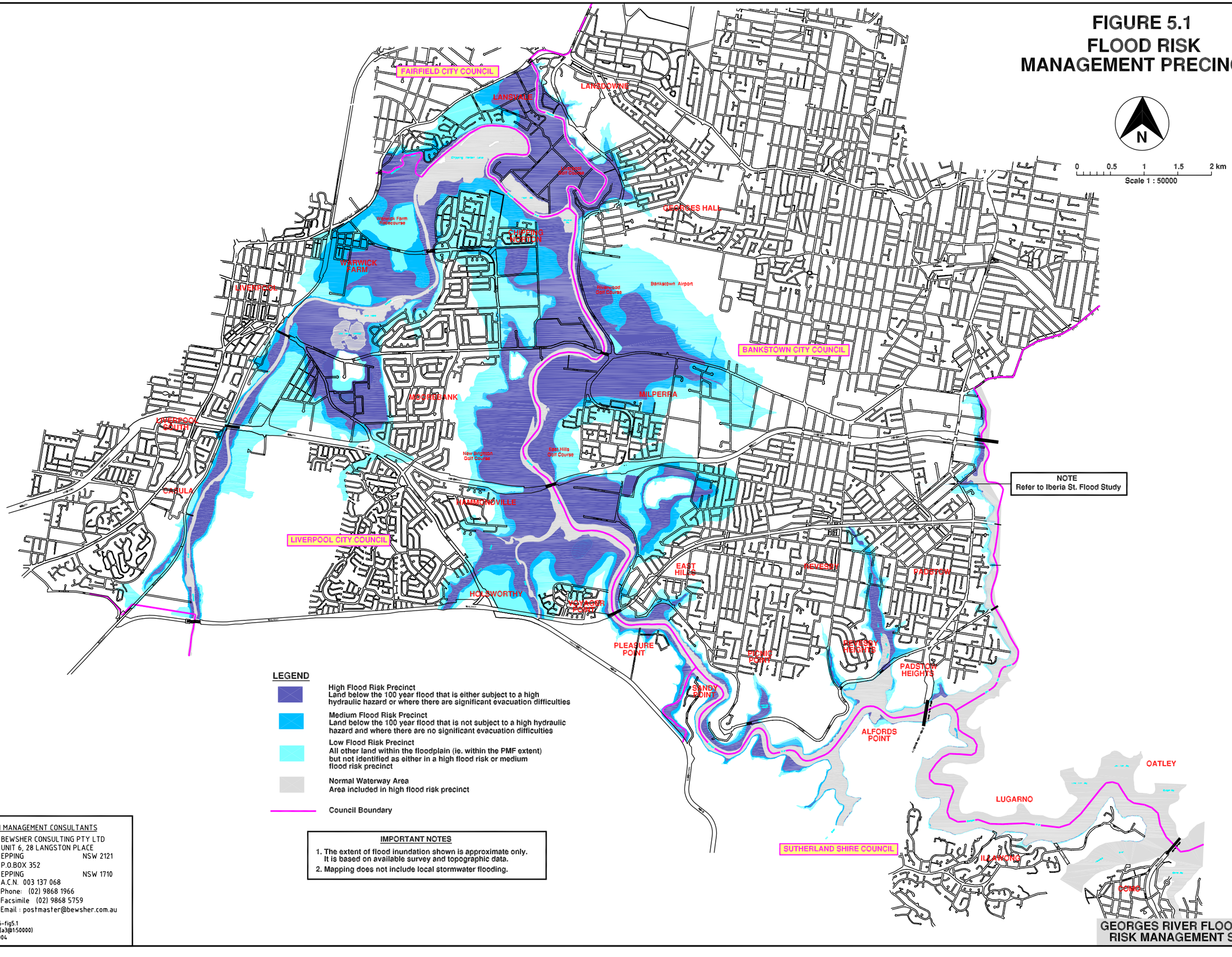
The high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted in this area.

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

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

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

FIGURE 5.1
FLOOD RISK MANAGEMENT PRECINCTS



LEGEND

- High Flood Risk Precinct
  Land below the 100 year flood that is either subject to a high hydraulic hazard or where there are significant evacuation difficulties
- Medium Flood Risk Precinct
  Land below the 100 year flood that is not subject to a high hydraulic hazard and where there are no significant evacuation difficulties
- Low Flood Risk Precinct
  All other land within the floodplain (ie. within the PMF extent) but not identified as either in a high flood risk or medium flood risk precinct
- Normal Waterway Area
  Area included in high flood risk precinct
- Council Boundary

IMPORTANT NOTES

1. The extent of flood inundation shown is approximate only. It is based on available survey and topographic data.
2. Mapping does not include local stormwater flooding.

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Plot file : J1046-fig5.1
Plot scale : 50 (a3@1:50000)
Date : 5 May 2004

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

5.4 THE PROBABLE MAXIMUM FLOOD

Some residents along the Georges River will remember the 1986 and 1988 floods, which are estimated to be close to a 20 year flood. A few residents may also remember the larger flood that occurred in 1956. But even larger floods have occurred in the late 1800's, and are likely to occur again in the future. The 1873 flood, for example, is estimated to have been over 2m higher than the 1956 flood, and also over 1m higher than the estimated 100 year flood at Liverpool (refer to Figure 2.3).

This begs the question – how much higher again can floods rise?

In order to gain an appreciation of the upper limit of possible flooding, an extreme flood event, known as the probable maximum flood (or PMF) can be calculated. This flood was investigated as part of the Georges River Flood Study [PWD, 1991], however the results of the analysis appear to have been largely overlooked. With the release of the 2001 Floodplain Management Manual, the State Government has recognised the importance of considering such extreme floods. Consequently, there is now a greater obligation on all Councils to consider what might happen in such an extreme flood.

To illustrate the magnitude of the PMF in relation to the 100 year flood and other floods experienced by some residents, these levels are shown relative to a typical house located in Newbridge Road at Moorebank. The watermark left from the 1986 flood can be clearly seen on this two-storey house, at a level that would inundate the upper floor. The 100 year flood is higher, and the PMF is about 4m higher yet again, well over the roof of most two storey houses in this locality.

The topography of the Georges River is fairly unique, in that the river downstream of East Hills is confined to a narrow gorge. This acts as a restriction during very large floods, and consequently there is a wide range in flood levels between the 100 year flood and larger floods. Unlike other most other flood prone communities where the difference can be as little as one metre, the difference on the Georges River can be as much as five metres.

This has significant consequences for development that is located just above the 100 year flood, which is the traditional flood planning level that has been adopted by many councils in New South Wales. For example, almost the entire suburb of Chipping Norton has been built on land that is just above the 100 year flood level (see photo 6). An extreme flood would result in widespread inundation of this area, and other areas along the Georges River. Over 5,200 homes are likely to be flooded in such an event.

The magnitude of the flood problem on the Georges River puts greater emphasis on the need to maximise the use of flood warning in the catchment, and the ability of emergency personnel and the community to effectively respond to such warnings. Community awareness of the risks of flooding is also an important consideration, particularly for those residents who are just above the 100 year flood, and mistakenly interpret this to mean they are free from the risk of flooding.

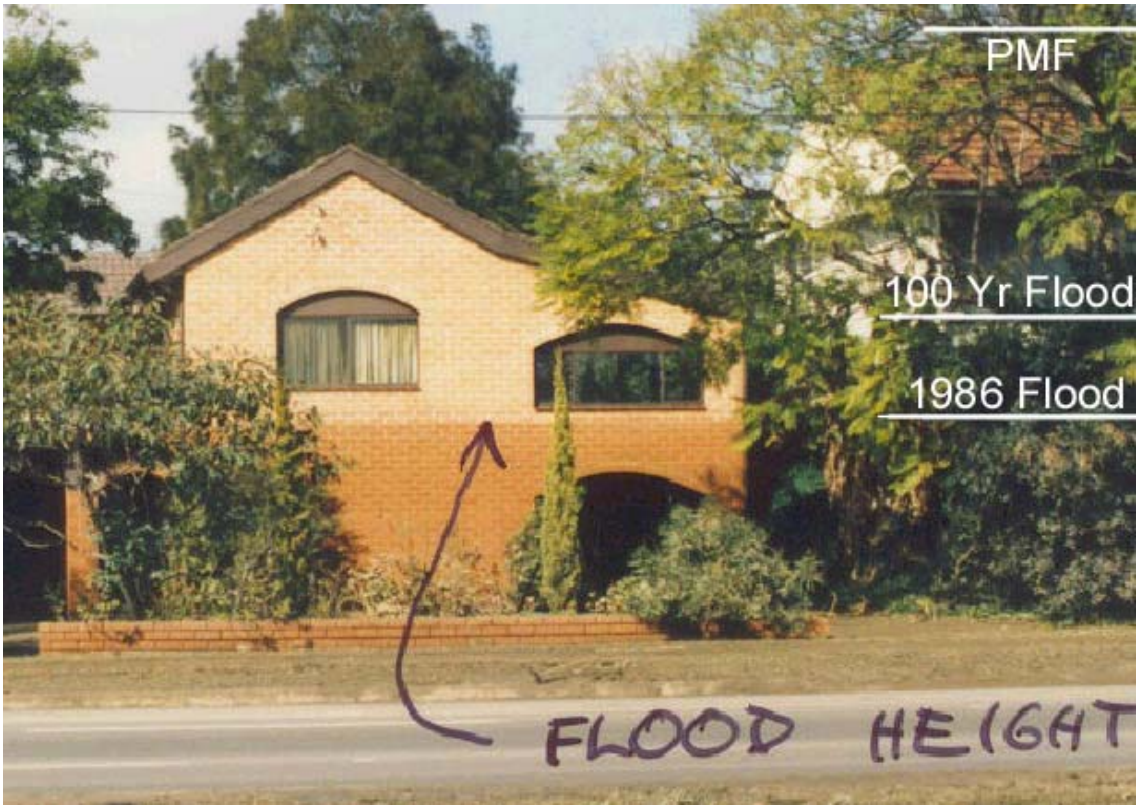

Photo 5 – The range in flood levels for many houses in Moorebank

Photo 6 – Chipping Norton in the 1986 flood

5.5 ROAD INUNDATION PROBLEMS

An appreciation of where and when roads are cut by floodwaters is an important issue for residents in the Georges River catchment. Residents that are directly affected by flooding may need to evacuate their homes. Other people may be indirectly affected by flooding where road closures restrict them from travelling to or from work, or other destinations. Road access is also an important issue for the planning of emergency management operations in response to flooding.

Flooding along the major arterial roads through the study area has been investigated as part of this study. This includes an assessment of potential problem areas along:

- The Hume Highway;
- Newbridge Road;
- Milperra Road; and
- Henry Lawson Drive.

The road inundation assessment is based on a variety of available survey data. Spot levels along the Hume Highway (Prospect Creek), Newbridge Road and Milperra Road were obtained as part of the Georges River Flood Study [PWD, 1991]. Contours at 0.25m intervals were available for the Hume Highway at Cabramatta Creek from the Cabramatta Creek Floodplain Management Study [Bewsher Consulting 1999]. Other data along Henry Lawson Drive was based on Bankstown Council's survey of road pits.

Heathcote Road is also recognised as a major arterial road, which is potentially cut by floodwaters at Harris Creek, Williams Creek and Deadmans Creek. However, there is insufficient survey data to assess the level of overtopping. Further survey and review of flood conditions at these locations may therefore be warranted.

A map of the study area showing the major arterial roads and locations potentially affected by flooding is shown on **Figure 5.2**. Long section plots for nine potential problem areas are also shown on **Figures 5.3** and **5.4**. These problem areas are briefly discussed below.

5.5.1 Hume Highway at Prospect Creek

The Hume Highway is potentially cut by floodwaters on the southern side of the Lansdowne Bridge, on Prospect Creek. The road is first inundated at about the 20 year flood level. The highway would be inundated in the 100 year flood over a length of some 330m, with a maximum depth of about 0.9m. At this level the road would be impassable by most vehicles. The bridge itself is above the 100 year flood, but could be affected in more extreme floods.

5.5.2 Hume Highway at Cabramatta Creek

Flooding problems are greater on the Hume Highway near the Cabramatta Creek crossing. The highway is inundated well before the 20 year flood at three different locations on either side of the bridge. The depth of inundation in the 20 year flood is approximately 0.6m, which would be impassable by normal vehicular traffic.

Inundation depths increase to 1.5m in the 100 year flood, with the road and bridge inundated over a distance of 1km.

5.5.3 Newbridge Road at Liverpool

The bridge over the Georges River at Liverpool is high and not affected by flooding. Newbridge Road drops down from the bridge in an easterly direction, and is first inundated by floodwater some 600m to the east of the bridge. The depth of inundation in the 20 year flood is estimated to be 0.8m, making it impassable to most vehicles. Inundation depths increase to 1.7m in the 100 year flood, with the road being inundated over a length of about 450m.

5.5.4 Newbridge Road/Milperra Road

Newbridge Road is also severely affected by flooding on the western side of Milperra Bridge, on the Liverpool side of the river. The worst affected area is approximately 1km west of the bridge, where the road is as low as 2.0m AHD. Inundation can be anticipated at this location and the road will be impassable to most vehicles on a very frequent basis. The 20 year flood results in a maximum inundation depth of 2.8m and extends over a distance of 1.4km to the west of Milperra Bridge. Inundation depths increase to 3.8m in the 100 year flood.

Major problems also occur on the Bankstown side of the river on Milperra Road, adjacent to Bankstown airport. The road is inundated by at least 0.9m in the 20 year flood, and also inundated over a length of 1.4km. Inundation depths increase to 1.9m in the 100 year flood.

Milperra Bridge effectively becomes an Island in relatively frequent floods. The bridge itself is above the 100 year flood, but can be inundated during more extreme floods.

5.5.5 Henry Lawson Drive

Henry Lawson Drive is potentially cut by floodwaters at a number of locations. The road can be cut in at least three different locations between Milperra Road and the Hume Highway. The timing and depth of inundation is similar at the three locations. Inundation depths of 1.4 to 1.5m can be anticipated for the 20 year flood, with depths increasing by a further 1m during the 100 year flood.

The road is also cut at various locations to the south of Milperra Road. The worst affected area is adjacent to the Kelso Creek levee, where inundation depths can be as great as 2.0m in the 20 year flood, and 3.0m in the 100 year flood.

5.6 OTHER FLOODING CHARACTERISTICS

The duration of flooding and the rate at which floodwaters can be expected to rise are also important characteristics of flood behaviour. However, it is important to realise that not all floods will behave in the same manner, and whilst some floods may rise rapidly, or persist over a long duration, other floods may behave differently.

In order to gain an appreciation of the likely range of these characteristics, plots of flood height versus time have been prepared at Liverpool and Milperra for the 100 year flood, and for the 1986, 1988 and 1996 floods. These plots are illustrated on **Figure 5.5**, with additional details provided in **Tables 5.6** and **5.7**.

TABLE 5.6
Flooding Characteristics at Liverpool Weir

Flood Event	Max Rate of Rise (m/hr) (based on 3 hr period)	Duration of Flooding (Hours)	
		(Above RL 6.0m AHD)	(Above RL 7.0m AHD)
100 Year	0.8	16	13
August 1986	0.3	22	7
April 1988	0.4	13	5
August 1996	0.6	n/a	n/a

TABLE 5.7
Flooding Characteristics at Milperra Bridge

Flood Event	Max Rate of Rise (m/hr) (based on 3 hr period)	Duration of Flooding (Hours)	
		(Above RL 3.0m AHD)	(Above RL 4.0m AHD)
100 Year	0.5	23	16
August 1986	0.3	31	17
April 1988	0.3	20	12
August 1996	0.3	n/a	n/a

The 1996 flood was a fairly small flood, but has been included because the rate of rise for this flood was quite rapid. If the flood had continue to rise at the rate in which it commenced for another 6-7 hours, then the flood would have been similar to the 100 year flood (at Liverpool). This flood would then have become a major event, rather than just a nuisance flood.

The maximum rate of rise of floodwater at Liverpool has varied between 0.3m/hour to 0.6m/hour for the three historical floods, and 0.8m/hour for the 100 year flood. The rate of rise at Milperra Bridge (and elsewhere downstream) is generally slower, at 0.3m/hour for the three historic floods and 0.5m/hour for the 100 year flood. For planning purposes, a rate of rise of 0.5m/hour would appear to be an appropriate value to adopt for the majority of the river.

The duration of flooding was based on the time that a particular flood height was exceeded. Two levels were chosen for this assessment, a relatively low level where only minor flood conditions are expected, and a higher level where more significant flooding problems are anticipated. The results indicate that the duration of flooding generally increases between Liverpool and Milperra. Minor flooding can persist for up to 31 hours (based on the 1986 flood), but significant flooding is more likely to be limited to less than 20 hours.

FIGURE 5.2
ROAD INUNDATION PROBLEM AREAS

N

0 0.5 1 1.5 2 km

Scale 1 : 40000

FAIRFIELD CITY COUNCIL

LIVERPOOL CITY COUNCIL

BANKSTOWN CITY COUNCIL

SUTHERLAND SHIRE COUNCIL

LANSVALE

LANSDOWNE

WARWICK FARM

CHIPPING NORTON

LIVERPOOL

MOOREBANK

LIVERPOOL SOUTH

CASULA

HAMMONDVILLE

HOLSWORTHY

GEORGES HALL

MILPERRA

EAST HILLS

REVESBY

PADSTOW

VOYAGER POINT

PLEASURE POINT

PICNIC POINT

SANDY POINT

REVESBY HEIGHTS

PADSTOW HEIGHTS

ALFORDS POINT

Warwick Farm Racecourse

Liverpool Golf Course

Riverwood Golf Course

Bankstown Airport

New Brighton Golf Course

East Hills Golf Course

Limit of Mapping

LEGEND

- Council Boundary
- Potential problem areas on major arterial roads
- ⑨ Refers to road centreline profile (Figures 5.3 & 5.4) where there is sufficient survey data
- Estimated extent of flooding for the 100 year Flood
- Estimated extent of flooding for the Probable Maximum Flood

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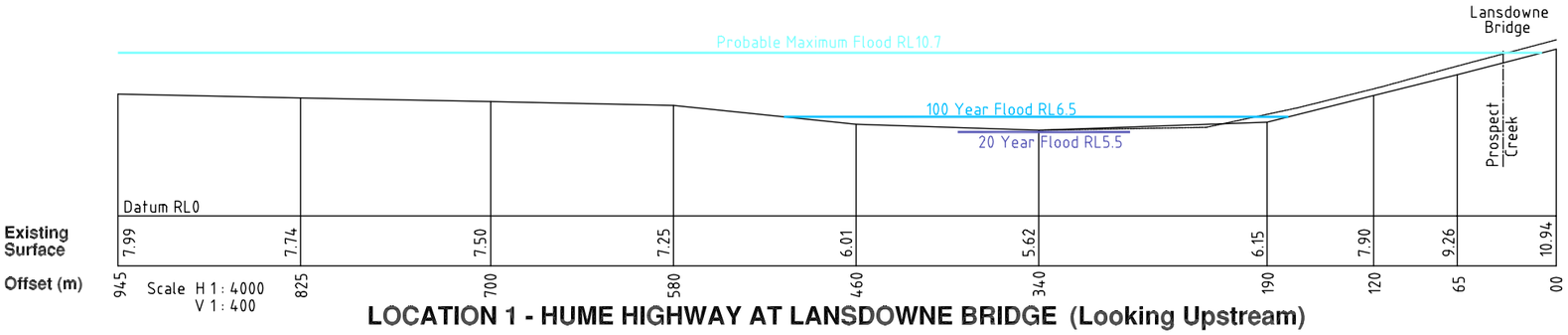
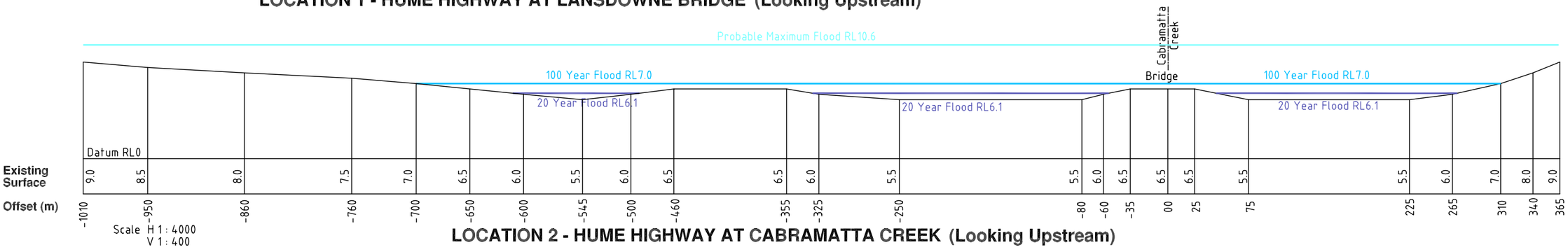
Plot file : Road-closures
Plot scale : 40 (a3@1:40000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

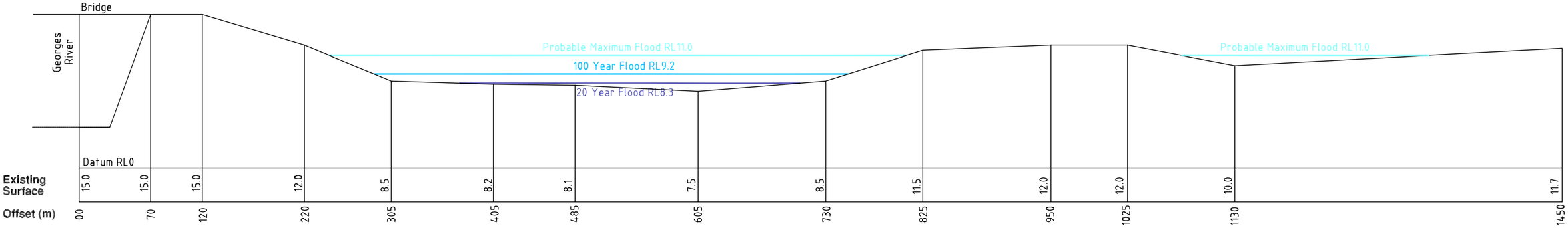
FIGURE 5.3
ROAD INUNDATION CENTRELINE PROFILES
(Sheet 1 of 2)



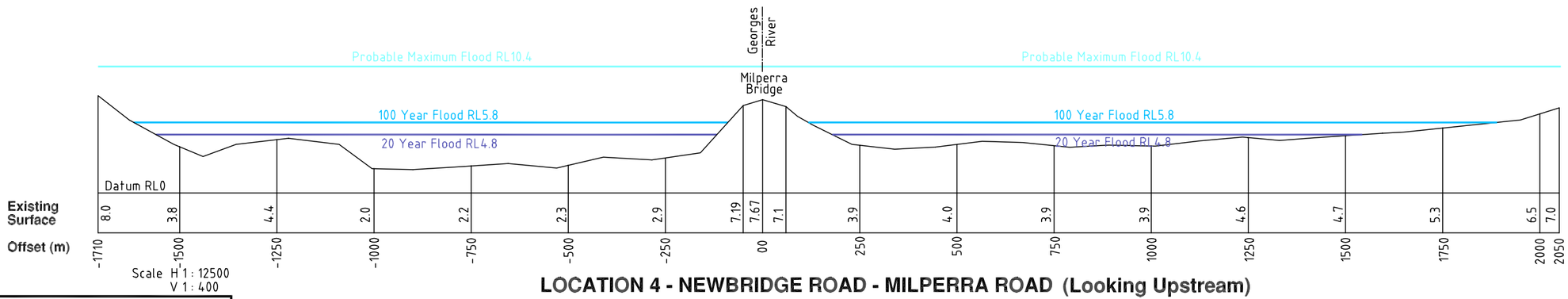
LOCATION 1 - HUME HIGHWAY AT LANSDOWNE BRIDGE (Looking Upstream)



LOCATION 2 - HUME HIGHWAY AT CABRAMATTA CREEK (Looking Upstream)



LOCATION 3 - NEWBRIDGE ROAD - AT LIVERPOOL (Looking Downstream)



LOCATION 4 - NEWBRIDGE ROAD - MILPERRA ROAD (Looking Upstream)

Notes :
1. Refer to Figure 5.2 for locations
2. Profiles are viewed as indicated
3. All levels to Australian Height Datum (AHD)

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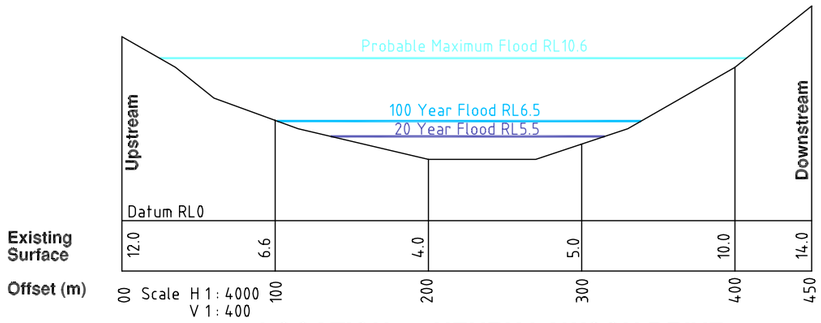
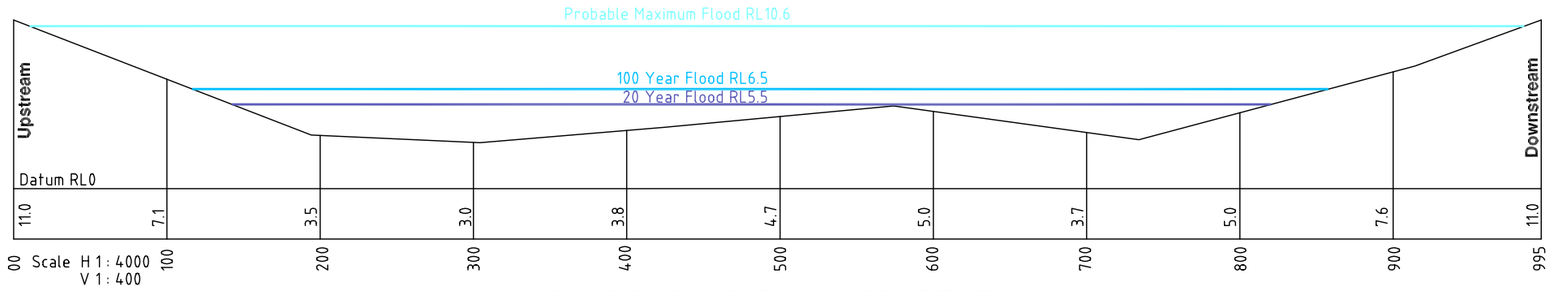
Plot file : J1046-fig5.3
Plot scale : 40 (a3@1:40000)
Date : 5 May 2004

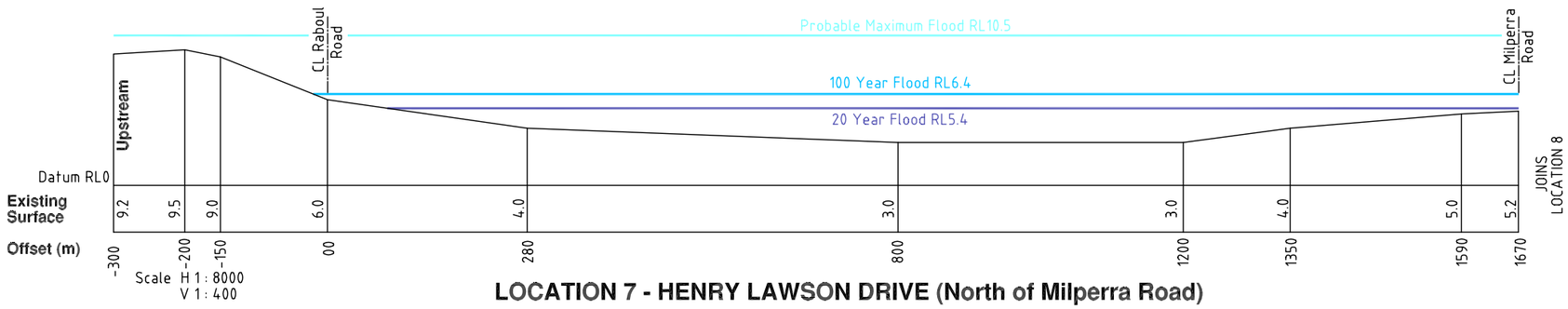
FIGURE 5.4
ROAD INUNDATION CENTRELINE PROFILES
(Sheet 2 of 2)



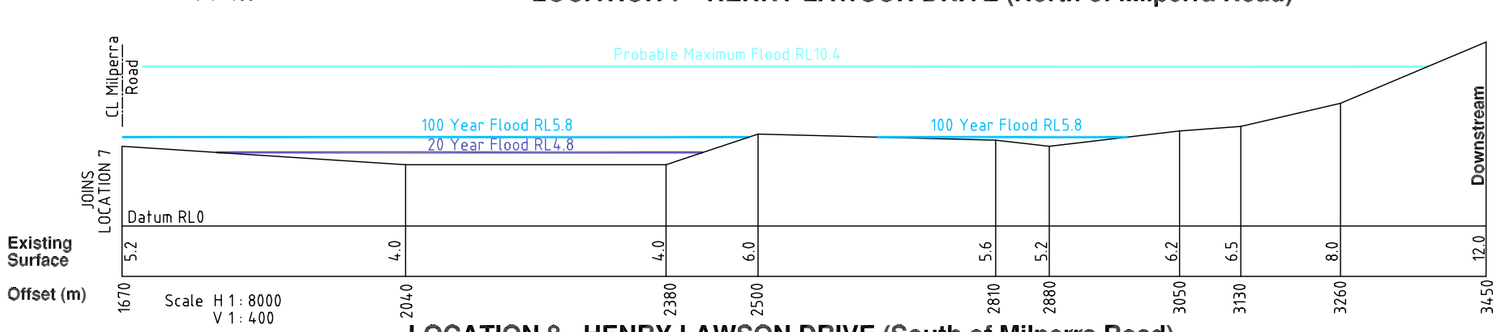
LOCATION 5 - HENRY LAWSON DRIVE



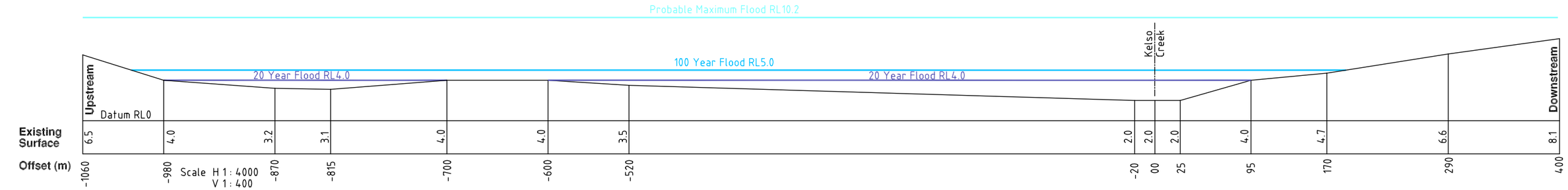
LOCATION 6 - HENRY LAWSON DRIVE



LOCATION 7 - HENRY LAWSON DRIVE (North of Milperra Road)



LOCATION 8 - HENRY LAWSON DRIVE (South of Milperra Road)



LOCATION 9 - HENRY LAWSON DRIVE - KELSO LEVEE

Notes :
1. Refer to Figure 5.2 for locations
2. Profiles are viewed as indicated
3. All levels to Australian Height Datum (AHD)

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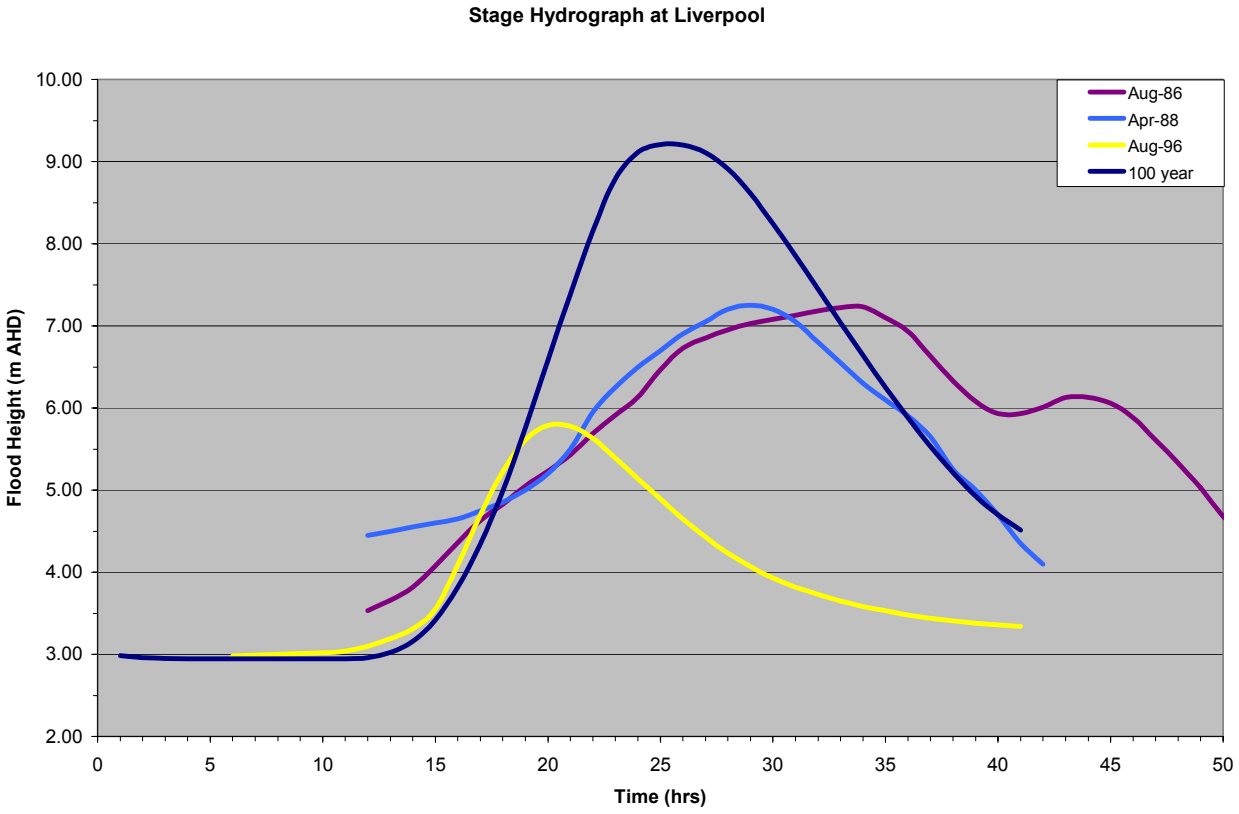
Plot file : J1046-fig5.4
Plot scale : 40 (a3@1:40000)
Date : 5 May 2004

GEORGES RIVER FLOODPLAIN
RISK MANAGEMENT STUDY



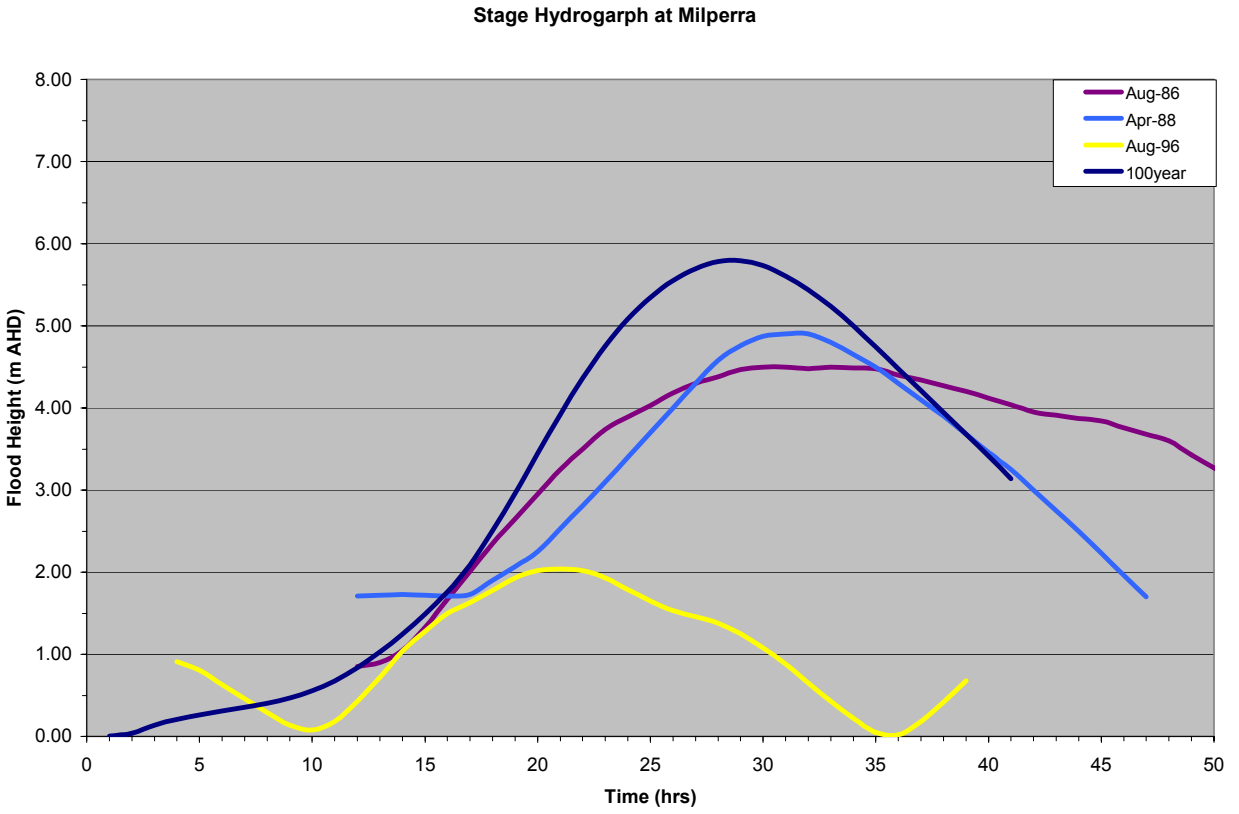


FIGURE 5.5
FLOOD HYDROGRAPHS AT LIVERPOOL AND MILPERRA

6. FLOOD DAMAGES ASSESSMENT

6.1 FLOOD DAMAGES DATABASE

A flood damages database has been established for this study to quantify the economic impacts of flooding in the Georges River study area, and to allow an economic appraisal of potential floodplain management measures.

6.1.1 Property within the Database

The flood damages database contains details of those properties that are potentially affected by flooding up to the probable maximum flood (PMF). Properties within the database were identified using flood level estimates for the PMF from the Georges River Model Study (Bewsher Consulting, 1998), which was updated as part of the current floodplain management study. Property details were then extracted for this region using Council's computerised geographical information system (GIS) and rates database.

There are some 8,800 properties included in the database. These have been divided into four separate council areas. Each Council area was then further subdivided into a number of sub-areas, as shown in **Table 6.1**.

TABLE 6.1
PROPERTIES INCLUDED IN THE DATABASE

Area	Total Properties (including vacant lots)		
	Residential	Industrial/ Commercial	Total
Liverpool City Council Area			
Upstream of Newbridge Road at Liverpool	716	196	912
Newbridge Road to Governor Macquarie Drive	438	23	461
Governor Macquarie Drive to M5 Bridge	1,508	92	1,600
Downstream of M5 Bridge	560	10	570
TOTAL	*3,222*	*321*	*3,543*
Fairfield City Council			
TOTAL	*714*	*111*	*825*
Bankstown City Council Area			
North of Milperra Road	762	100	862
South of Milperra Road	2,041	302	2,343
Kelso Levee area	756	9	765
TOTAL	*3,559*	*411*	*3,970*
Sutherland Shire Council Area [1]			
Sandy Point Area	199	1	200
Illawong Area	285	1	286
TOTAL	*484*	*2*	*486*
TOTAL	**7,979**	**845**	**8,824**

1. Sutherland Shire data includes a number of steeply sloping properties with buildings located above the PMF flood level.

6.1.2 Ground and Floor Level Estimates

Representative ground levels and floor levels (where buildings are present) were assigned to each property in the database.

Where available, actual floor and ground level survey data has been used. Survey data was available from various sources that have been collected over a number of years from previous investigations. Recent building and development applications also contained some additional ground and floor level data. Actual survey data was available for about 9% of buildings within the flood damages database.

Where there was no survey data, floor and ground levels were estimated from a digital terrain model, developed by Bewsher Consulting using available topographic and other survey data. Ground levels were extracted from the terrain model at the 'tag point' of each property (usually the centre of the property). Floor levels were then estimated by adding an average 'height above ground' level of 0.5m to the ground level estimates. This value was determined from a correlation of surveyed floor levels (where available) and ground level estimates.

6.1.3 Flood Level Estimates for Flood Damage Assessment

Flood level estimates from the MIKE-11 model were determined at the tag point location for every property within the database. Estimates were provided for the 20 year, 100 year and PMF floods.

It is important to note that the MIKE-11 model results are an approximation only (within about 0.2m for the 100 year flood) of the design flood levels that have previously been adopted by each of the four Councils. The MIKE-11 results are appropriate for use with flood damage estimates, but should not be used when specifying minimum floor levels or related development controls. Reference should always be made to the flood level results in the adopted flood study reports (eg Upper Georges River Flood Study, Georges River Flood Study, Cabramatta Creek Flood Study, Lower Prospect Creek Flood Study, Little Salt Pan Creek Flood Study, Salt Pan Creek Flood Study and Deadmans Creek Flood Study).

6.1.4 Output from the Flood Damages Database

The database provides the following information:

- which properties are subject to flooding over the range of floods considered;
- the depth of inundation above floor level for each property subject to inundation;
- the provisional flood hazard (subject to site conditions) for each property, based on depth of inundation and velocity of floodwaters in a 100 year flood; and
- the potential flood damage for each property in the database for existing or proposed flood conditions.

The database also allows quantification of flood damages and identification of problem areas within different parts of the study area. It also allows quantification of economic flood benefits of measures that lower flood levels in the study area.

Copies of the database have been provided to each Council.

6.2 TYPES OF FLOOD DAMAGE

The definitions and methodology used in estimating flood damage have been established by a number of previous investigations. **Figure 6.1** summarises all the types of flood damages examined in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

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

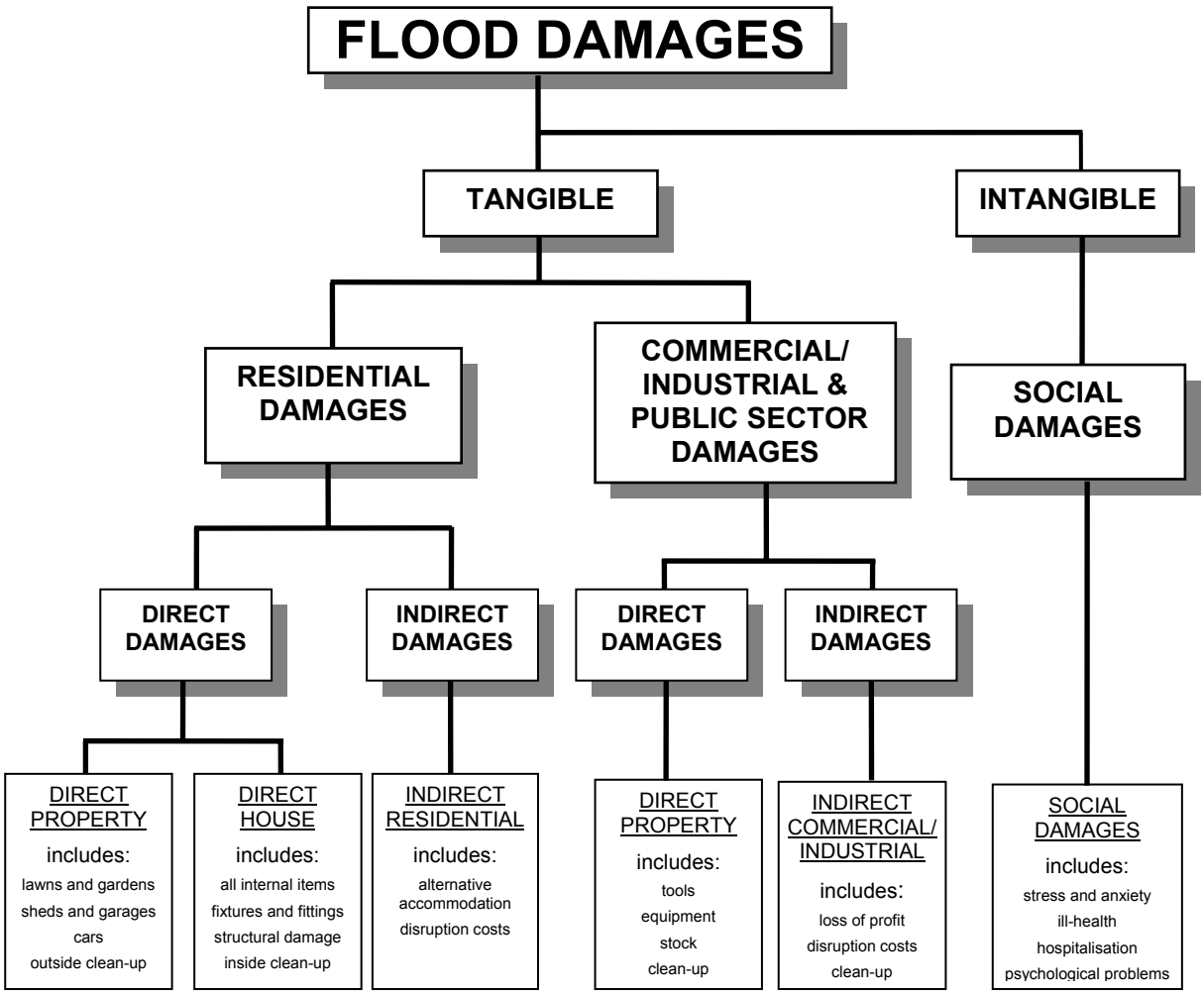


FIGURE 6.1
TYPES OF FLOOD DAMAGE

6.3 BASIS OF FLOOD DAMAGE CALCULATIONS

Potential flood damages have been calculated by applying a number of stage-damage curves to every property included in the database. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type.

Predicted flood damages have then been estimated by reducing the potential flood damage to allow for damage reduction measures that are likely to be taken during an actual flood. This will depend on the effective flood warning time and the flood awareness of the community.

The stage-damage curves for the Georges River have been based on specific consideration of the types of development within the catchment, information available from previous investigations, and flood damage surveys undertaken following major floods in Coffs Harbour (1996); Inverell (1991); Forbes (1990); Nyngan (1990); and the Georges River (1986). The damage estimates also include a multiplier of two, to allow for anticipated under valuing of some insurable loss data in these studies (based on advice from the then DLWC in 2001). All estimates have been updated to reflect current values.

Different stage damage curves for direct property damage have been derived for:

- residential dwellings (categorised into small, typical or raised categories);
- commercial premises (categorised into low, medium or high damage categories);
- industrial premises (categorised into low, medium or high damage categories).

The database also accounts for other flood damage components, including:

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

All stage damage curves and other economic assumptions are included in a full listing of the flood damages database, which has been provided to each Council.

6.4 SUMMARY OF FLOOD DAMAGES

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

Flood damage calculations for each area have been determined from the flood damages database. The different components of flood damage in the Georges River study area is illustrated on **Figure 6.2**, whilst **Table 6.2** summarises the predicted flood damages.

The following key points are relevant from these results:

- Components of expected average annual flood damages within the study area are estimated as:

- Direct House Damage	$ 2,981,000	(31%)
- Direct Property Damage	$ 793,000	(10%)
- Indirect Residential Damage	$ 188,000	(3%)
- Direct Industrial & Commercial	$ 1,373,000	(17%)
- Indirect Industrial & Commercial	$ 754,000	(9%)
- Infrastructure & Public Sector Damage	$ 1,828,000	(22%)
- Social Damages	$ 289,000	(4%)
- TOTAL	$ 8,200,000	

- Flood damage (average annual damage) is distributed within the study area as follows:

Liverpool City Council Area	$3.8M
Fairfield City Council Area	$1.6M
Bankstown City Council Area	$2.7M
Sutherland Shire Council Area	$0.1M
	$8.2M

- The present value of expected flood damages within the study area is estimated at $91M.

- The total expected flood damage estimated to occur in a 100 year flood is $99M;

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

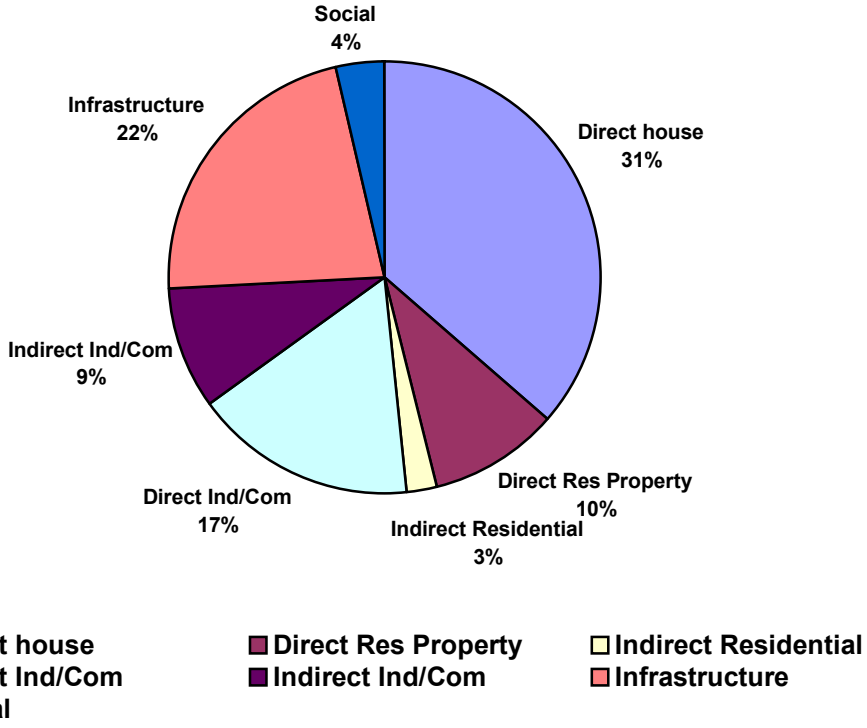


FIGURE 6.2
COMPONENTS OF FLOOD DAMAGE FOR THE GEORGES RIVER (AVERAGE ANNUAL DAMAGE)

TABLE 6.2
Predicted Total Flood Damages under Existing Conditions

Location	Damage in Flood Event ($)			Average Annual Damage	Present Value of Damage
	20 Year	100 Year	PMF		
Liverpool City Council Area					
Upstream of Newbridge Rd at Liverpool	4,020,000	26,250,000	121,950,000	1,450,000	15,940,000
Newbridge Rd to Governor Macquarie Dr	450,000	2,960,000	41,600,000	300,000	3,270,000
Governor Macquarie Dr to M5 Bridge	5,430,000	15,570,000	194,710,000	1,670,000	18,390,000
Downstream of M5 Bridge	860,000	2,970,000	49,620,000	370,000	4,060,000
TOTAL	10,760,000	47,750,000	407,870,000	3,790,000	41,660,000
Fairfield City Council					
TOTAL	8,910,000	22,420,000	104,830,000	1,590,000	18,010,000
Bankstown City Council Area					
North of Milperra Rd	2,740,000	5,740,000	50,090,000	550,000	6,150,000
South of Milperra Rd	5,870,000	20,990,000	187,280,000	1,780,000	19,580,000
Kelso Levee area	60,000	1,170,000	72,940,000	400,000	4,240,000
TOTAL	8,660,000	27,890,000	310,300,000	2,720,000	29,940,000
Sutherland Shire Council Area					
Sandy Point Area	360,000	930,000	3,750,000	60,000	710,000
Illawong Area	230,000	470,000	3,200,000	40,000	470,000
TOTAL	590,000	1,400,000	6,950,000	100,000	1,180,000
TOTAL	**28,920,000**	**99,460,000**	**829,950,000**	**8,200,000**	**90,790,000**

7 FLOODPLAIN MANAGEMENT CONSIDERATIONS

7.1 SELECTION OF THE FLOOD PLANNING LEVELS

The flood planning levels are the flood levels selected for planning purposes, and will directly determine the area of land that should be subject to flood-related building and development controls.

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

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

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

To overcome the shortcomings of a singular flood planning level, a graded set of controls that consider the variation of damage risk with flood frequency and land use, have been proposed for the Georges River study area. These are contained in the *Planning Matrix* approach, which is discussed further in **Volume 2** of the study.

The planning matrix approach does not rely on the definition of a singular flood planning level. In essence, the approach makes use of a range of flood planning levels for various land uses within the flood prone land below the PMF, in relation to different ameliorative controls (eg. floor levels, evacuation routes, flood compatible materials, etc.).

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

- procedures and philosophy espoused in the Government's 2001 Floodplain Management Manual;
- investigations carried out within the current study;
- community attitudes expressed during the current study;
- minimising Council's exposure to legal actions in relation to flooding;
- each Council's previous development policies; and
- experience gained from the development of planning controls and flood policies for various communities across NSW in recent years.

The 100 year flood level (plus freeboard) has been retained as the principal floor level control for residential land uses in the study area. This is an important component of the proposed planning controls. The decision was based on a consideration of:

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

Liverpool, Fairfield and Bankstown Councils have been applying design flood levels from the Georges River Flood Study Report [PWD, 1991] for many years now. A review of flood behaviour undertaken as part of the current investigations, in particular the impact of changes that have occurred within the catchment since the previous flood study, has confirmed that the levels provided in that flood study are still appropriate and should continue to be applied.

7.2 TYPES OF FLOODPLAIN MANAGEMENT MEASURES

Floodplain management measures can be divided into three general groups:

(i) those that modify flood behaviour;

(ii) those that modify property in order to minimise flood damage; and

(iii) those that modify people's response to flooding.

Measures that modify flood behaviour usually include structural or engineering works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. Examples include dams, retarding basins, levee banks, bridge and culvert amplifications, dredging, and modifications to the watercourse to improve its ability to convey floodwaters. Many of these measures were favourably supported by the community, particularly dredging the river, the construction of upstream dams, and levee banks. Some of these measures have already been implemented within the Georges River study area, including the Kelso levee, finger levees and deflector levees at East Hills and Carinya Road, and channel amplification on Milperra Drain. However, the scope for additional structural measures is likely to be limited, due to cost and/or environmental issues.

Measures that modify property in order to minimise flood damage include voluntary purchase, house raising and controls on new development. Several voluntary purchase schemes and house raising schemes are already being implemented within the study area, and these are probably the largest schemes in Australia. The adoption of additional voluntary purchase and house raising schemes received mixed community support, whilst controls on new development were strongly supported. These controls can be implemented for minimal cost and will ensure that the potential for flood damage does not increase. Consistent controls on future

development are therefore seen to be a major component of the Georges River Floodplain Risk Management Plan.

Measures that modify people's response to flooding usually includes measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management measures during floods. All these measures were strongly supported by the community, and can be implemented at little cost. These catchment-wide measures have been largely overlooked in previous studies, which have tended to concentrate on solutions for specific areas. The measures can also be very effective in reducing flood risk and flood damage, and are considered to form a major component of the Georges River Floodplain Risk Management Plan.

7.3 SUMMARY OF FLOODPLAIN MANAGEMENT MEASURES CONSIDERED

There are a number of floodplain management measures that have previously been adopted in specific areas of the Georges River floodplain. Some of these measures have already been implemented, whilst other measures are currently in the process of being implemented. A review of these measures is appropriate as part of the current study. There will also be other measures that have not been considered or thoroughly assessed, particularly the catchment-wide measures.

Floodplain management measures that have been considered in this study are summarised in **Table 7.1**. These measures are further discussed in **Sections 8 & 9**. The recommended floodplain risk management plan is provided in **Section 10**.

TABLE 7.1
Potential Floodplain Management Measures

Description	Report Section
1. Review of Existing Measures	
Liverpool Voluntary Purchase Scheme	8.1
Bankstown Voluntary Purchase Scheme	8.2
Milperra Drain Channel Augmentation	8.3
Kelso Levee	8.4
East Hills Finger Levees	8.5
Carinya Road Finger Levees	8.6
2. Other Potential Floodplain Management Measures	
Flood Mitigation Dam in the Upper Catchment	9.1
River Dredging	9.2
Levee at Milperra	9.3
Stormwater Considerations	9.4
Additional Investigations	9.5
Compensatory Development Measures	9.6
Planning and Development Controls	9.7
Flood Warning Enhancements	9.8
Emergency Management Operations	9.9
Public Awareness	9.10

8 EXISTING FLOODPLAIN MANAGEMENT MEASURES

8.1 LIVERPOOL VOLUNTARY PURCHASE SCHEME

Findings: Investigation of self funding initiatives for remaining 71 properties

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

A major voluntary purchase scheme was adopted by Liverpool City Council in 1984 for property located on the Milperra floodway. The Scheme originated from a study undertaken by the Public Works Department on the Moorebank-Milperra floodway in the early 1980s [PWD, 1983]. The study identified the area as one of the worst floodways in New South Wales and recommended the removal of all development from the floodway on both the Liverpool and Bankstown sides of the river.

A review of the Liverpool voluntary purchase scheme was recently undertaken [Bewsher Consulting, 2000]. This review includes:

- details concerning the origins of the scheme;
- the flood behaviour of the site;
- properties included in the scheme;
- administrative matters concerning the scheme;
- the basis of property valuations;
- the method of prioritising property purchases; and
- development controls that are appropriate for the remaining properties in the scheme.

The Liverpool Scheme originally included some 146 buildings, located in Rickard Road, Newbridge Road and Davy Robinson Drive. Later records refer to the inclusion of vacant properties within the scheme, with the total number of identified properties increasing to 174. However, four of the identified properties are believed to be reserved for County Open Space, and may not fall into the ambit of the voluntary purchase scheme [Bewsher Consulting, 2000]. Therefore, the total number of properties in the scheme is believed to total 170.

Liverpool Council, with the assistance of the State and Commonwealth Governments, has purchased 99 properties to date over the first 20 years of the scheme. This leaves 71 properties still to be purchased. The location of purchased properties and remaining properties still to be purchased are shown on **Figure 8.1**.

The cost of acquiring the 99 properties purchased to date has totalled some $16M. However, with recent price rises in the property market, future property purchases

will be considerably higher. It is likely that the cost of acquiring the remaining 71 properties could be $30M or higher (based on 2003 values). This increase in property values places a significant impediment to the completion of the voluntary purchase scheme. Another impediment to the Scheme is that the Commonwealth Government withdrew financial support for floodplain management programs in urban areas several years ago, placing increased financial burden on both Liverpool Council and the State Government to complete the Scheme.

The original Moorebank-Milperra Floodway Study investigated alternative floodplain management measures for this area, but concluded that removal of all development from the floodway, through a voluntary purchase scheme, provided the only complete solution to the flood problem. Also, as the scheme has progressed, it could be argued that the flood risk to the remaining properties has actually increased. This is largely due to anticipated increases in overbank velocities as more of the properties are gradually removed. There may also be increased evacuation concerns, as the remaining properties become more isolated.

Thus there appears to be little alternative but to complete the scheme, and to do this in as short a time frame as possible. However, the financial burden on Council and the State Government is high, and this objective may not be achievable under current practice. If house prices were to remain static, and the current level of funding (at about $2M per annum) were to continue, the scheme is likely to take at least a further 15 years to complete. In reality, it is likely that there will be further property price rises, and there is no guarantee that the level of government funding will continue.

In view of the above, it is recommended that other self-funding initiatives to complete the scheme are investigated. This could include encouraging private-sector development in the area in order to provide a source of funds to acquire the remaining properties. Examples of development that might be considered include:

- sand extraction for commercial gain;
- flood compatible tourist developments, such as golf courses or marinas;
- commercial development on the fringe of the floodway; or
- a combination of the above.

Commercial development, such as a business park, could be considered on the western strip of the voluntary purchase area, adjoining Riverside Road. This would require compensatory excavation from elsewhere in the floodway to provide a strip of land that could be developed (say 150m in width by 600m in length) that is at or above the 100 year flood level. The remainder of the floodway would need to be dedicated to more flood compatible uses such as lakes, recreation areas, temporary parking, etc, all of which could be integrated with the business park, or could be part of separate facilities.

Land already acquired by Liverpool Council could be transferred to the development consortium at little or no cost, on the understanding that the consortium purchases the remaining properties in the Scheme (approximate cost $30M). Therefore the value of the development project would need to be able to return a profit to the consortium of at least this amount.

It is beyond the scope of this study to determine development proposals within the voluntary purchase site. However, it is recommended that Liverpool Council further pursue the possibility of the potential for private-sector development of part or all of the site in order to fund the purchase of the remaining properties in the Liverpool Voluntary Purchase Scheme.

8.2 BANKSTOWN VOLUNTARY PURCHASE SCHEME

Findings: Acquisition of remaining 4 properties pending agreements from owners

The Bankstown voluntary purchase scheme originated from the same Moorebank-Milperra Floodway Study [PWD, 1983] as the Liverpool Scheme. The Floodway Study identified the area on the Bankstown side of the river, downstream of the Milperra Bridge, as an extremely hazardous area and recommended voluntary purchase as the only acceptable flood management strategy for the area.

The Scheme originally identified the purchase of 16 privately owned houses located along Auld Avenue and Henry Lawson Drive. It is understood that the scheme was subsequently expanded to also include vacant properties, as was the case for the Liverpool Scheme. It was further expanded in 1984 to also include two other properties south of the Flower Power Development on Henry Lawson Drive. The total number of properties included in the Scheme is now 25.

To date, Bankstown Council, with the assistance of the State and Commonwealth Government, has purchased 21 of the 25 properties. The location of properties purchased to date, and those remaining in the Scheme, is shown on **Figure 8.1**.

Each of the four remaining properties still to be acquired contains a house. The estimated completion cost of the Scheme (based on 2003 prices) is approximately $2M.

Completion of the scheme has similar problems as the Liverpool Scheme. Increases in property costs and the withdrawal of Commonwealth funding to the scheme has placed increased burden on both Bankstown Council and the State Government. There has also been a reluctance of the four property owners to participate in the Scheme in recent years, although this may be largely due to diminishing awareness of both the voluntary purchase scheme and the flood risk of the area.

Fortunately, there are only four remaining properties still to be purchased, and the financial costs are not insurmountable. Nevertheless, Bankstown Council could pursue other self-funding initiatives to complete the Scheme. This could involve generating some form of income from those properties already purchased in order to acquire the remaining four properties (subject to agreements from the remaining property owners).

FIGURE 8.1
MOOREBANK-MILPERRA VOLUNTARY PURCHASE SCHEME

0 100 200m
Scale

N

LEGEND

Properties that have been purchased

Properties still to be purchased

LIVERPOOL CITY COUNCIL

BANKSTOWN CITY COUNCIL

MOOREBANK

MILPERRA

Bankstown Airport

Bankstown Golf Course

Georges River

Peterson Park

Hind Park

Auld Reserve

Vale of Ah Reserve

Milperra Bridge

RIVERSIDE ROAD

ARTHUR STREET

FICKARD ROAD

NEWBRIDGE ROAD

DAVY ROBINSON DRIVE

AULD AV

HENRY LAWSON DRIVE

MILPERRA ROAD

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Plot file :Voluntary Acquisition
Plot scale : 5 (a3@1:5000)
Date : 3 July 2003

GEORGES RIVER FLOODPLAIN
RISK MANAGEMENT STUDY

8.3 MILPERRA DRAIN CHANNEL AUGMENTATION

Findings: Local flood conditions to be reviewed as part of the Milperra Drain Drainage Study

Milperra Drain is a tributary of the Georges River, which drains an industrial area adjacent to Milperra Road, in Bankstown. It is an area that is particularly susceptible to high flood damages, largely due to the type of industrial development located adjacent to the Drain.

Milperra Drain suffers both backwater flooding, when the Georges River is in flood, and local flooding from short duration floods over its local catchment area. A flood investigation for the Milperra Industrial Area was completed in 1990 [Willing & Partners, 1990]. The report noted that there was little scope to improve flood behaviour in a Georges River type flood, but improvements to Milperra Drain could alleviate inundation in local flood conditions.

Improvements to Milperra Drain commenced in 1990-1991. This involved channel widening, channel lining, and culvert amplification. The original channel improvement works have now been completed. More recently, further improvements have been identified as being desirable for the downstream reach of the Drain, which would involve widening the drain to increase its capacity in this area. It is understood that these works would impact on sensitive vegetation and other private land, and as such these works have been deferred.

The Milperra Drain channel improvement works are effective in local catchment flooding only. Bankstown Council recently commissioned drainage studies on a number of local catchments, including the Milperra Drain catchment. This study should review the effectiveness of drainage improvements to date and assess the need for further augmentation. The impact of earthworks and other drainage modifications within Bankstown Airport on local flood behaviour should also be considered as part of that investigation.

8.4 KELSO LEVEE

Findings: Minor levee bank modifications and geotechnical review recommended

The Kelso Park Levee provides protection for up to 275 residential homes in the Kelso Park and Panania areas from a Georges River flood.

A feasibility study for the levee was completed in 1984 [PWD, 1984], with construction commencing in 1986. Construction was still in progress when the August 1986 flood occurred. The first benefits of the levee were realised during the April 1988 flood.

Local drainage within the area protected by the levee is an important component of the levee scheme. Local runoff is drained to the river through four 1200mm diameter pipes under the levee bank. These pipes have manually operated floodgates that are usually left open to allow tidal exchange with Kelso Creek. The SES close the floodgates when flood warnings are issued by the Bureau of Meteorology.

There are a number of key issues associated with the Kelso Levee. These include:

- the level of internal ponding behind the levee when the flood gates are closed;
- the actual level of protection provided by the levee;
- behaviour under large floods that overtop the levee;
- reliance on the manual closure of the flood gates when potential flooding is likely; and
- development within the area protected by the levee bank.

The original feasibility study estimated an internal ponding level of RL 3.5m AHD during a 100 year flood when the flood gates are closed. This level approximately coincides with the lowest floor levels of existing residential homes within the protected area. Numerous investigations have since been undertaken to confirm or refine this estimate. The most recent Kelso Creek Floodplain Management Study [Bewsher Consulting, 2000] provided a revised 100 year flood level estimate of RL 3.75m AHD for the area "protected" by the levee. The 100 year Georges River flood level is RL 5.0m AHD. The effect of the levee is therefore to reduce flooding levels in the area upstream (east) of the levee by 1.25 metres in this flood event. The levee will overtop in larger floods, such as the PMF, and flood levels behind the levee will rapidly rise to the same level as the Georges River.

The feasibility study recommended that the levee be constructed at a level 0.5m above the 100 year Georges River flood level. This equates to a level of RL 5.5m AHD. The additional 0.5m is a freeboard allowance that caters for various uncertainties, including accuracy of computational methods; wave action; possible increases due to greenhouse effects; and construction tolerances. Many levees in New South Wales include a freeboard allowance of 1.0m.

A recent survey by Bankstown Council indicates that the crest of the levee is generally at a level of RL 6.0m AHD or slightly higher, although there are two low points where overtopping could commence at RL 5.8m AHD. The first low point is located about 40m north of the outlet structure, and extends over a distance of some 75m. The second low point is further north, where an access road has been constructed to the Australian Rules Oval and the Baseball fields, and also extends over a distance of about 75m. Thus the existing levee is providing a level of protection that is 0.8m above the 100 year flood. This increase in height above the 100 year flood is within the normal freeboard allowance (ie 0.5m to 1.0m) that would normally be applied to levee banks in New South Wales. The increase in height should therefore not be mistaken as providing an increased level of protection beyond the 100 year flood.

Given that two low points along the levee crest have been identified, at least 0.2m below the general crest height, consideration needs to be given to whether modifications to the levee to remove the low points are warranted. Whilst low points along the levee reduce the potential freeboard provided by the levee, there can be some advantages during large floods that overtop the levee. One advantage is being able to concentrate the point of overtopping to areas of the levee that are unlikely to fail when overtopped. This would prevent rapid inundation of the area behind the

levee, which would be a consequence of levee failure. Also, a controlled low point in the levee will allow some limited overtopping to occur prior to widespread overtopping, which will provide residents with some visual indication of the problem prior to the more hazardous conditions occurring.

The first low point, immediately north of the outlet structure, is not considered to be an appropriate location for overtopping to first occur. This is due to its proximity to the outlet structure and the height of the embankment at this location. Minor levee adjustments are therefore recommended at this location to increase the level of the crest by approximately 0.2m to a minimum height of RL6.0m AHD.

The second low point, where the access road crosses the levee to the sporting fields, is considered to be a more appropriate location for controlled overtopping. The crest level is generally wider at this location and the height of the embankment considerably reduced. Minor works are recommended to stabilise this low point for overtopping flows. Existing log barriers should be removed and replaced with more flood compatible and non-floating structures, such as bollards.

A final issue to be considered is the desirability of further development, or intensification of existing development, within the area that is "protected" by the levee. This should be considered carefully by Council for the following reasons:

- there may be some instances when the flood gates are not closed during a flood, either due to insufficient warning, absence of key personnel, or mechanical failure;
- the levee may fail at a level below the crest height of the levee;
- there is an increase in flood hazard during large floods that overtop the levee, due to the anticipated rapid rise in floodwaters that would occur; and
- any development or filling that reduces the available ponding storage volume will increase the internal ponding level behind the levee bank.

Apart from the minor works required to raise the low spot in the levee crest to the north of the outlet structure, a review of the structural integrity of the levee would be timely. The review and minor levee works is estimated to cost of the order of $50,000.

8.5 EAST HILLS FINGER LEVEES

Findings: Voluntary removal/relocation of 7 houses adjacent to the river

There are up to 80 residential properties that are potentially affected by flooding in the 100 year flood on the banks of the Georges River at East Hills, between the East Hills Railway line and Bass Avenue. The combination of flood depths and high flood velocities presents potentially hazardous conditions to a number of these properties.

Various schemes to reduce the flood hazard were investigated by the Public Works Department in the mid 1980's, as part of the East Hills Floodway Model Investigation [PWD, 1987]. A number of options were considered, including:

- removal of development through a voluntary purchase scheme;

- construction of a ring levee enclosing all flood liable development;
- construction of a combination of deflector levees and finger levees across the floodplain to reduce flood velocities;
- relocation or removal of selected buildings; and
- improvements to property access conditions.

The preferred scheme, which was adopted by Bankstown Council in consultation with the community, essentially involved the construction of a number of finger levees and improvements to property access during floods. It is important to note that the scheme does not alleviate flooding to homes in the area – it only attempts to reduce the flood velocities and improve access conditions.

Implementation of the scheme commenced in 1995. The location of some of the finger levees was slightly amended during the construction phase, largely as a result of objections by some residents. In particular, agreement to the construction of the final levee wall could not be reached. Bankstown Council subsequently commissioned an investigation to review the performance of the constructed scheme [WBM, 2001] and to assess an alternative position for the final finger levee.

The review indicated that the constructed scheme had reduced high hazard conditions for up to 24 buildings, but 7 buildings within the area remained subject to a high flood hazard. Furthermore, it was determined that it was unlikely that further levee works, that would be aesthetically acceptable to residents, would reduce the level of hazard for these houses. The seven buildings that are still subject to a high flood hazard are those that are located close to the river bank (ie Nos 494, 502, 504, 536, 538, 544 and 552 Henry Lawson Drive). These same properties are among those that were previously identified for relocation or removal in the various schemes investigated by the Public Works Department in the mid 1980's.

It is understood that voluntary purchase was an unpopular option with residents in the area when this was first examined, and this will most likely still be the case today. However, there is an opportunity to relocate four of the seven buildings further up the property, away from the river, to reduce the high flood risk for these buildings. This could be undertaken as a special relocation program or alternatively it could be made a condition of any subsequent redevelopment that may be proposed within the property. There is less scope to relocate the other three buildings, which already have other buildings at the front of the property, and the removal of the buildings close to the river may need to be considered in conjunction with a voluntary acquisition scheme, if and when the property owners agree to participate.

The estimated cost of the relocation/removal of the 7 buildings is likely to be of the order of $1.2M. However, there may be scope for this cost to be reduced should the objectives be achieved through future redevelopment.

Part of the access improvement works recently constructed at East Hills includes the construction of an embankment/wall between Henry Lawson Drive and the Slip Road. This embankment/wall would provide protection to up to 11 properties on the eastern side of Henry Lawson Drive in a 100 year flood, except for a gap that occurs at the intersection of Maclaurin Avenue and Henry Lawson Drive. The temporary

closure of this gap during major floods (by sand bagging or other means) may also be worthy of consideration by the State Emergency Service.

8.6 CARINYA ROAD FINGER LEVEES

Findings: Detailed review of existing flood mitigation measures recommended

The floodplain at Carinya Road, Picnic Point, is subject to similar flood conditions as experienced at East Hills. Similar flood mitigation schemes were investigated by the Public Works Department during the 1980's [PWD, 1983]. Options considered included:

- removal of development through a voluntary purchase scheme;
- construction of a ring levee enclosing all flood liable development; and
- construction of a combination of partial levees (known as finger levees) across the floodplain to reduce flood flow velocities.

The preferred option was the construction of an upstream deflector levee and several finger levees along property boundaries. The scheme, which was implemented some time ago, aims to reduce the flood hazard of the area by reducing flood velocities on the floodplain, much the same as the East Hills Scheme.

It was also intended to reduce the residual flood risk to existing dwellings by the application of building controls for any new development or redevelopment. The main objective of the controls is to encourage the gradual relocation of dwellings from the low-lying land on the river-side of the property to higher ground towards the back of the property. Opportunities to improve flood access conditions were also an objective.

Whilst the scheme was completed a number of years ago, it would be timely to undertake a detailed review of the constructed scheme, similar to the review that was recently undertaken for East Hills. This would include the establishment of a 2-dimensional hydraulic model to assess the reduction in flood hazard arising from the constructed scheme, and the identification of any residual high hazard areas where further measures should be considered. It would also be appropriate to include a review of flood-related planning provisions, such as the requirements for elevated walkways, in this assessment.

The estimated cost of the review is $30,000.

9. OTHER POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

9.1 FLOOD MITIGATION DAM IN THE UPPER CATCHMENT

Findings: Not recommended due to high costs and environmental concerns

Construction of a flood mitigation dam or detention basin in the upper catchment area was strongly supported in the community questionnaire. Some 62% of respondents favoured this option, whilst 18% of respondents were against the option. It also rated highly in the list of "top 5" measures suggested by the community.

These dams or basins act to temporarily store floodwater from the upper catchment areas during floods, releasing the water at a controlled rate. As a result, peak flows downstream of the basin sites are reduced and flood levels are lowered. The Georges River catchment area is such that a conventional size detention basin, which would be considered in other smaller catchments, would be ineffective in reducing downstream flood levels in the lower Georges River. A much larger structure, such as a flood mitigation dam, would be required to have an appreciable impact on flood behaviour.

Flood mitigation dams have previously been investigated in the upper Georges River catchment, both for flood mitigation benefits and for recreational purposes. Dams can also provide a water supply component, but this does not appear to have been a consideration on the Georges River. The Georges River Upper Valley Flood Mitigation Storage – Damsite Investigation [PWD, 1985] looked at five different sites where a suitable dam could be constructed. Preliminary plans and cost estimates were prepared for dams at each of these locations.

Whilst a preferred dam location was identified, no firm recommendation was provided as to whether the dam should or should not be constructed. This could, in part, be due to an absence of flood data at that time from which the flood mitigation benefits could be properly assessed. The flood model and flood damages database that has been assembled as part of the current study provide an opportunity to further evaluate the merits of a flood mitigation dam in the upper catchment, particularly in view of the community support for such a measure.

Further assessment of the previously preferred flood mitigation dam has therefore been undertaken. The preferred dam site, which was referred to as Dam Site 2A, is shown on **Figure 9.1**. The dam site is located in a deep gorge in the Georges River, adjacent to Kentlyn, near Campbelltown. Various dam types were considered, including a mass concrete gravity structure, a roller compacted concrete gravity dam, and a decked rockfill dam. The more conventional mass concrete gravity dam was estimated to cost $52M (1983).

Two different dam options were considered in the current assessment. The first option largely included the dam as originally proposed. This included a permanent water depth within the dam, for recreational purposes, 20m above the normal creek bed. The main outlet from the dam was a 2.5m diameter conduit tunnel, with a higher level spillway provided for floods exceeding the 100 year flood. The second

dam option was a smaller structure with no permanent water, in an attempt to reduce the size and cost of the dam. The 2.5m diameter conduit was also replaced by a 2m wide rectangular slot through the dam wall, in order to increase normal outflows and further reduce the necessary size of the dam. This second option results in a smaller, less costly dam, but the flood mitigation benefits will not be as great. Further details concerning the dam structure and the impact on flood behaviour, is summarised in **Table 9.1**.

TABLE 9.1
Summary of Dam Characteristics and Flood Benefits

Description	Option 1 (Large Dam)	Option 2 (Smaller Dam)
Details of Dam		
Invert of dam (existing bed level)	44.0m AHD	44.0m AHD
Permanent water level	64.0m AHD	N/A
Permanent water volume	3,500 ML	N/A
Normal outlet structure	1.5m diameter tunnel	2.0m rectangular slot
Height of main spillway	96.0m AHD	78.0m
Flood storage volume (to spillway)	42,500 ML	13,100 ML
Total embankment height	58m	41m
Impact on Flood Behaviour (100 year flood)		
Peak Inflow	1,060 m^3/s	1,060 m^3/s
Peak outflow	83 m^3/s	677 m^3/s
Flood level reduction at Liverpool	1.8m	0.8m
Flood level reduction at Milperra Bridge	0.9m	0.6m
Flood level reduction at East Hills	0.6m	0.4m
Reduction in houses flooded	456	287
Reduction in commercial buildings flooded	150	124
Economic Evaluation		
Approximate cost*	$100M	$60M
Savings in 100 year flood	$74M	$57M
Savings in average annual damage	$3.2M	$2.5M
Net Present Value of flood benefits	$37M	$28M
Benefit/cost ratio	0.4	0.5

* Costs based on previous estimates [PWD, 1985] and increased to reflect 2003 values.

Both dam options considered result in significant flood mitigation benefits.

For the larger dam, the number of houses that would be flooded in a 100 year is reduced from 721 to 265 (ie 456 houses benefit). The number of commercial and industrial buildings that would be flooded is also reduced from 216 to 66 (150 buildings benefit). The present value of flood damage (from all floods) is reduced from $91M to $54M (a saving of $37M).

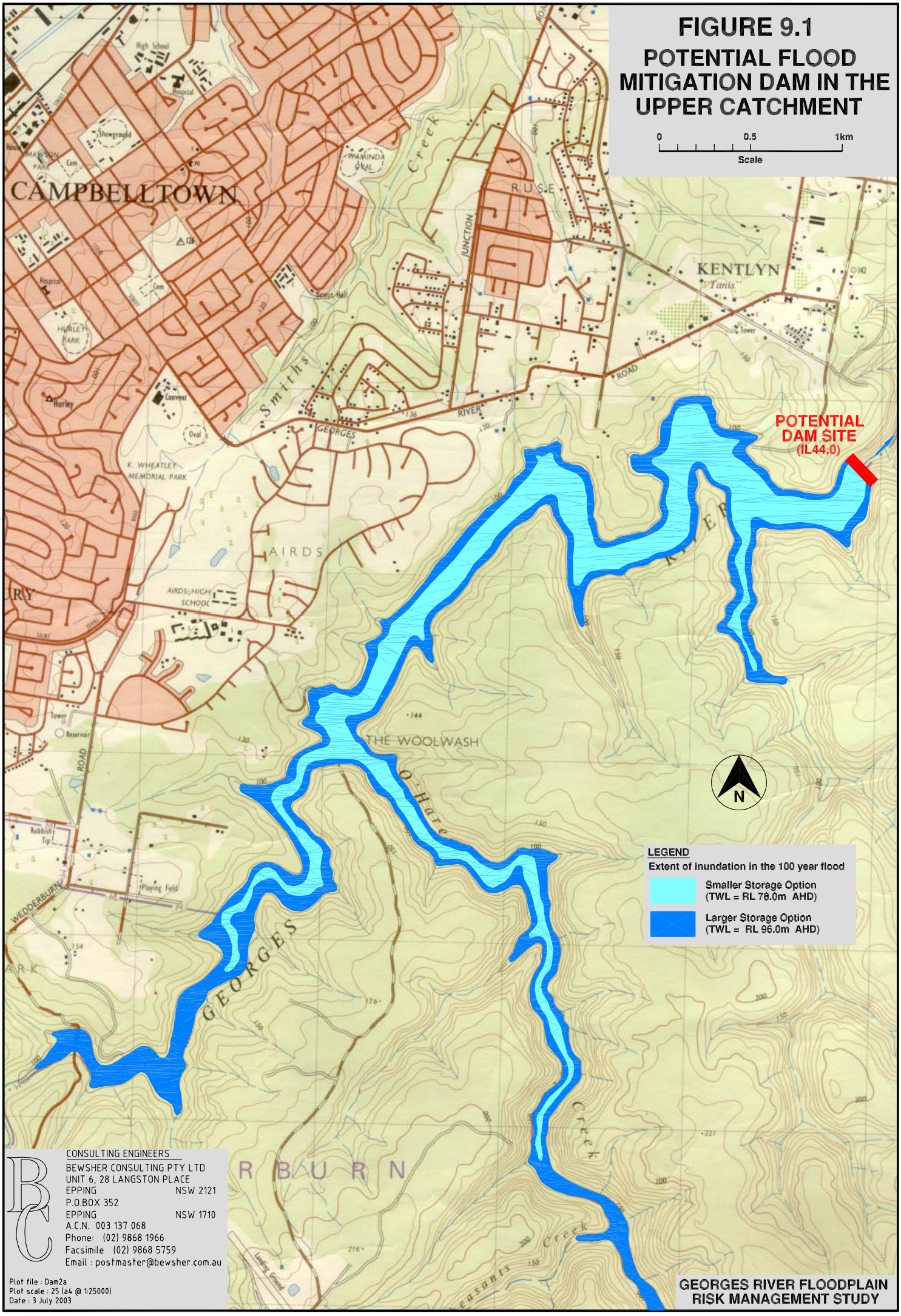
FIGURE 9.1
POTENTIAL FLOOD MITIGATION DAM IN THE UPPER CATCHMENT
0
0.5
1km
Scale
CAMPBELLTOWN
KENTLYN
"Tanis"
RUSE
JUNCTION
ROAD
Smiths Creek
GEORGES RIVER
POTENTIAL DAM SITE (IL44.0)
AIRDS
AIRDS HIGH SCHOOL
K. WHEATLEY MEMORIAL PARK
THE WOOLWASH
O'Hare Creek
GEORGES
WEDDERBURN
Rubbish Tip
Playing Field
Reservoir
Tower
Hospital
High School
Showground
Cem
Oval
Convent
Hurley
HURLEY PARK
WAMINDA OVAL
Scout Hall
N
LEGEND
Extent of inundation in the 100 year flood
Smaller Storage Option (TWL = RL 78.0m AHD)
Larger Storage Option (TWL = RL 96.0m AHD)
CONSULTING ENGINEERS
BEWSHER CONSULTING PTY LTD
UNIT 6, 28 LANGSTON PLACE
EPPING NSW 2121
P.O.BOX 352
EPPING NSW 1710
A.C.N. 003 137 068
Phone: (02) 9868 1966
Facsimile (02) 9868 5759
Email : postmaster@bewsher.com.au
Plot file : Dam2a
Plot scale : 25 (a4 @ 1:25000)
Date : 3 July 2003
GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

For the smaller dam, the number of houses that would be flooded in a 100 year is reduced from 721 to 434 (ie 287 houses benefit). The number of commercial and industrial buildings that would be flooded is also reduced from 216 to 92 (124 buildings benefit). The present value of flood damage (from all floods) is reduced from $91M to $63M (a saving of $28M).

Whilst the flood mitigation benefits of both dam options are high, the cost of constructing the dam is higher. Both options have benefit cost ratios that are less that 1.0, and their adoption would be difficult to justify from a purely economic viewpoint.

It should also be noted that both dam options are also likely to result in major environmental concerns, with many areas of the Upper Georges River catchment previously being recognised for their important biodiversity values. Some of the environmental issues associated with the proposed dam include:

- backwater effects into high quality ecosystems such as O'Hares Creek (NPWS working with former Planning NSW have undertaken extensive biodiversity surveys in this area with significant community involvement);
- dams and basins that impound water often result in litter and weed seed to deposit up the river bank wall, thus impacting on otherwise good bushland (ie. the low flow channel area is usually the most heavily impacted);
- slow release from dams and basins can result in sediment deposition that may smother vegetation or make vegetation more disease prone with time;
- the dam wall may immediately shade the adjacent riparian vegetation;
- the dam wall will form a barrier to fauna movement along the river/ creek corridor eg. some species will not pass through a tunnel or other narrow opening;
- funnelling of fauna through dam openings in the base of the wall can result in "ambush" by predators such as foxes, cats & dogs;
- changed hydrology/altered flow regime can result in changes to vegetation communities in the long-term;
- likely erosion problems downstream of the outlet structure; and
- visual amenity issues in relation to the dam wall are also likely to be a major issue.

Significant opposition from environmental groups to the proposal could be anticipated.

Given the high costs, environmental and other concerns, neither dam option is recommended for inclusion in the floodplain management plan.

9.2 RIVER DREDGING

Findings: Not recommended due to environmental concerns

Dredging of the Georges River to increase its capacity to carry floodwater was also a very popular option suggested by the community. This option featured more in the list of "top 5" options than any other option. Interestingly, it also featured most

frequently in the "top 5" least favoured options. This suggests that there is somewhat mixed community support for dredging.

The impact of dredging on flood behaviour was assessed using the MIKE-11 flood model and flood benefits quantified using the flood damages database. Two variations of dredging were considered for this assessment. The first assumed dredging between Milperra Bridge and the East Hills Railway Bridge, a distance of approximately 6.0km. The second assumed dredging between the East Hills Railway Bridge and a location just downstream of Salt Pan Creek, a distance of some 10.0km. In both cases, it was assumed that dredging would increase the existing river depths by an average of 1.0m.

TABLE 9.2
Impact of Dredging on Flood Behaviour

Description	Option 1 Milperra to East Hills	Option 2 East Hills to Salt Pan
Impact on Flood Behaviour (100 year flood)		
Maximum flood level reduction	0.20m	0.41m
Maximum increase in downstream flood level	0.02m	0.05m
Flood level reduction at Liverpool	0.00m	0.00m
Flood level reduction at Milperra Bridge	0.10m	0.04m
Flood level reduction at East Hills	0.01m	0.38m
Reduction in houses flooded	34	64
Reduction in commercial buildings flooded	5	5
Economic Evaluation		
Quantity of dredged material	580,000 m^3	1,430,000 m^3
Approximate cost	$12M	$28M
Savings in 100 year flood	$5.6M	$5.3M
Savings in average annual damage	$0.45M	$0.41M
Net Present Value of flood benefits	$5.3M	$4.8M
Benefit/cost ratio	0.4	0.2

Dredging increases the capacity of the river to convey floodwaters. Consequently there is a reduction in flood levels through the dredged area, and immediately upstream. Conversely, there is also a slight increase in flood levels downstream of the dredged area.

Maximum flood level reductions in the 100 year flood of 0.20 and 0.41m were obtained for the two dredging options considered. This reduction is sufficient to reduce the number of houses that would be flooded in a 100 year flood from 721 to 687 (benefits 34 houses) or 657 for the second option (benefits 64 houses). The present value of flood damage (from all floods) is reduced from $91M to $86M for both options.

The cost of dredging can be highly variable. It is dependent on such factors as the dredging techniques, potential contaminants in the dredged material, and how the

material is to be disposed of. Large scale dredging of clean sand, where there are no disposal problems, can be as low as $5 to $10 per m^3. Additional environmental safeguards are likely to be required along the Georges River, and disposal of the dredged material may not be that simple. A rate of $20 per m^3 is considered more appropriate for the Georges River.

The estimated cost of dredging is $12M (Option 1) and $28M (Option 2). This provides an economic benefit/cost ratio of 0.4 (Option 1) and 0.2 (Option 2). Both benefit cost ratios are less than 1.0 and from an economic viewpoint would be difficult to justify on flood mitigation benefits alone.

Other problems associated with dredging include:

- it disturbs sediments and releases organics as well as a range of potential pollutants into the water column. This can directly smother or reduce the light to remaining aquatic plants, kill or seriously impact animal life (from microscopic organisms in the food chains to fish and waterbirds) and cause chemical changes to the water resulting in events such as fish kills;
- it physically disturbs aquatic and semi-aquatic vegetation;
- bed lowering in the river as a result of dredging can result in bank collapse, loss of riparian vegetation and loss of property;
- subsequent deposition of material will require further dredging in future years;
- results in the loss of instream habitat eg. sand bars and tree logs for fish and other animals; and
- a full environmental impact assessment would be required, and numerous permits from various authorities obtained (eg Fisheries, EPA, DIPNR). Also, many environmental groups are likely to be opposed to dredging of the River.

Given the cost, limited flood mitigation benefits and significant environmental concerns, dredging is not recommended for inclusion in the floodplain management plan.

9.3 LEVEE AT MILPERRA

Findings: Individual property measures to be further evaluated

The Milperra Industrial Estate was identified as an area with high potential flood damages. An option to build a levee in the vicinity of Henry Lawson Drive was previously considered to protect this area, but it is understood that this option was not pursued due to the likely increase in flood levels elsewhere. Further review of this option has been undertaken as part of this study.

The levee could be formed as an earth embankment or block wall beside Henry Lawson Drive, to the south of Milperra Road. The levee would also need to run in an east-west direction along Milperra Road. Alternatively, Henry Lawson Drive and Milperra Road could be raised to form the levee, which would also improve flood access. This later option is likely to be very costly due to the required height that the road would need to be raised.

The levee option was previously investigated during the 1980's using the Georges River physical model. It was estimated that the levee would result in an increase in flood levels of approximately 0.15m and it was not considered further. The adverse impact on flood behaviour is largely due to the lost floodplain storage and the obstruction of a potential flow path through the airport leading to the Milperra Drain area, as a result of the proposed levee. However, recent filling of the airport site has significantly reduced the floodplain storage and overland flow path through this area. The impact of the proposed levee will therefore be smaller than previous estimates if the recent activities within the airport site can not be rectified.

The change in flood behaviour and estimated flood benefits of the proposed levee are shown in **Table 9.3**. These impacts are additional to the impacts of recent earthworks undertaken within the airport site. Should the airport earthworks be removed or other compensatory measures undertaken (as recommended) then the impacts on flood behaviour due to the levee will increase.

TABLE 9.3
Impact of Milperra Levee on Flood Behaviour

Description	Impact
Impact on Flood Behaviour (100 year flood)*	
Maximum flood level reduction	River flooding excluded behind levee#
Maximum increase in flood level	+0.03m
Flood level increase at Liverpool	+0.00m
Flood level increase at Milperra Bridge	+0.03m
Flood level increase at East Hills	+0.02m
Reduction in houses flooded	24
Reduction in commercial buildings flooded	45
Economic Evaluation	
Approximate cost	$6M
Savings in 100 year flood	$16M
Savings in average annual damage	$0.63M
Net Present Value of flood benefits	$7M
Benefit/cost ratio	1.2

* Additional to impacts already realised from earthworks within the airport site
# It may be impractical to exclude all river floods due to the height of the levee required.

The proposed levee has a good economic benefit/cost ratio, particularly if the adverse impacts from the airport activities are not considered. However, the benefits are mainly realised by the industrial sector, and government assistance to fund the work may not be forthcoming, particularly as there are some adverse impacts to other residential areas.

The flood benefits may also be somewhat overstated as flooding will still occur under local catchment floods, or during extreme floods in the river. The levee can actually

exacerbate local flood conditions, as drainage to the river will be impeded by the outlet structure provided in the levee.

An alternative to the levee bank option that could be considered is the construction of local floodwalls, or property filling, within the Milperra Industrial Estate to exclude floodwater from entering individual developments. This measure was in fact examined in the Milperra Industrial Area Hydraulic Study [Willing & Partners, 1990]. The advantages of this measure over the levee option include:

- it achieves similar objectives;
- the total loss in floodplain storage is reduced;
- local catchment flooding will not be impeded; and
- it can be funded by individual businesses.

It is difficult to provide a recommendation on the above works whilst the outcome of negotiations with Bankstown Airport Limited over the removal of recent fill, or other compensatory works, are still uncertain. However, the individual property measures would appear to be more desirable and practicable then the main levee option.

It is understood that a local catchment study has recently been commissioned by Bankstown Council for the Milperra Drain area. The drainage study could further investigate issues associated with the airport and the merits of the individual property measures.

9.4 STORMWATER CONSIDERATIONS

Findings: On-going local catchment studies recommended

The focus of the current study is flooding from the Georges River. However, flooding can also occur in local catchment areas, due to poor local drainage, blockage of culverts or inadequate overland flow paths. This type of flooding is often referred to as stormwater or local catchment flooding.

Many respondents to the community questionnaire raised stormwater issues as a major concern. The issue was also raised in several of the community workshops.

In the past, many of these local flood problems were overlooked or paid inadequate attention by many NSW councils. The State Government Flood Policy also did not address the issue and funding for studies or remedial works was generally unavailable. The recently released Floodplain Management Manual [NSW Government, 2001] now includes local flood considerations within the Flood Policy, and funding for studies and works are now available.

The magnitude of potential stormwater problems within the Georges River catchment is likely to be considerable, and is beyond the scope of the current study. Nevertheless, recommendations have been provided on planning considerations for stormwater flooding issues. These recommendations are included in the report that has been prepared on planning issues for the study (**Volume 2**).

A coordinated program of local catchment studies to identify the main problem areas and to assess works to alleviate these problems is recommended for each of the four councils. It is understood that all four councils have already commenced programs to undertake such studies.

9.5 ADDITIONAL INVESTIGATIONS

Findings: Anzac Creek Flood Study & refinement of flood risk maps recommended

A potential flood problem area was identified on a tributary in the upper catchment area, known as Anzac Creek. No previous flood studies have been undertaken on this creek, and the full extent of potential flood problems is uncertain.

Anzac Creek commences in the military reserve, between Chatham Village and Holsworthy Village. The creek drains in a northerly direction beside Holsworthy Village and Anzac Village to Heathcote Road, and through Moorebank to Newbridge Road, where it finally joins Lake Moore and the Georges River. Whilst some flood risk mapping of the lower reaches of this creek have been undertaken on the assumption of backwater flooding from the Georges River, there is the possibility that the level of flooding could be elevated due to additional flood flows from this creek. Flood problems could also extend further upstream on this tributary.

It is recommended that a flood study on this creek be undertaken to provide additional flood data. This will involve the collection of additional survey data, levels of low-lying buildings, and additional flood modelling. The existing Georges River MIKE-11 flood model could be extended upstream to include this tributary. This would ensure consistency with results in the main Georges River, and allow the effects of tailwater conditions to be properly considered. The estimated cost of the survey and flood study is estimated to be about $80,000.

Fairfield and Bankstown Councils have recently commissioned airborne laser scanning of their local government areas. This is a relatively new technique that provides a cost-effective means of obtaining accurate topographic data over a wide area. The topographic data has principally been obtained as base data to help identify local overland flow paths that are to be investigated as part of various stormwater studies proposed by both councils. The improved topographic data can also be used to refine the flood risk mapping that was undertaken during the early stages of the current study, or to define other hydraulic criteria. Once this data is available, it is recommended that the flood risk maps are reviewed and refined in accordance with the improved topographic data.

Liverpool and Sutherland Shire Councils could also consider the collection of airborne laser scanning. This would not only assist in the refinement of their flood risk maps, but the data could be used for many other purposes (for example the proposed flood study on Anzac Creek of other proposed stormwater studies).

9.6 COMPENSATORY DEVELOPMENT MEASURES

Findings: Compensatory measures for past development recommended

This study has identified several activities that have been undertaken within the catchment that are estimated to have had a detrimental impact on flood behaviour. This includes:

- filling that has occurred on the Bankstown Airport site;
- the access track constructed below the M5 Motorway bridge across the Georges River at Hammondville; and
- temporary stockpiling and earthworks associated with dredging and other activities at Moorebank, between the M5 motorway and Newbridge Road.

Whilst some discussion has occurred between officers from Bankstown Council, the Georges River Floodplain Management Committee and Bankstown Airport Limited, no agreement has yet been reached on what, if any, compensatory measures are to be undertaken. The main problem from these activities is loss in floodplain storage, and the only complete solution is the removal of the material from the floodplain, or the excavation of similar quantities from elsewhere in the floodplain. It is recommended that the Georges River Floodplain Management Committee further pursue this issue with Bankstown Airport Limited. Assurances should also be sought that no further filling will occur within the floodplain on this site without appropriate compensatory works.

Negotiations held with the operators of the M5 Motorway have been successful in reaching an agreement to remove the access track under the M5 Motorway bridge at Hammondville. It is anticipated that the access track will be removed prior to the end of 2003.

It is understood that stockpiling and other earthworks that have occurred at Moorebank have been approved on the condition that the floodplain will ultimately be returned to natural floodplain conditions. It is understood that these conditions were made a number of years ago, and there may have been a subsequent change in ownership since this time. It is recommended that Liverpool Council review the development conditions associated with the activities in this area and to seek further advice on their legal standing in relation to these conditions. The area needs to be carefully monitored to ensure that further exacerbation on flood conditions does not occur, and when opportunities arise to correct for past activities, these opportunities are not lost.

9.7 PLANNING AND DEVELOPMENT CONTROLS

Findings: Consistent planning controls recommended to be applied through new flood risk management DCPs

Land use planning and development controls are key mechanisms by which the four councils can manage flood-affected areas within the Georges River study area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to

reduce flood risks may be lost. There was also strong support from the community for controls on future development in flood prone areas (78% of questionnaire respondents believed that development in areas subject to flooding should be controlled through building controls, whilst only 7% favoured no building controls).

The general approach to floodplain planning and a review of existing flood related planning controls is presented in Volume 2 – Planning Issues. Specific amendments to existing planning controls have been proposed and revised development control plans (DCPs) recommended for the four councils, in order to provide consistent planning controls for floodplains across the study area.

The proposed floodplain risk management DCPs have been prepared in a generic form to allow their application across the entire LGA of each Council area. A matrix of planning controls for use in the assessment of individual development applications has been formulated specifically for the Georges River floodplain. A second matrix of planning controls was also formulated for application to other floodplains within the LGA (excluding Bankstown Council, where this is currently under review), as well as areas affected by local overland flooding, pending the development of specific matrices for other areas through other floodplain risk management studies. These would be appended to the DCPs as additional matrices once the other studies have been completed.

The matrices provide a graded set of planning controls tailored to the proposed land use and flood level, and which recognise flood risks up to and including the probable maximum flood. The matrix of planning controls proposed for the Georges River floodplain is included on **Figure 9.2**. The matrix proposed for other areas (including areas affected by stormwater overland flow) is shown on **Figure 9.3**. These planning matrices should be monitored and reviewed and updated as future floodplain management plans are prepared, or existing ones reviewed.

The recommended planning issues, as summarised in **Volume 2**, include:

a) That the Floodplain Management Committee endorses the planning approach outlined within this study. This approach requires a graded set of planning controls for different land uses relative to different levels of flood risk within the study area, be adopted, consistent with the requirements of the NSW Floodplain Management Manual.
b) That the Committee formally endorses the recommended changes to the Georges River REP provided in **Volume 2** (Appendix A), for referral to Planning NSW.
c) That each Council considers amending their LEP in the manner outlined above and summarised in **Volume 2** (Appendix B), to provide a consistent framework for more detail controls to be provided in a DCP.
d) That Sutherland Shire Council discourage building in the High Flood Risk precinct by utilising foreshore building line provisions embodied within LEPs and the other Councils utilise alternate suitable mechanisms. (These mechanisms include a review of zonings within the High Flood Risk precinct having regard to the ambit of planning considerations, including flooding).
e) That each Council adopt or amend their current DCPs and/or Policies to generally accord with the Model DCPs appended to the **Volume 2** report (Appendices C to F).

GEORGES RIVER FLOODPLAIN

Planning & Development Controls

Templa V4.0

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

COLOUR LEGEND: Not Relevant; Unsuitable Land Use

General Notes

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

Floor Level

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

Building Components & Method

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

Structural Soundness

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

Flood Effects

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

Note: (1) If a *Boundary of Significant Flow* has been defined for this floodplain, any development inside this area will normally be unacceptable as it will reduce flood conveyance and increase flood effects elsewhere. (2) If a *Flood Storage Area*

Car Parking and Driveway Access

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

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

Evacuation

1	Reliable access for pedestrians or vehicles required during a 100 year flood.
2	Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel.
3	The development is to be consistent with any relevant *flood evacuation strategy, Flood Plan adopted by Council* or similar plan.
4	The evacuation requirements of the development are to be considered. An engineers report will be required if circumstances are possible where the evacuation of persons might not be achieved within the *effective warning time*.
5	Reliable access for pedestrians or vehicles required to a publicly accessible location above the *PMF*.
6	Applicant to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development flowing from the subdivision proposal.

Management and Design

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

FIGURE 9.2
PROPOSED PLANNING MATRIX – GEORGES RIVER FLOODPLAINS

Other Floodplains Including Areas Affected by Local Overland Flooding

Planning & Development Controls

Templa V4.0

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

COLOUR LEGEND: Not Relevant; Unsuitable Land Use

General Notes

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

Floor Level

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

Building Components & Method

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

Structural Soundness

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

Flood Effects

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

Note: (1) If a *Boundary of Significant Flow* has been defined for this floodplain, any development inside this area will normally be unacceptable as it will reduce flood conveyance and increase flood effects elsewhere. (2) If a *Flood Storage Area*

Car Parking and Driveway Access

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

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

Evacuation

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

Management and Design

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

FIGURE 9.3
PROPOSED PLANNING MATRIX – OTHER FLOODPLAINS
(Excluding Bankstown Council, where this is currently under review)

f) That each Council incorporates notations upon Section 149(2) Certificates, the wording subject to consideration by each Council, consistent with the approach discussed above and summarised in the **Volume 2** report.

It is considered that the above recommendations provide appropriate responses to the issues raised and evaluated within the context of the floodplain risk management plan and the legislative framework associated with planning.

The above measures can be implemented now at minimal cost, and should be pursued by each council with a high priority.

9.8 FLOOD WARNING ENHANCEMENTS

Findings: Better utilisation of existing flood warning scheme recommended

Flood warning is an important part of floodplain management. It provides advice on impending flooding so that people and relevant agencies can take action to minimise the impacts of flooding.

Flood warning systems usually monitor rainfall and river gauges in the upper catchment in real time and, through hydrologic/hydraulic models, predict the resulting flow and flood levels at some time in the future in the lower catchment. The Bureau of Meteorology provides an excellent flood warning system for the Georges River. However, other flood intelligence data concerning the number and location of property likely to be affected by a particular flood prediction is not currently available.

Development of a property database system that is able to link a flood warning prediction for one or more gauges on the Georges River with affected property would significantly improve emergency management operations.

Software could be quite readily developed that links information from the flood damages database developed as part of the current study with flood warning advice issued by the Bureau of Meteorology. With some manipulation of the existing databases, it would be possible to translate a flood warning prediction on the Georges River to a specific flood level at every property within the database. A determination can then be made on which properties are likely to be directly affected by the flood warning prediction. The information can be tabulated on a locality basis to allow the State Emergency Service to direct personnel to evacuate or otherwise assist those residents that are likely to be affected by flooding. If flood warning predictions are revised, a new list of potentially affected residents could be readily generated.

The database could be imported into a GIS system, such as MapInfo. This would allow a spatial representation of property likely to be affected by a particular flood warning prediction. Scripts could also be developed to improve the method of entering the flood warning prediction and in the graphical and tabular results that are provided.

There is also scope to extend the system as a flood awareness initiative, by providing advice to individual residents on the critical gauge heights that will affect

their property. With this knowledge, residents will be better able to appreciate the likely magnitude of a particular flood warning prediction and whether or not they are likely to be directly affected. It will allow increased time for residents to take appropriate action to reduce their personal risks and to minimise the potential flood damage to their homes.

The nearest gauge would need to be related to some point within the property, preferably the floor level of the building. The information could be attached to the inside of the meter box of each house or building below the PMF. As the majority of floor levels contained in the database have been estimated, floor levels should be confirmed by survey prior to fixing this advice.

The database would also need to be reviewed and updated from time to time to account for development or redevelopment within the study area. Most changes are likely to be confined to the area above the 100 year flood, where planning controls will be less restrictive. The database should be reviewed and updated at say 5 yearly intervals. Responsibility for this will need to be determined between the State Emergency Service and the councils.

The cost of preparing the necessary software and database for use by the State Emergency Service is estimated to cost $20,000. This is recommended as a priority measure.

Extension of the system as a flood awareness initiative would involve additional costs, particularly if accurate floor level surveys were required. It would also need to be undertaken in conjunction with a carefully planned community awareness program. Further consideration of this component of the scheme is recommended once the initial software and databases are developed.

9.9 EMERGENCY MANAGEMENT OPERATIONS

Findings: Update local flood plans and undertake an Evacuation Strategy Study

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, the various councils, police, fire brigade, ambulance and community groups.

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

Emergency management operations in relation to flooding are outlined in Local Flood Plans that are developed by the SES.

It is recommended that the Local Flood Plan covering the Georges River is updated with additional flood information developed as part of this study. This includes:

- mapping of the different flood risk areas (**Figure 5.1**);
- details of residential property affected by flooding (**Table 5.1**);
- details of commercial and industrial property affected by flooding (**Table 5.2**);
- inundation depths for houses in the 100 year flood (**Table 5.3**);
- inundation depths for other buildings in the 100 year flood (**Table 5.4**);
- details of main arterial roads likely to be affected by flooding (**Section 5.5**);
- other flooding characteristics, such as rate of rise of floodwaters and duration of flooding (**Tables 5.6** and **5.7**); and
- results from the evacuation strategy study (see recommendation below).

Additionally, information from the flood damages database will also provide valuable data on specific properties that are affected for a range of floods up to the PMF. The database includes estimated ground, floor and flood levels for every property within the Georges River study area.

The above details will assist the SES develop an improved Local Flood Plan for the Georges River, comprising flood preparedness measures, the conduct of response operations, and the coordination of immediate recovery measures. The Georges River Floodplain Management Committee would be an ideal group to help progress the development of the Local Flood Plan and to enlist the support of other authorities.

Given the potential for most of the major arterial roads to be cut early by floodwaters, and the large number of residents that could be affected during severe floods, an evacuation strategy study is recommended. This would determine appropriate evacuation centres, numbers to be allowed for, evacuation routes and other evacuation methods. The cost of the evacuation study is estimated to be about $50,000.

These measures can be implemented now at minimal cost, and are therefore recommended as part of the recommended floodplain risk management plan.

9.10 PUBLIC AWARENESS

Findings: Program recommended incorporating flood certificates and flood markers

Raising and maintaining flood awareness will provide residents with an appreciation of the flood problem and what can be expected during floods. It will provide them with an opportunity to plan what to do to reduce potential flood damage and to avoid personal risk during future floods.

The majority of respondents from the community questionnaire (84%) believed that information on flood risks should be made available to the community. Many respondents (70% in favour, 11% opposed) also believed that council should advise every resident and property owner of the flood risk on a regular basis by way of a flood certificate. There was also strong support for flood markers (70%) and public education programs (73%).

There are many means of raising and maintaining flood awareness within the community. These measures include:

- the issue of Section 149 Certificates;
- the issue of flood certificates;
- community education programs; and
- the construction of flood markers.

Whilst there are merits in all of these measure, the most effective solution is the regular issue of flood certificates to all occupiers of the floodplain [Bewsher, Grech and Maddocks, 1998]. The NSW Government's Floodplain Management Manual also recommends that Councils promote community flood readiness by supplying flood data and advice, which can readily be achieved by the use of flood certificates.

A flood certificate issued to individual property owners would inform them of the flood situation at their particular property. The certificate would contain vital information such as the expected flood levels in a range of design floods. It would also provide information on ground and floor levels where this information is available, which would allow an assessment of the depths of flooding over the property and building. Where property levels are unknown, residents could be encouraged to obtain these levels using a registered surveyor.

Much of this data is currently available from the flood damages database developed as part of the floodplain risk management study. The database would need to be incorporated into Council's GIS computer based system and mechanisms to keep the data up-to-date established. It would be relatively simple to print out a flood certificate for one or more properties once this link is established.

A sample flood certificate is included as **Figure 9.4**. Different certificates would be produced where information on floor levels are either known or unknown. The certificate could be attached to Section 149 certificates and also posted out with Council Rates Notices every 1 – 2 years. The certificate could also be provided on request for a nominal fee.

A second method of raising flood awareness, which is also recommended, is the construction of one or more flood markers within the Georges River floodplain. Flood markers can be constructed in parks, reserves or along low points in roads. An appropriate location where a flood marker might be considered is along Newbridge Road, adjacent to the Liverpool voluntary purchase area. This is a particularly flood prone area where there are already flood depth indicators to show the depth of floodwater over the road. There is likely to be less community opposition to a flood marker at this location then other locations within the catchment. The height of different probability floods could also be shown, along with heights of previous flood events, such as the 1988, 1956 and 1873 floods.

An awareness program, as outlined above, could be implemented for a very low cost. Approximate costs are $40,000 for its development and about $5,000 per annum to maintain, and is recommended for further consideration.

Fairfield City Council

Flood Certificate

Certificate Issued for Property at : 16 River Road, Lansvale
Lot 14, DP 25843

Owners Name : Mr & Mrs John Smith

1. Classification of Flood Risk

Council records indicate that the above property is located within a Medium Flood Risk area.

Land that is potentially subject to inundation is classified as low, medium or high flood risk. Council has prepared a development control plan that provides details of flood related controls that may be applicable.

2. Known Floor and Ground Levels

The lowest floor level of the main building on this property is : 6.3m AHD
Source of information : 1997 Survey

The lowest ground level on this property is : 5.2m AHD
Source of information : Estimate from plans

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

3. Estimated Flood Levels

Flood levels in the vicinity of the above property have been extracted from the "Georges River Flood Study" report (Public Works Department, 1991).

Size of Flood*	Flood Level	Depth over Lowest Floor Level	Depth over Lowest Ground Level
Probable Maximum Flood	9.1m AHD	2.8m	3.9m
100 Year Flood	6.4m AHD	0.1m	1.2m
20 Year Flood	5.4m AHD	Not flooded	0.2m

**The Probable Maximum Flood (or PMF) is the largest flood likely to occur, and is extremely rare.*
A 100 year flood is a large flood. It has a 1 in 100 (ie 1%) chance of occurring in any year.
A 20 year flood has a 1 in 20 (ie 5%) chance of occurring in any year.

Issued by Fairfield City Council
24th April 2003.

FIGURE 9.4
SAMPLE FLOOD CERTIFICATE

10 DRAFT FLOODPLAIN MANAGEMENT PLAN

10.1 THE RECOMMENDED MEASURES

The works and other measures that are recommended for inclusion in the Georges River Floodplain Risk Management Plan are shown on **Figure 10.1** and are summarised in **Table 10.1**.

10.1.1 Findings from Review of Existing Works and Measures

Floodplain management works and measures that have been undertaken within the study area since the early 1980s have been reviewed as part of the current study. Some of these works are on-going, and provision for their completion is included in the Plan. In some cases, variations to previous schemes or works have also been proposed. These measures comprise:

- Voluntary acquisition of the remaining 71 properties in the Liverpool Voluntary Purchase Scheme at Moorebank (99 properties have been purchased to date). Increasing property prices and the withdrawal of Commonwealth funds are a major impediment to the completion of the scheme. Investigation of self-funding initiatives involving private-sector development are recommended, to provide a source of income to complete the scheme in as short a time frame as possible.
- Voluntary acquisition of the remaining 4 properties in the Bankstown Voluntary Purchase Scheme at Milperra (21 properties purchased to date). There are similar impediments as the Liverpool Scheme, however costs to complete the scheme are manageable.
- A geotechnical review of the Kelso levee, including raising of a low spot along the crest of the levee by approximately 0.2m on the north side of the outlet structure. A second low spot further to the north to be reinforced and maintained as a defacto spillway.
- Relocation/removal of seven buildings within the East Hills Flood Mitigation Scheme. These buildings are located adjacent to the river and experience high hazard flood conditions. Four of the seven buildings could be relocated towards the front of the property (away from the river), possibly as part of eventual redevelopment proposals. Bankstown Council should address the most appropriate means of addressing this issue.
- A detailed review of the Carinya Road flood mitigation measures, using a 2-dimensional hydraulic model, to assess the reduction in flood hazard arising from the constructed scheme, the identification of any residual high hazard areas where further measures should be considered, and a review of flood-related planning provisions such as elevated walkway requirements.

10.1.2 Recommended Measures in Specific Areas

Other measures that have been proposed for specific areas comprise:

- The preparation of local catchment studies to address stormwater issues and overland flow issues within the four local government areas. This was identified as a major issue by a number of residents during the study. The 2001 Floodplain Management Manual also recommends such studies in potential problem areas.

- A flood study for Anzac Creek, upstream of Newbridge Road and Heathcote Road at Liverpool, to quantify potential flood problems in this area.
- Airborne laser scanning to provide improved topographic data within the Liverpool and Sutherland Shire Council areas, to assist with local catchment studies and also to be used to further refine the flood risk maps, or other hydraulic criteria, for the Georges River and other floodplains.
- Council to pursue compensatory measures to be undertaken by BAL/Commonwealth Government to mitigate the impact of various earthworks that have occurred at the Bankstown Airport site. Remedial measures are also required to address the impacts of earthworks that have occurred below the M5 Motorway bridge at Hammondville, and stockpiling activities on land adjacent to the river at Moorebank. These matters should be pursued with the owners or operators of these facilities.

10.1.3 Recommended Measures for all Floodplains

The most effective components of the floodplain risk management plan are a number of catchment-wide measures. These measures are expected to provide significant benefits over the full range of floods that can be anticipated within the catchment, and can be implemented at a relatively low cost. The catchment-wide measures that are recommended for inclusion in the Plan comprise:

- Adoption of consistent planning and development controls between the four councils, to be applied through a new flood risk management DCP. The application of sensible planning controls will ensure that the potential for flood damage does not increase in time, but actually reduces as flood-compatible redevelopment gradually takes place.

  Specific planning recommendations are outlined in the **Volume 2** report and summarised in **Section 9.7** of this report. They include the adoption of a graded set of planning controls for different land uses relative to different levels of flood risk within the study area through a flood risk management DCP; proposed amendments to the Georges River REP and each Council's LEP; and incorporation of notations upon Section 149 Certificates to identify the flood risk category up to the PMF event.
- Flood warning enhancements to make better use of the existing flood warning service provided by the Bureau of Meteorology for the Georges River. This involves the development of software to link flood warning predictions with the database of potentially flood liable properties that was developed during the current study. This will greatly assist SES operations during floods. An extension of this proposal is to provide individual residents with specific notification (eg affixed to meter boxes) on the critical gauge height that will inundate their home.
- Improved emergency management operations, including the update of SES Local Flood Plans with information available in this study and an evacuation strategy study to determine appropriate evacuation centres, numbers to be accommodated, evacuation routes and other evacuation methods.
- Improved public awareness of flooding. A flood aware community will be able to take steps to reduce flood damage and to minimise their own personal risk (eg by raising contents to higher levels and evacuating at an early stage). Councils' computer-based GIS systems should be updated with information from the flood

damages database developed during the study to facilitate the provision of flood advice to the community. It is also recommended that flood certificates are used as a means of providing information on flood risks, and these could be distributed on a regular basis. The construction of one or more flood markers is also recommended within the floodplain to indicate the levels of historic floods.

10.1.4 Measures Not Recommended

Several other floodplain management works were also investigated, but have not been recommended due to high capital costs, low economic benefits, and/or significant environmental issues associated with these proposals. Works that were considered, but not recommended include:

- a large flood mitigation dam in the upper catchment;
- dredging of the river; and
- a levee to protect the Milperra Industrial Estate.

10.2 FUNDING AND IMPLEMENTATION

10.2.1 Estimated Costs

The total cost of implementing the Georges River Floodplain Risk Management Plan is approximately $33.6M. This amount is dominated by the $30M that is estimated to be required for the completion of the Liverpool Voluntary Purchase Scheme at Moorebank.

The $30M for the Liverpool Voluntary Purchase Scheme is a high financial burden on both Liverpool Council and the State Government. The investigation of alternative self-funding initiatives, involving private sector development within the voluntary purchase area, has been recommended. If such initiatives are fruitful, then the total cost of the Georges River Floodplain Risk Management Plan will reduce to a much more modest $3.6M

10.2.2 Other Funding Sources

Apart from potential private sector funding, there are a variety of sources of funding that could be considered to implement the Plan. These include:

- State funding for flood risk management measures through the Department of Infrastructure, Planning and Natural Resources through the subsidised Flood Mitigation Program;
- Council funds;
- Section 94 contributions from future development where a nexus can be established between that development and flooding; and
- contributions from residents or businesses to fund measures from which they will benefit.

Councils can expect to receive the majority of financial assistance through the Department of Infrastructure, Planning and Natural Resources. These funds are available to implement measures that contribute to reducing existing flood problems.

Funding assistance is usually provided on a 2:1 basis (State:Council).

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Funding of investigation and design activities as well as any works and on-going programs such as voluntary purchase schemes is normally available.

10.2.3 The Next Steps

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

- the draft Georges River Floodplain Risk Management Study and Plan is placed on public exhibition by each of the four Councils;
- the Georges River Floodplain Management Committee reviews the comments and submissions received on the draft study and plan;
- any amendments considered necessary are made, and a final report prepared and submitted to each of the four Councils for adoption;
- each Council determines a program of works that are their responsibility, based on overall priority, available Council funds and any other constraints;
- each Council submits an application for funding assistance to the Department of Infrastructure, Planning and Natural Resources and negotiates other sources of funding;
- implementation of the Plan proceeds, as funds become available and in accordance with established priorities.

10.3 ON-GOING REVIEW OF PLAN

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

TABLE 10.1
Recommended Floodplain Management Measures

Report Section	Description	Estimated Cost	Potential Funding Sources	Principal Responsibility	Priority
8.1	**Liverpool Voluntary Purchase Scheme**				
	a) Investigate self-funding initiatives	$50,000	Council, DIPNR	Liverpool	High
	b) Purchase remaining 71 properties	$30,000,000	Council, DIPNR, Private Sector	Liverpool	Medium
8.2	**Bankstown Voluntary Purchase Scheme**				
	a) Purchase remaining 4 properties	$2,000,000	Council, DIPNR	Bankstown	Medium
8.4	**Kelso Levee**				
	a) Geotechnical review and minor crest adjustment	$50,000	Council, DIPNR	Bankstown	High
8.5	**East Hills Flood Mitigation Scheme**				
	a) Relocation/removal of 7 buildings	$1,200,000	Council, DIPNR, Owners	Bankstown	Medium
8.6	**Carinya Road Flood Mitigation Scheme**				
	a) Review existing scheme, including 2D model.	$30,000	Council, DIPNR	Bankstown	Medium
9.4	**Stormwater/Local Catchment Studies**	TBA	Council, DIPNR	All Councils	Medium
9.5	**Additional Flood Investigations**				
	a) Anzac Creek Flood Study (incl. survey)	$80,000	Council, DIPNR	Liverpool	High
	b) Airborne Laser Scanning	TBA	Council, DIPNR	Liverpool, Sutherl.	High
	c) Update Floodplain Risk Management Maps	$20,000	Council, DIPNR	All Councils	Medium
9.6	**Compensatory Development Measures**				
	a) Mitigation of fill on Bankstown Airport	N/A	Bankstown Airport Limited	All Councils	High
	b) Remove access track under M5 Motorway	N/A	Interlink Pty Ltd	Liverpool	High
	c) Activities at Moorebank	N/A	Owners/developers	Liverpool	Medium
9.7	**Consistent Planning & Development Controls**				
	a) Adoption of low/medium/high flood risk classification	Staff costs	Council	All Councils	High
	b) Adoption of Flood Risk Management DCP	Staff costs	Council	All Councils	High
	c) Remove inconsistencies in the GR REP and LEPs	Staff costs	Council	All Councils, StGovt	High
	d) Improve notations on S149 Certificates	Staff costs	Council	All Councils	High
9.8	**Flood Warning Enhancements**				
	a) Link flood warning prediction with property database	$20,000	Council, DIPNR, SES	SES	High
	b) Survey of floor levels	$80,000	Council, DIPNR, SES	SES	Low
	c) Advise residents with specific advice on prediction	$50,000	Council, DIPNR, SES	SES	Low
9.9	**Emergency Management Operations**				
	a) Update Local Flood Plans	Staff costs	Council, SES	SES	High
	b) Evacuation Strategy Study	$50,000	Council, DIPNR, SES	SES	High
9.10	**Improved Public Awareness**				
	a) Update Council's GIS databases	Staff costs	Council	All Councils	High
	b) Provide Flood Certificates	$20,000	Council, DIPNR	All Councils	Medium
	c) Flood markers to indicate levels of historic floods	$20,000	Council, DIPNR	All Councils	Medium

Total $33,670,000

FIGURE 10.1
RECOMMENDED FLOODPLAIN RISK MANAGEMENT PLAN

Consistent Planning Controls
- Adoption of Low/Medium/High Flood Risk Classification
- Application of a graded set of Planning Controls
- Adoption of Flood Risk Management DCP's
- Remove inconsistencies in the Georges River REP and Council LEP's
- Improve notations on S149 Certificates

Flood Warning Enhancements
- Review application of existing flood warning procedures
- Prepare GIS database to relate flood warning predictions to individual properties
- Provide residents with specific advice concerning prediction levels

Liverpool Voluntary Purchase Scheme
- Complete purchase of remaining 71 properties
- Investigate alternative, self funding initiatives

Compensatory Measures
- Pursue measures to mitigate impact of Airport fill with BAL

Bankstown Voluntary Purchase Scheme
- Complete purchase of remaining 4 properties

Anzac Creek Flood Study
- Detailed Flood Investigations

Remove Obstruction
- Removal of access track under M5 bridge at Hammondville

Kelso Levee Augmentation
- Geotechnical review and minor crest adjustment

Emergency Management Measures
- Update Local Flood Plans
- Formulate Evacuation Strategy
- Flood Warning Dissemination Study

East Hills Flood Mitigation
- Relocate/remove up to 7 buildings

Carinya Road Flood Mitigation
- Review existing scheme and planning provisions, including 2D model

Public Awareness
- Update Council GIS databases
- Provide Flood Certificates
- Construct Flood Markers indicating heights of historic floods

Stormwater Inundation
- Local drainage studies to define stormwater problems
- Formulate measures to reduce problems

Improved Survey Data & Mapping
- Airborne Laser Scanning or other survey
- Update Flood Risk Maps

N

0 0.5 1 1.5 2 km
Scale 1 : 50000

LEGEND
Probable Maximum Flood Extent

FAIRFIELD CITY COUNCIL
LANSVALE
LANSDOWNE
Liverpool Golf Course
Warwick Farm Racecourse
CHIPPING NORTON
GEORGES HALL
WARWICK FARM
LIVERPOOL
Riverwood Golf Course
Bankstown Airport
BANKSTOWN CITY COUNCIL
MILPERRA
MOOREBANK
LIVERPOOL SOUTH
CASULA
New Brighton Golf Course
East Hills Golf Course
HAMMONDVILLE
LIVERPOOL CITY COUNCIL
HOLSWORTHY
VOYAGER POINT
EAST HILLS
REVESBY
PADSTOW
PLEASURE POINT
PICNIC POINT
REVESBY HEIGHTS
PADSTOW HEIGHTS
SANDY POINT
ALFORDS POINT
OATLEY
LUGARNO
SUTHERLAND SHIRE COUNCIL
ILLAWONG
COMO

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Plot scale : 50 (a3@1:50000)
Date : 5 May 2003

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

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13 GLOSSARY

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

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

discharge	The rate of flow of water measured in terms of volume per unit time, for example, **cubic metres per second (m^3/s)**. Discharge is different from the speed or **velocity** of flow, which is a measure of how fast the water is moving.
DLWC	Department of Land and Water Conservation. Since May 1995, this is the new name for the Department of Water Resources (DWR), the Department of Conservation and Land Management (CALM) and flood sections of the Public Works Department (PWD). DLWC has been used in this report, except for work and/or studies carried out by these departments prior to May 1995.
DUAP	The former Department of Urban Affairs and Planning (NSW**)**. Previously the Department of Planning (NSW). Now called **Planning NSW.**
DWR	The former Department of Water Resources. This department became a major component of the Department of Land and Water Conservation (DLWC) in May 1995.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the *Local Government Act 1993*.
effective warning time	The time available after receiving advice of an impending **flood** and before the floodwaters prevent appropriate flood response actions being undertaken. The **effective warning time** is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	*Environmental Planning and Assessment Act, 1979*.
extreme flood	An estimate of the **probable maximum flood (PMF)**, which is the largest flood likely to occur.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a **flood**. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the **flood** described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as **Australian Height Datum** (eg the flood level was 7.8m AHD). Terms also used include **flood stage** and **water level**.

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

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

mm	millimetres. 1m = 1,000mm
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum **flow** or **discharge** during a flood.
Planning NSW	Formerly the **Department of Urban Affairs and Planning (NSW)** and the Department of Planning (NSW), at present DIPNR (since March 2003)
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**. The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
PWD	Public Works Department. Formerly the State Government Department responsible for floodplain management matters in tidal waterways.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route, and other relevant factors.
REP	Regional Environmental Plan. A plan prepared in accordance with the EP&A Act that provides objectives and controls for a region, or part of a region. For example, the Georges River REP.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	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.
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in **m/s** (metres per second). 10km/h = 2.7m/s.
water level	see **flood level**.
water surface profile	A graph showing the height of the **flood** (**flood stage**, **water level** or **flood level**) at any given location along a watercourse at a particular time.

APPENDIX A

CONSULTATION MATERIAL

Community Correspondence,
Community Questionnaires,
Issues Raised through the Questionnaires

Georges River Floodplain Management Committee

For more information:
Please visit the study web site at www.bewsher.com.au/georges.htm
or contact your Council liaison officer

14th October 2002

«BCC_Owners_Name»
«BCC_Address_Line_1»
«BCC_Address_Line_2»

Dear Sir/Madam,

Ref: Georges River Floodplain Management Study

The Georges River has created a beautiful environment, but the very nature of the landscape leaves it prone to flooding. The recent floods in Europe, which were much larger than most people had ever experienced, should remind us all of the importance of being prepared for such risks. Significant floods have also occurred on the Georges River in the 1980s, and in 1956, and much larger floods also occurred in the late 1800s.

Under the State Government's new Floodplain Management Manual, Councils now have a responsibility to manage land that could be potentially affected by all floods, up to what is known as the "probable maximum flood". A floodplain management study on the Georges River is currently underway, which will look at ways to manage the risk of flooding. **This letter has been sent to you because your property could be affected by flooding some time in the future.**

The Georges River Floodplain Management Committee is preparing this Study. The committee includes representatives from the State Emergency Service, Liverpool City Council, Fairfield City Council, Bankstown City Council, Sutherland Shire Council, Department of Land and Water Conservation, and a number of community representatives. Outcomes from the floodplain management study will include:

- improved public awareness of flooding;
- improved flood warning times and evacuation procedures, thereby ensuring better security for our residents;
- an assessment of the impacts of recent development on flood conditions;
- an investigation of measures to reduce the flood risk; and
- development of a strategic plan to manage the flood risk within the catchment.

The study will also categorise all land that could be at risk of flooding into three different flood risk areas (high, medium and low). Land above Council's previous standard (the 100 year flood), would generally be categorised as having a "low flood risk".

The Committee is now seeking the views of the community on how to manage land that may be subject to flooding. This is your opportunity to participate in the study. If you would like further information, or would like to complete a questionnaire or attend one of several workshops planned to commence in late November, please fill out the attached form and return it in the enclosed envelope (no stamp is required). The workshops will be held in local centres and will provide you with an opportunity to have your say as the study progresses.

I have also attached a "FloodSafe" brochure for your information. Finally, if you have any questions, please contact me on 9707-9890.

Yours faithfully

Martin Beveridge
Georges River Floodplain Management Committee
(Bankstown Council Liaison Officer)

Georges River Floodplain Management Study

For more information:
Please visit the study web site at www.bewsher.com.au/georges.htm
or contact your Council liaison officer

Please complete this form and return it to your local Council by Friday 1 November. A Reply Paid Envelope has been provided.

All information provided will remain confidential, and only used for the purpose of this study.

	Please tick (Yes or No)	
Would you like to be included on the mailing list for the study? We can then send you further information as the study progresses.	❑ **Yes**	❑ **No**
Would you like to be sent a Questionnaire? This will provide us with information about your flood experiences, your views on floodplain management measures, and other issues that you feel are important.	❑ **Yes**	❑ **No**
Would you like to participate in a workshop? The workshops are scheduled to commence in late November. They will provide more information about the study and allow you to have your say in the floodplain management plan that is prepared.	❑ **Yes**	❑ **No**
Are there any issues that you would like the study to consider? Please provide your comments below, or provide your contact details so we may call you.	❑ **Yes**	❑ **No**

Other Comments

Contact Details *(Please complete if you answered yes to any of the above)*

Name: _____

Address: _____

_____

Telephone Business: _____ Home: _____

Thank you for your participation in this study

For more information:
Please visit the study web site at www.bewsher.com.au/georges.htm
or contact your Council liaison officer

6th December 2002

«Name»
«Other_Name_Organisation_etc»
«Street_Address»
«Suburb»

Dear Sir/Madam,

Ref: Georges River Floodplain Management Study

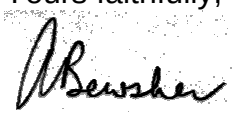
Thank you for your interest in the Georges River Floodplain Management Study, and for taking the time to complete the response form that was distributed to residents in late October. We are now pleased to enclose a copy of the Study Questionnaire, which you requested.

The questionnaire will provide us with information on your flood experience and your attitudes to the types of controls Council should consider for development. The questionnaire also provides a range of measures that could be considered to minimise the effects of flooding from the Georges River. Your opinions on these measures, and any other measure you think should be considered, will greatly assist our study. Please feel free to also raise any other issues or concerns that you would like the study to address.

We would appreciate it if you could complete the questionnaire and return it to us in the reply paid envelope by Friday 20th December. Please note that no postage stamp is required.

Again, thank you for your interest in the study. We look forward to receiving your views on the study through the questionnaire.

Yours faithfully,



Drew Bewsher
Georges River Floodplain Management Committee
(Bewsher Consulting)

GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY

IMPORTANT COMMUNITY QUESTIONNAIRE FOR RESIDENTS AND BUSINESSES

ARE YOU "FLOOD READY"?

What if a very large flood, like those that struck the Georges River more than 100 years ago, happened tomorrow? Rather than 'if', it is 'when' a big flood like this happens again. Are you "Flood Ready"? There would be many of you who have not experienced a 'big flood'. Would you know WHAT to do, WHERE to go and WHO to contact? This will be one the key issues of the **Georges River Floodplain Risk Management Study**, currently being undertaken jointly by Sutherland Shire, Bankstown, Fairfield and Liverpool Councils.

This questionnaire will help us determine the flood issues that are important to you. If you have a residential property near the Georges River, please complete Parts A to F. If you have a business property, please complete Parts A to G.

Please place your completed questionnaire in the postage paid envelope provided and return it before FRIDAY 20 DECEMBER 2002

No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is: **Reply Paid Permit Number 32**
GEORGES RIVER FLOOD QUESTIONNAIRE
Bewsher Consulting Pty Ltd
P.O. Box 352, Epping NSW 1710

Your Address (optional) _____

Name of Business/Organisation (if applicable) _____

PART A — YOUR FLOOD READINESS

1. Do you think your property could be flooded sometime in the future?

a. No 29% b. Yes 63%

Could you please supply some details below:

_____

Details provided for 71% of respondents

_____

_____

2. What information about flooding have you received about the property?
(Tick one or more boxes)

a.	No information whatsoever	33%
b.	General advice from Council	38%
c.	Flood levels from Council	22%
d.	Viewed a Council Planning Certificate	10%
e.	Information from Real Estate Agent	7%
f.	Information from relatives, neighbours, friends or the previous owner	16%
g.	Experienced flood myself	29%
h.	Other (please specify _____)	2%

3. Where would you expect to get information about what was happening if you thought a big flood was imminent (eg. what roads were cut, how high the flood might go, whether you needed to evacuate, etc.)?

a.	Door knock by Police or SES etc.	68%
b.	Phone hotline	30%
c.	Internet	10%
d.	Radio	71%
e.	TV	32%
f.	Neighbours, relatives, friends, etc.	20%
g.	Other (please specify _____)	3%

PART B — YOUR FLOOD EXPERIENCE

4. Have you ever experienced a flood at the property?

a. No 62% (go to Part C) b. Yes 34%

If yes, which floods?

c.	June 1991	19%
d.	April 1988	26%
e.	August 1986	22%
f.	June 1964	5%
g.	November 1961	4%
h.	February 1956	5%
i.	Other (please specify _____)	5%

5. In the biggest flood you have experienced, was the property flooded above floor level of the main residence?

a. No 43% b. Yes 8%

If yes, what was the depth of water over the floor? 0.79m average

What year? _____

6. In this biggest flood, what was the maximum depth of water over your grounds? (as best you can remember) 1.04m average

What year? _____

7. In this biggest flood, what was the actual warning time you received to take action to prevent possible flood damage?

a. Less than half an hour 10%
b. Half an hour to 2 hours 7%
c. 2 hours to 6 hours 11%
d. More than 6 hours 5%
If more than 6 hours, how long? 15 hrs

8. In this biggest flood where did you hear the flood warning? (Tick one or more boxes)

a. No warning whatsoever 14%
b. Witnessed with own eyes 26%
c. Police 3%
d. State Emergency Service (SES) 6%
e. Local radio 15%
f. TV 12%
g. Neighbours, relatives or friends 8%
h. Other (source _____) 1%

PART C
YOUR ATTITUDES TO COUNCIL'S CONTROLS ON DEVELOPMENT

9. Please rank the following development types according to which you think are the most important to protect from floods (1=highest priority to 7=least priority)

a. Commercial or industrial 4
b. Residential 1
c. Essential community facilities 3
d. Critical utilities 2
e. Minor development and additions 6
f. Recreation or agricultural land 7
g. New residential subdivisions 5

10. What level of control do you consider Council should place on new development to minimise flood-related risks? (Tick only one box please)

a. Prohibit all new development on land with any potential to flood. 29%
b. Prohibit all new development only in those locations where it would be extremely hazardous to people and property. 38%
c. Place restrictions on development such as minimum floor levels and/or the use of flood compatible building materials. 34%
d. Advise of the flood risks, and allow people to choose how they would reduce flood damage. 13%
e. Provide no advice regarding the potential to flood nor of the measures that could minimise potential flood risk. 0%

11. What notifications do you consider Council should give about the potential flood affectation of individual properties?
(Tick one or more boxes)

a. Advise every resident and property owner on a regular basis of the known potential threat. 70%
b. Advise only those who enquire to Council about the known potential flood threat. 15%
c. Advise prospective purchasers of property of the known potential flood threat. 52%

PART D
YOUR OPINIONS ON FLOODPLAIN RISK MANAGEMENT MEASURES

12. What floodplain risk management measures are most important to you?

Please list your 5 most favoured options in order. You can choose from the list provided in Question 14 or you can include your own options. (No.1 is your highest priority)

1. Dredge the river
2. Review/maintain existing flood mitigation work
3. Construct upstream dam(s)
4. Maintenance programs/clear unnecessary veg
5. Construct permanent levees

Please list your 5 least favoured options in order. (No.1 is your least favoured option)

1. Dredge the river
2. Enlarge bridges
3. Construct permanent levees
4. Flood proofing individual properties
5. Accelerate Voluntary Purchase Scheme

13. Are you aware of any flood mitigation measures that affect you and would reduce your flood risk should a big flood occur?
(Tick one or more boxes)

a. Not aware of any measures 61%
b. House built at minimum floor level 19%
c. House raised 12%
d. Flood compatible building materials 5%
e. Area has finger or deflector levees 6%
f. Area 'protected' by levees 7%
g. Channel capacity has been enlarged 10%
h. Known evacuation route 10%
i. Other (please specify _____) 4%

Have you received any information about these measures?

a. No 71% Yes 14%

If yes, what information did you receive and who was it from? What you know about these measures? How do they affect you? Do you think they are adequate?.

_____

_____

_____

Please use the space at the end of this questionnaire if more space is required.

14. Below is a list of possible options that may be looked at to try to minimise the effects of flooding from the Georges River.

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes" or "no" to indicate whether you favour the option and think it should be investigated in detail. Please leave blank if undecided.

		Yes	No
	Measures that modify the way a flood behaves		
a.	Increase capacity of bridge crossings	35%	36%
b.	Dredge the river to increase capacity	62%	23%
c.	Maintenance programs to clear river of unnecessary vegetation.	74%	11%
d.	Review/maintain existing flood mitigation works.	86%	1%
e.	Construct upstream dams/basins to temporarily store floodwaters.	62%	18%
f.	Construct permanent levees.	52%	25%
	Measures that modify properties		
g.	Accelerate the current voluntary purchase schemes in Moorebank and Milperra	46%	27%
h.	Identify other areas where Council could offer to purchase the most severely flood-affected properties.	56%	20%
i.	Provide funding or subsidies to raise houses above 100 year flood level.	48%	31%
j.	Flood proof individual properties eg. by waterproofing walls, installing shutters	29%	43%
	Measures that control building and development		
k.	Ensure controls on future development in flood-liable areas (eg. minimum floor levels, controls on extent of filling allowed etc)	78%	7%
l.	Prohibit subdivision of properties within the floodplain	61%	23%
m.	Prohibit all rezoning for new development within the floodplain.	58%	23%
	Measures that provide more information about flooding		
n.	Improve flood warning both before and during a flood.	87%	2%
o.	Improve evacuation and emergency assistance plans.	77%	6%
p.	Community education, participation and flood awareness programs.	73%	8%
q.	Ensure all information about the potential risks of flooding is available to residents and business owners.	84%	3%
r.	Provide a certificate to all residents stating whether their property is flood affected and to what extent.	70%	11%
s.	Making sure residents and business owners have a Flood Action Plan that outlines WHAT to do, WHERE to go and WHO to contact in a flood.	76%	6%
t.	Install flood markers (eg. on power poles) to act as reminders of heights of previous floods.	70%	11%

PART E — ABOUT YOUR PROPERTY

15. What is your property?

a.	House	93%
b.	Business	5%
c.	Villa/Townhouse	1%
d.	Unit/Flat/Apartment	0%
e.	Vacant land	0%
f.	Other (type _____)	2%

16. What is the residential status of the property?

a.	Residential Owner	93%
b.	Owner-operated business	3%
c.	Residential Tenant	1%
d.	Tenant operated business	0%
e.	Other (please specify _____)	1%

17. How long have you owned, lived at or conducted business at this property?

average = 20 years

18. If you are a resident, how many people normally reside in your house?

average = 3.0 people

19. Do you expect to undertake any further development on your land in the future?

a.	None	65%
b.	Minor extensions/alterations	26%
c.	New dwelling	5%
d.	Dual occupancy (granny flat)	3%
e.	Subdivision	2%
f.	Other (please specify _____)	1%

20. Have you undertaken any steps to obtain approvals for further development on your land?

a.	No	87%
b.	Made preliminary enquiries with Council	3%
c.	Engaged someone to prepare plans	1%
d.	Lodged plans with Council	1%
e.	Have approved plans but not proceeded	3%

PART F — OTHER INFORMATION

21. How would you like to become more involved in this project? (Tick one or more boxes)

a. Please put me on your mailing list 86%
b. Please contact me for a phone interview 18%
c. I am interested in attending a meeting of Council's Floodplain Risk Management Committee 31%
d. I am interested in attending one of the public workshops to be held later in the study to consider options for my area 43%

22. How do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? (Tick one or more boxes)

a. Council's website 24%
b. Articles in local newspaper 72%
c. Open days or drop-in days 22%
d. Community workshops 25%
e. Public meetings 34%
f. At formal Council meetings 9%
g. Through Council's Floodplain Risk Management Committee 40%
h. Other (please specify _____) 14%

23. Do you have any information relating to the location of threatened species (plants and animals) in your local area?

a. No 90% b. Yes 3%

If yes, could you please provide details at the end of this questionnaire about the type of information you have and how we can contact you.

24. Please provide more information here if required. More space is available on the back of Part G 'Supplementary Questions for Businesses' or please attach a separate sheet.

_____
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25. If you ticked any of the boxes where you would like us to contact you, please provide your details below:

Name: _____
Address: _____
_____
Phone (Home) _____
Best time to call is _____
Phone (Work) _____
Best time to call is _____
Fax No. _____
Email: _____

Are you a member of any local community group? If yes, please specify:

_____

For additional questionnaires or further information about the Georges River Floodplain Risk Management Study, please visit our web site at:

www.bewsher.com.au/georges.htm

or contact one of the following:

Bewsher Consulting Pty Ltd
John Maddocks
Phone: 9868-1966

Sutherland Shire Council
Guy Amos
Phone: 9710-0857

Bankstown City Council
Martin Beveridge
Phone: 9707-9920

Fairfield City Council
Nilmini De Silva
Phone: 9725-0881

Liverpool City Council
Arvind Lal
Phone: 9821-9381

Thank you for being part of this study

PART G — SUPPLEMENTARY QUESTIONS FOR BUSINESSES

Please complete this part only if you operate a business from this property.

25. Name of Business:

_____

_____

26. Which of the following best describes the type of building you operate your business from?
(Tick one or more boxes)

a. Industrial unit in larger complex ❑
b. Stand alone factory ❑
c. Stand alone warehouse ❑
d. Shop ❑
e. Office ❑
f. Education ❑
g. Club ❑
h. Community building ❑
i. Other ❑
If other, please specify _____

27. What is the approximate floor area of these premises? _____m^2

28. How many employees are there normally working at your premises?

a. 1–5 ❑
b. 5–10 ❑
c. 10–20 ❑
d. More than 20 (_____ employees) ❑

If you have not experienced a flood at this property, please go to Part F.

29. In the biggest flood, what action did you take to protect your property against flood damage?

a. Took no action ❑
b. Moved vehicles ❑
c. Lifted carpet, stock, equipment ❑
d. Used sandbags to try to prevent water entering the premises ❑
e. Other action ❑
If other, please specify: _____

30. In the biggest flood, was your business or facility closed or disrupted in any way (including any clean up)?

a. No ❑ b. Yes ❑

If yes, for how long was your business or facility closed or disrupted?

c. Less than 1 day ❑
d. 1 to 2 days ❑
e. 2 days to 1 week ❑
f. More than 1 week ❑

31. During the biggest flood, were your premises flooded above the floor level of the main work area?

a. No ❑ b. Yes ❑
If yes, what was the depth of the water over the floor? _____

32. During the biggest flood, did floodwaters damage any of the following?
(Tick one or more boxes)

a. No damage occurred ❑
b. Vehicles ❑
c. Electrical equipment, machinery, tools ❑
d. Stock and other goods ❑
e. Carpet, furniture, fittings and/or office equipment ❑
f. Your premises (paint, structurally, etc.) ❑
g. Other part of your property ❑
If other, please specify _____

33. During the biggest flood, what was the approximate cost to you (at the time) from the damage caused by the flood?

$_____

34. As a result of the biggest flood, did any of the following happen to you or any of your staff during or after the flood? (Tick one or more boxes)

a. No problems experienced ❑
b. Inconvenience or disruption to normal routine ❑
c. Isolation (blocked by floodwaters) ❑
d. Employees unable to come to work ❑
e. Loss of business trade ❑
f. Experienced general ill-health ❑
g. Higher employee absenteeism ❑
h. Higher insurance premiums ❑
i. Considered selling/moving the business ❑

PLEASE USE THIS SHEET FOR MORE COMMENTS IF REQUIRED

TABLE A1
Issues Raised from Short Questionnaire

ID	Issue Raised
Bankstown	
B4	Study should address the determination of flood risk categorisation and available flood warning time.
B14	Blocked drains, Property runoff.
B20	Concern over bank erosion of private property, which is reportedly due to waves from boats that use the river. No one is prepared to fund or undertake bank protection works on private property.
B30	Pollution during floods or otherwise.
B32	A study of the effect of flooding on the sewerage system, electrical supply, and phone service would be useful. Back-up generators could be considered. The relevant authorities could be invited for input to the study.
B33	The clearing of street drains so in a sudden downpour the streets don't flood.
B36	Traffic management & property access guidelines.
B37	What, if any, work is being done to involve insurance companies - to enable them to assess or cover flood risks?
B39	Clearing of rubbish that is dumped into the river or is washed in during high tides. Dredging of the river.
B40	Concern that Council permits solid fences, which stop the natural flow of water in a flood area, causing flooding to other houses.
B43	Post flood clean-up assistance.
B45	Would like to know how high Saltpan Creek can rise in a flood.
B47	Would like to know the location of appropriate response centres to contact in the event of flooding. Where are the nearest centres for each Council ward in Panania/East Hills?
B49	Effect on houses (new and old) - Is building allowed? What about new residential buildings?
B51	Dredge the river. Investigate the flood levee at Kelso and new development behind the levee. Concerned about the impact of the levee on flood levels and whether there is entitlement to compensation should flooding be caused by the levee.
B57	Would like to know the percentage of impervious developed area of catchment in 1873, 1986 & 1988. Concerned that development has and will increase flooding.
B62	Would like to know the maximum height that floodwater can reach and whether house raising is a practical solution.
B63	Smell and visual pollution from sewer pipe outlet into Little Salt Pan Creek from Main Sewer Line.
B65	The implementation of appropriate civil engineering works to eliminate/minimise risk.
B66	Concerned about how the study will affect their property, in particular their property value. Also concerned that a larger area of land is now affected by floodwater, despite much previous work being undertaken.
B67	What provision, if any, can be made to remove & store furniture.
B72	Current & future sewerage outflows, and plans to preserve and improve fishing health in the river.
B80	Management/Maintenance of drainage systems, especially between properties and Bankstown Golf Course.
B81	Approvals for development and building (and also drainage works) outside the flood area which impact on properties downstream. Lack of maintenance and clearing of drain, canals and creeks downstream from developed areas which results in floodwater backing up in developed areas.
B86	The effect of development at Bankstown airport - both proposed and completed - and how this will affect flood levels in commercial and residential districts nearby.
B89	Clean up of Mangroves as the over-population has congested the water.
B93	The impact of the growth of mangroves in the river systems on build up of silt and subsequent flooding.
B96	Impact of higher density housing, eg dual occupancies and townhouses or villa developments.
B97	Is there a working model of the flood plan program? How effective is the current flood mitigation program?
B101	My husband and his farther were flood wardens in the 1956 flood at Georges Hall. Hanley Street was severely affected and Council bought all the houses (Garrisons Point). We moved our house to a higher point within our property.

ID	Issue Raised
B120	Alternative evacuation procedures other than by road.
B122	I have lived in Milperra for 32 years and I do not see a great improvement in the river water quality. River banks are not cleared on a regular basis - more maintenance could be carried out during drought times.
B123	Most concerned that Council can change the natural fall of the land by building up area around Killara Ave (Park), thus stopping natural runoff to river. This area has flooded previously and should the occasion arise again, natural flow would be impeded substantially.
B126	Clean out creek under Killara Ave so water can escape quicker.
B128	Concerned about drainage system at back of property. Her neighbour has built a 2 storey home resulting in water running onto her property.
B129	Restrictions on government bodies with land fill to allow further development where once floodwater flowed. Floodwater has now been redirected elsewhere, affecting other properties that were previously OK.
B130	Saltpan Creek should be dredged out, made wider and mangroves cleared. The creek has been spoiled with sludge. At one time you could catch prawns in it and it had the best green weed, but it has all been spoiled.
B138	Survey showed that one small corner of this property was affected by the 100 year flood. We have lived here for 30 years and this street has never flooded. We believe that the flooding notation should be removed from this property.
B139	The explosion of multi-development on single blocks and particularly the town houses built on the old dog track in Horsley Road, Panania. The impact on flooding was the main reason local residents were so against the development.
B140	Earthworks need to be done on the northern side of Milperra Road to protect the properties on the northern side of Milperra Road.
B143	All rivers need to be cleared of debris that may block flows. Flooding can also be caused by uncleared gutters.
B144	Removal of silt on a regular basis from Lucas Drain to prevent flooding in minor situations.
B145	Concern that Lucas Drain is not cleared of silt on a regular basis. As a result, heavy rain frequently results in flooding problems. Particular problem area is near the culvert under Henry Lawson Drive, which is an eyesore and a health risk.
B146	Many residents at Carinya Rd use the Reserve as the access to their property, even though Council has requested access is to be from Carinya Rd. This situation is not only bad for the Reserve but could be a considerable problem should there be a flood. In 1986 trees fell across the roads cutting off access roads. Cars were left stranded and required emergency services.
B148	Removal of Debris after Floods & High Tides
B160	Flooding problems on Little Salt Pan Creek, on road from No.59 Virginius Street to end of street. Has flooded once in 30 years and close to flooding on a number of other occasions.
B169	Witnessed the 1986 flood at East Hills. The grounds of Kelso Park have since been raised and no further flooding has occurred.
B177	I think it is a good idea to develop this kind of study, so residents can be prepared. I would be interested in knowing more about the river.
B178	We have recently moved to this address and were aware that we are in the 100 year flood zone. Would appreciate any updated information on the ongoing management of this beautiful area.
B180	Study is a waste of money. Money should be used to plant trees along Rabaul Road to make it look more suburban.
B182	Lived at this address for more than 53 years and have not experienced a flood on this property since 1946.
B185	Enquiry concerning the status of levees that were proposed along the river following a management plan prepared after the 1956 flood.
B189	Would like the study to consider dredging of the river.
B193	Received a Letter from BCC that their property was not flood prone.
B194	Home in Iberia St, Padstow is classed as flood prone. Major drainage reconstruction took place in 1994, and a subsequent study recommended the lifting of the flood zone. All results lost in the Council fire. Would like to see Iberia street rezoned.
B196	I would like to know what effect the works in Amaroo Reserve are likely to have on any flood situation.
B197	All property owners should be advised of evacuation centres. Need to plan where we will need to go.
B208	Would be helpful if the maximum extent of flooding were overlaid on relevant street directory maps and provided to residents.
B209	Very concerned with further development of Bankstown Airport, which would have an impact on flooding. Also increased density of new houses being built. Also reluctance of Council to clean and cut back local bushland.

ID	Issue Raised
B210	Concern over impacts of global warming and rising ocean and river levels on natural flooding.
B211	1988 flood rose 2.1m above the high water mark, and my waterfront land and boatshed at Picnic Point were badly affected. The water would need to rise another 2.6m above that level to affect this residence and property.
B215	Evacuation Procedures, exits roads, effects of University grounds on possible flooding.
B219	What future development is Council planning at the old Bankstown tip area? Would like more information on proposals for this area.
B226	Wildlife concerns during flooding.
B233	Impact on drainage caused by leaves and branches blocking drains
B234	Feels that it is unlikely that this property could be affected by flooding. Is there any information available showing the extent of the 100 year flood?
B236	I have been a resident of the area for over 50 years, including my involvement in the 1956 floods. I feel I could contribute to the study and would like to be involved.
B237	Flooding is always a concern in these areas and I would be interested in participating or assisting in such a study.
B240	Some information on the likelihood of a flood occurring to break the current drought.
B250	Redevelopment of Bankstown airport & effect on flooding. Also change in land use of golf courses close to the river and possible increase in flood problems.
B259	Main problem is access. Employees are unable to get to work in moderate rain, which impacts on business. Other problems include backing up of water in the canals that feed into the Georges River.
B267	Deepening and/or widening the Georges river and its feeder streams where silt has built up due to man made structures (such as the road bridge on Henry Lawson Drive over Salt Pan Creek. Another problem area is at Deadmans Creek where it joins the Georges River.
B273	The study needs to consider the impact on persons already living in areas designated as flood prone - their amenity, investment and lifestyle - and their ability to make decisions about their lifestyle and property without undue beaurocratic influence.
B274	Concern over land filling operations in the area. Widen the river in narrow areas.
B276	Can be flooded by both the Georges River and from runoff that is trapped by the park at the western end of Lawson Street and diverted into private property. This has happened on two occasions. Suspect there is no drainage from the park to the river.
B277	Concerned that the East Hills footbridge has not been repaired/replaced. Would like to know when it will be opened.
B278	Would like to know statistics or estimates on how high the 100 year flood could get.
B283	Would like to participate in any activity to help the neighbourhood and help save our home.
B286	Concern over access from property being cut by the creek that flows through the front of the property. The neighbouring property has been filled to alleviate the problem, but Council will not permit filling of this property.
B292	The provision of adequate sewerage and drainage; as it appears that every house that is pulled down is replaced by 2 or 3 new ones. Also problem with stormwater drainage almost flooding this house.
B305	I don't consider my property as flood prone and hope it is not classes as such if I wish to sell.
B306	Stores Chemicals on site what to do.
B307	Concerns about the creek at Auld Ave
B310	Keep the Georges River free of pollutants, especially from Industry.
B319	Believe that business has come first over resident's safety. Development at Bankstown Airport (KFC, Tacobell & Burger King) has resulted in land being raised above surrounding residential land at Milperra, which will increase flood problems. It will be too late for Council to take action when there is a lot of rain. Council needs to take notice now. Why isn't anything being done about the development?
B320	Believe that this property is above any flood level.
B323	Build more dams and canals for the main water to run into.
B328	Concerned over impact of levee around Bankstown Golf Course and Kelso Park, and the filling of land opposite the airport on Milperra Road. All these measures will divert floodwaters to residential areas instead of over golf courses, open areas, etc. Also concerned over the issue of flood maps that could lead to devaluation of properties.

ID	Issue Raised
Liverpool	
L4	Flood levels in Bent Street raised in new sub-division, drainage problems
L10	Land fill in Voyager Point, new release of land and the use of land fill in new development
L12	Development Controls on flood prone land, Flood prone land should be recreation areas, residents need training for emergency evacuation.
L15	Flood mitigation methods
L22	Flood water removal
L24	Support from the Council to clean up the banks of the river
L26	Development along the river - older areas
L36	Best management practices for run-off from new developments.
L40	Impact of Hammondville Sports Fields on the area.
L42	Closure of Milperra and Newbridge Roads.
L45	Water heights are the sewerage, electricity, phone cut and access roads.
L46	Residential development upstream – Bringelly? What effects will stormwater have?
L48	What precautions are put in place for local flooding?
L51	Efficient management of access to waterways
L54	New Development, run off and flooding due to new development replacing open parklands and green space.
L55	Immediate response and direction by people on the ground who have been given authority to deal with it.
L56	Interested in how to help keep the river clean and healthy and free of rubbish.
L57	Council responsibility; changes to natural levels of land on the river flats where there are now residents.
L63	Vulnerability of transport links, details to residents of flood depths, duration and flow velocities, changes in flood patterns and catchment
L65	Regenerate flood plain areas rather than building.
L71	The provision of a map which shows high, medium and low risk areas along the river - to each property that is affected.
L72	Local flooding - stormwater drains not cleared of rubbish - people not keeping drains and gutters clear.
L74	Removing 100 year flood restriction on our land.
L75	What are the possibilities of a major flood in the next 5-10 years? What strategies are in place for the outlet roads eg. Governor Macquarie Drive; Riverside Road; and Barry Road, all of which are in drastic disrepair.
L77	Sand bagging strategy. Better mapping of real (1 in 50) with reference to 86 and 88 flood levels (1 in 100). Preparing your belongings could include 200L garbage tie bags for clothes, books etc.
L78	I am interested in revegetation of reserves with a limited number of suitable trees to back up the very old trees close to the bank.
L79	I have had no flood experiences directly, but I am interested to find out more about the Chipping Norton Lakes & Georges River and its water quality and projects that may be also underway.
L82	Concerned about the filling of creek beds or similar, for developments which could lead to a problem for existing housing which is currently above 100 year flooding - but within possible flooding levels which puts this level of housing at increased risk.
L83	Incentive to make homes safer upgrading of drainage systems.
L85	Where Anzac Creek goes under M5 & Heathcote Road in a moderate storm the water backs up.
L86	The 1986 flood at East Hills was for a short duration. Was it caused because of the choking affect of the river plain downstream near Carinya Ave? After a prior flood the people living there managed to have lesser block fences and earth brought in to make
L87	I have lived in Liverpool since 1940 and have experienced periodic floods since then. 1956 was the worst. Albert Childs Mayor of Liverpool in 1940 took me around Moorebank Chipping Norton other areas including the old tip (now called Lighthorse Park).
L88	I would like to talk to somebody regarding the parkland at the western end of Riverside Road at Chipping Norton, which has not been opened and has mounds of dirt and weeds growing in the park.
L92	Consideration of the damming of the Georges River at Georges Hall, with a view to having a fresh water lake in the metropolitan area for Liverpool Fairfield/Bankstown Councils usage, ie, gardens etc.

ID	Issue Raised
L93	Likely water level at each suburb (on street, house) in the event of 'very rare flood' a detailed evacuation plan, drill (?) Impact study on house prices in flood affected areas.
L94	Please it is necessary to indicate a height to the area you have indicated in your regional map as compared to your 1956 flood level. It would be an idea to install a height-gauge on say a few spots an Governor Macquarie Drive or a comparison to the 1956
L103	I have photos of the floods mentioned and at one time I was a dredge operator on the Georges River working for T Gal Ex Mayor Liverpool when the floods took all our lines and reached up almost Newbridge Road from Epsom Road.
L104	I would like to know when a workshop will be (weekday / weeknight etc) and whether sign language interpreter for the deaf can be provided.
L105	If there is ever a flood in the Chipping Norton area, why hasn't Liverpool Council widened Governor Macquarie Drive, to accommodate the extra traffic that would be generated when residents evacuate??? There is plenty of land to do this and there is very l
L125	With the very serious risk of bush fires destroying homes this summer perhaps it would have been appropriate to include information covering that topic.
L129	Will it affect land valuations?
L135	The choking effect of the box drains which are in the creek to the west of our property with particular notice being taken of the box drains which pass under the M5 Motorway. It has been my experience in recent downpours that the drains do not cope with
L141	Williams Creek flooding at Voyager Point.
L145	Does the water retention system (reserve) on the corner of Yachtsmans Drive and Frank Oliveri Drive make any difference to the drainage of Chipping Norton's Lakeside estate? We were told when we purchased the land that it would.
L149	I would like the Harris Creek near Holsworthy train station to be dug out throughout the length of the creek. Beginning from its mouth, the Georges River at Voyager Point so that it becomes a nice flowing creek instead of what it is a the moment - stagnant
L151	Impact upon insurance as a result (potential) of find of study.
L152	Trees are our main concern, we built our home back in 1980 when this area was just starting up we were told that it was going to be the gate way to Liverpool, with landscaping on the nature strip opposite. The nature strip has been planted with Gum trees
L156	Probably of a selfish nature: "What particular management work is being considered or carried out in the Chipping Norton area!"
L159	Recent floods in Europe were an abnormal situation. No one can prepare for that. Georges River floods quite regularly and the water levels and their impact on the area are well documented. Some 20 years ago I did attend a flood demonstration, at Manly
L161	Keep me informed of the proposed developments. Good Stuff!!
L163	Would like to see AHD (Australian Height Data) or dive in one hundred flood levels marked in every street so that people are able to access their property's and street's exposure to flood levels.
L165	Preventing rubbish going into drains and rivers that can increase severity of flooding.
L172	Have the flood levels of 1 in 100 years, 1 in 20 years etc. changed in the last 10 to 20 years? Will these levels be effected now that sand dredging has stopped in the river at Chipping Norton?
L174	Insurance coverage? How impact could be minimised? Readiness of the SES to deal with flooding?
L178	The amount of new development and drainage into the river since 1986. How this would effect water flows when the river is in flood. Because flooding last time did not come from the river but up through the drains in to the streets.
L184	The clearing on a regular basis of stormwater drains to prevent road flooding.
L185	Basically I would like to know the current flood risk for my street and to what level the water could reach as a maximum, as current Council regulations are to build .05m above sea level.
L187	The study should consider the impact, if any on "classification" and its influence on insurance companies and their policies in respect to flooding.
L188	We own property in Chipping Norton and Pleasure Point.
L195	Planning is required to identify "safe areas" within the flood zone where livestock and goods might be stored dry and safe. Affected local residents and businesses would have access when flood warnings are issued, eg furniture, horses etc
L201	I am older and lived at Flinders Road, Georges Hall from late 1937, for 28 years. Have lived in Warwick Farm and Chipping Norton for the past 30 years so, have experienced a few of the Georges River floods. Maybe I can give some help.
L204	Cleaning up of the Georges River foreshores, in the upper end of river in Chipping Norton area. If someone travels by boat up river, it will be obvious, if this is not this committees job please advise the correct parties.

ID	Issue Raised
L212	We are planning to build shortly. Is there a way that the height restriction of a flood affected property can be raised so that the house can be built with a higher ground level?
L215	Council stormwater drains are congested with rubbish, promoting water retention. Council constructed a footpath on the eastern side of Ernie Smith Reserve, no drainage or runoff. This allows water to "pond" between the houses in Gall Crescent and the foot
L216	What the chances are of the flood effecting us?
L217	I would specifically like to know whether my street is considered flood prone given that the 1873 flood (on the map) looks as though it covered the area now occupied by the suburb of Wattle Grove.
L221	Environmental impact measures to reduce flood risk may have.
L223	The drains on Newbridge Road opposite Flower Power don't seem to cope with excess water.
L226	We are particularly interested in how Council plans to reduce the risk of flooding is this to include improved drainage systems, building up riverbanks, retaining walls etc.
L229	How has recent development of land between Chippenham and Ascot Drive affected water run off and build up of water to surrounding houses? Ie there was a 5 metre valley stretching for the length of Chippenham and width of being the length of Bent Street.
L232	During rain periods some yards of houses in this street have problems with drainage from back up through drains in the street. Ring Council and they don't come near your for 3 weeks after the rain has subsided.
L239	Do you have a map which shows the worst case scenario superimposed on the Gregory's style street maps? Are the mounds of earth, in the reserve east of the WM Long Bridge?
L244	Just, the 1986 flood came within 50 yards from my house, in Greenwood Close, Hammondville. I took a video of duck swimming at the end of my block.
L247	We are concerned about runoff from new subdivisions and the large lot of land between Pleasure Point Road and Voyager Point (ex bushland)
L249	I think some study should be done on the dredging of Clinches Pond to remove all the bark and wood chips that the Council let be washed into it. I think this could be a factor in flood time.
L251	How we can prevent / divert impact?
L268	In the event of my home being listed as flood prone. Where do I stand in regard to future insurance coverage.
L270	If there are previous flood level records available, maybe those figures can be plotted as a graph to make people aware that what potential flood risk is around this area.
L271	Are people discouraged by Council to purchase our homes?
L273	Progress on clearing of houses at Milperra Bridge. I know this well overdue however I am sending in case you have not finalised workshops etc. I have been resident a Charlton Avenue since 1976. Have seen a few floods.
Fairfield	
F1	Not only flooding caused by the rising of The Georges River but also run off from housing as back in 1873 there would not have been the housing that is around today
F2	I would like to take part in the workshop or at least be kept informed. My availability due to work commitment is a problem. I have been a resident in Lansvale since 1990. The beautification the parkland and better boat launching facilities for local fisherman. Ie a new wider boat ramp. Our parkland and water access compared to the Chipping Norton side is disgusting. Pollution is also a factor to be considered socks must be placed on all discharge points into the river system
F3	Better cleaning up Prospect Creek of rubbish and noxious weeds and trees along the lower Prospect Creek Lansvale East from the Hume Highway to the junction of Georges River where the Prospect Creek and Georges River join.
F6	The impact further development of land in the catchment area has on flooding
F9	Prospect Creek dredging and Georges River catchment dredging to accommodate excess water/regular policing of polluters around the area
F10	Units and buildings built 2001-2002 Cnr Knight St & Hume Highway Lansvale that's where Prospect Creek first break bank between Caravan Park and Lansvale Bridge Hume Highway. Now with elevated ground approx. 1 1/2 metre filling higher making a dam, water will now go down Knight St now rather than old low ground to Day Street
F11	I would suggest that previous studies in the past be considered:- 1) The Chipping Norton Lake Planning Study (Cox & Corkill P/L Planning and Environment Oct 1977). 2) Water Resources Commission NSW Mitigation works, Fairfield City April 1983. 3) The Chipping Norton Lake Authority Act, passed by State Parliament in 1977 under which the Minister for Public Works became the Chipping Norton Lake Authority. I'm sure the above studies would benefit the committee.
F12	Free and quick movement of water down river

ID	Issue Raised
F13	I think you will find letter written after 1986 & 1988 + 1991 from my late husband, Mr Colin Strandgard sent to Fairfield Council concerning these floods just so you can tell how deep it truly was at this end of Lansvale.
F14	See completion of Lansvale foreshore embankments and pathways, see completion of parks area on Lansvale peninsula, see foot/bike bridges across Prospect Creek and Georges River.
F15	Issues to consider are in relation to 490 Hoxton Park Road site, which houses Integral Energy Depot. This site was once flooded in the past.
F23	I came to Lansvale in 1954, and until January 1971 lived in Beach Road which was subject to many floods. Luckily I haven't had any floods since living in Mars Place.
F30	We have already had 2 floods hope no more
F40	May I ask is there any chance in the future that "Lansvale" area will be flood? I mean which is the main parts or areas of Lansvale will actually occur flooding?
F41	I would be happy to help the Floodplain Management Committee in this serious issue, but my husband and I are old people
F43	My property is currently, just outside the 100 year flood area, if I understand correctly my property will be rezoned as Low Flood Risk so, in effect I am going from having no flood zoning on my property to being flood zoned. My question is this, what effect will that have on my insurance and land value?
Sutherland	
S4	I am interested to know about flooding in Illawong - what depth it floods to. What is the position now - have things improved?
S8	That Councils are consistent in their administering of any rules that may be voted for and not to succumb to the desires of individual applicants who have the expertise, money and fortitude to fight Government bodies as against those who are battlers or are less educated and not be financial enough to mount a fight against “City Hall”
S10	The effect of future residential development further up the river - recent newspaper reports 30,000 homes being planned for Bringelly area - the storm water from which will flow into the Georges River.
S11	Make sure you consult residents who have lived in the areas for the past 40-80 years as they have more idea of reality regarding floods than someone behind a desk making predictions. Put the two resources together and you should come up with something fair and applicable for everyone. PS Water conservation would be more applicable at this time considering the dry spell we’re going through at the moment Eg. Water tanks etc.
S13	How to control “Building” on the floodplain like what happened at Sandy point
S15	The impact on services infrastructure such as sewerage, water, gas and electricity.
S16	I was Involved with evacuating people from cottages near the Illawong – Lugana Ferry on many occasions and from memory the late 1940’s and possibly 51/52 floods were more impacting Illawong than the 1956. It would be interesting to overlay the effect of tide and the siltation of Jewfish and Gungah Bays on the impedance of flow through Como bridge.
S21	In my local area of Illawong flooding has been rare, this I know from personal experience and my father’s recollections. He has known the area since the late 1920’s. Local flooding only occurred during unusually high rainfall and unusually high tides.

TABLE A2
Issues Raised in Detailed Questionnaire

No.	Locality	Issue Raised
127	Cabramatta	When I bought my property Council had given me permission to build but had never told me up front that the property was flood affected. Only after 5 years Council gave me a letter stating that my land was flood affected in the 100 year flood. I complained to the general valuers for my land valuation and he said that Council has given them notice that my property was flood prone every 100 years. If I wanted to increase my land value that I had to go to court. This attitude from Council is very rude and bureaucratic. Council is there to help people and not to rip off or degrade people to make a profit. I hope my situation is considered and taken into account.
17	Chipping Norton	At Carinya Road, Picnic Point, after a flood, the residents living on the section where houses flooded complained. Construction of besser brick fences and earthwalls then occurred. This choked this section of the river and the next flood was at East Hills only to houses that were not flooded in two previous floods. This was a flood that lasted less than 3 hours, which suggests the choking of the river downstream. If I remember, no houses were flooded in Carinya Road. If a larger flood occurs and this choking stays, a higher level of flooding will occur in Moorebank, Milperra, Chipping Norton and Lansvale.
37	Chipping Norton	Could not go to work, roads blocked
46	Chipping Norton	Development controls and requirements for some types of developments above 1:100 level may be appropriate. For example, there are areas above 1:100 but close to Georges River. If development density is increased, eg conversion to medium density housing, requirements for runoff controls, detention basins, etc. may be desirable. Impact of flood events could be reduced by identifying and addressing local "hot spots" ie areas where there are problems such as local road disruptions. While these may be considered local rather than catchment flooding, they could be a large impact as they are often frequent and impact on many people.
51	Chipping Norton	I lived in Flinders Road, Georges Hall, from 1937 to 1964. Then in Manning Street, Warwick Farm, before coming to this address in 1984. I have not had any of my homes flooded at anytime but I am well aware there may be a problem here in the future. We had an acreage in Flinders Road and the water would come onto the back portion. I know how quickly the Georges River can overflow and cut off roads, etc.
111	Chipping Norton	Sea level controls river levels. Provide information on flood compatible building materials, please.
118	Chipping Norton	Road closed only. Our home does not flood but Newbridge Road at Flowerpower does and the drains always block in heavy rain and cause the road to close. I think they should be fixed to cope with the runoff.
134	Chipping Norton	Prevention is better than cure. The only way to prevent flooding is: 1) Stop (or slow) the water coming in. 2) Get the water out quicker. Remember the 1986 floods cost over $40 million in damages. That money did not come from Government. It is important to let the insurance companies know that flood minimisation is also their risk minimisation.
136	Chipping Norton	One of the main problems is drains. We have one outside our place. In 14 years I have never seen Council inspect or clean it out. Also the tree roots have damaged the gutter causing water to build up.
137	Chipping Norton	Although I am naturally concerned about the impact of floods on my property, I also believe that information should be handled discretely and that it should not be published in newspapers as this could cause media hysteria and unnecessarily reduce house values. If it turns out that my house is unsaleable, I believe it is the government's responsibility to buy me out because I was not provided with adequate information when I recently purchased my property.
170	Chipping Norton	Regular communication is a must.
206	Chipping Norton	Residents in Chipping Norton don't realise how high the water level can and will rise. Advising individual residents with a certificate whether their house will be affected and to what degree will certainly effect people's attitudes to the damage that floods can cause.
28	East Hills	Why can't they get the bridge fixed? It must be 12 months now and nothing has been done to get it back in operation.
98	East Hills	Separate letter attached. No development upstream of Georges River. No more controls on 1:100 flood level. Consultation should be with 3 groups, ie. low, medium and high
148	East Hills	See attached map of proposal at Kelso Levee

No.	Locality	Issue Raised
161	East Hills	The river has never risen up to the corner of Burbank and Henry Lawson Drive. The highest it has come since 1970 was in 86 or 88 when it crossed the Drive where the stormwater canal comes under the drive, skirts around Monash Park and into the river. Possibly 6 inches to a foot over the Drive. That's the highest it has ever come in 100 years. Can't see it ever being worse than that unless some river further back inland were to be diverted into the Georges. Still I am no expert, that's just my opinion.
185	East Hills	Water only reached the bottom of lower fence (nearer river)
53	Georges Hall	Councils should stop further expansion of Bankstown airport. They also allowed the food outlet garage on corner of Henry Lawson Drive and New Bridge Road. I have seen all this land under 2-3 feet of water. Henry Lawson Drive near where we live should be upgraded above river levels with better drainage on both sides not just for a large flood but for the general flooding which happens often.
72	Georges Hall	This house was moved to higher ground. Suggest more mangroves in the river to stabilise the banks.
92	Georges Hall	After reviewing the web site, we found no evidence as to why the present flood categories should be changed. The only apparent reason is to make the Council less liable for flood damage. But this does not help us as we stand to lose many thousands of dollars on our property price should it be rezoned into a flood area. I strongly object to completing a questionnaire which suggests that things have changed and we are now living in a flood zone. Your questionnaire does not provide scientific evidence. Please supply evidence such as street maps with proven new flood zone areas and flood mitigation work.
153	Georges Hall	Was flooded in 1990 when hail blocked the drains
109	Hammondville	All systems have drawbacks, as too many people are disinterested until there is a crisis. Sporting facilities and parks are satisfactory for less than 1 in 100 year flood areas. All new major developments to include emergency storage to cover flash flooding generated by impermeable surfaces in the area developed whether in a flood zone or elsewhere.
184	Illawong	Flooding on Ovens Reach between Lugarno and Como has not been experienced by me nor have other generations talked of flooding in the past. The only sign of flooding has been where floodwaters came downstream and there were a few unusually high tides for a brief period.
7	Lansvale	Quite serious erosion of river banks. Many trees falling into main river course - potential blockage and hazard to rescue craft. Would like to see riverside pedestrian/cycleway developed along river banks/levees (Not Liverpool Council's Plan). In 86 flood highway and access cut. Regular cleaning of stormwater drains. Connect waterways/cycle paths on Lansvale Peninsula with bridges to Mirambeena and Chipping Norton tracks.
154	Lansvale	Why build residential subdivisions in floodprone areas?
188	Lansvale	There was 10cm of water in front yard only
189	Lansvale	As I am 73 years old I don't know what could be done. All I want to do is not see another flood, it's too stressful. Received levels from Council after we were flooded.
194	Lansvale	Flooding in street only.
203	Lansvale	The local native bird population is being threatened by the increased invasion of Indian Mynor birds and sparrows
204	Lansvale	House has been raised since the 1956 flood.
8	Milperra	There are a number of rocky outcrops impeding the flow of the river at the Kelso Beach area at East Hills. These may be removed or lowered to ease river flow.
44	Milperra	Ground absorption of water prevents river from flooding. Houses should be able to allow water to go to ground. Gutters are a fire hazard. In some countries houses are designed without gutters. Dredging the river for more water storage. The river water level is determined by the ocean level. Dredging will therefore do nothing, as the hole is already full. If you want to do something really useful, then widen the river in its narrow parts. Stop raising the levels of surrounding properties, eg. airport and factories on Milperra Road.
64	Milperra	I am concerned that the changing government attitude to flood mitigation will now incorporate properties developed after the decisions of what is a flood affected property made in the mid 1980s where properties were indicated free and constructed as non-flood affected blocks. Large storage areas, such as the airport, are filling areas to make commercial gain. The study should recognise current storage areas, public and private, and assist in reducing the impact on river flooding.

No.	Locality	Issue Raised
123	Milperra	What a silly place to put the Blue Gum Farm. It floods there. It would not flood if the Council would not fill in the floodplain where the water crosses. But the Council made a tip on swampland where the water should go.
207	Milperra	We back onto Bankstown Golf Course and are concerned as to the soil they have put on the practice range to grow turf. When it does rain now the water sits against our back fence & does not drain away. I think this needs to be looked at.
3	Moorebank	Over 4 years ago Council promised to clean creek at the E. Smith Reserve, nothing has been done. The stormwater drains from the street go into this creek. Consequently all the water backs up.
52	Moorebank	As stormwater pipes which lay parallel with the street under the footpath get blocked, the stormwater will have no runoff from the property and will flood. Excess water will come from Heathcote Road between Cooper Avenue and Market Street which will run into Market Street. Heathcote Road has been widened from 2 to 4 lanes.
41	Padstow	I cannot attend any meetings because my wife is disabled. Also I am not near the Georges River but I do have Rieby Creek running through my property, we have been promised since I have been living here and that is 41 years.
99	Padstow	We are totally frustrated at Council's lack of action. Drainage work to eliminate flooding completed in 1994. We were advised Council would take the 1 in 100 zoning away, and a survey was done. Instead the Council INCREASED the flood zone. Monty Python would be proud. No more surveys Council. Remove the flood zone at the lower end of Iberia. We began writing to Council in 1994. We were actually told all our correspondence was destroyed in the fire. We have copies should anyone be interested.
26	Panania	I would like to know what work is being done with Councils, Governments and Insurers to address flood risk assessment standards and creating a significant and equitable insurance option.
197	Panania	With respect, we say these are too complex for the everyday person, they are more in keeping wth a barrister and an engineer. We know Council and its associates do a splendid job servicing the public. We have total trust and confidence that they shall continue to do so. When disasters like bush fires or flooding occur there is very little that anyone can do to stop them. We are of the opinion that the citizens should do more to keep themselves well informed of pending disasters.
19	Picnic Point	Council controls don't make sense and are mainly ignorant of local conditions. They change in interpretation under influence. Some can subdivide, some can't. Some can build at the front. Why? Garages and storage areas up the back, why? Walkways are dangerous, both before and during floods, ask the SES. Councils should provide advice, not controls, and stay out of our homes! Council should concern itself with levees, dams, weirs, and drains. Our area is tidal, the flood rises slowly new levees in place. We need to keep sightseers out of the area during floods and fires. We expect a flood and will put up with it. If they help us clean up that would be a bonus. What about a tidal control gate or lock downstream, eg. Menai bridge to stop the incoming tide raising the flood level 1-2m.
124	Picnic Point	I am affected by a lack of stormwater control from above my property and from the Georges River below my property. I have been affected by a landslide and have photos but Bankstown Council couldn't care less until a life is lost.
10	Pleasure Point	I am concerned about development and vegetation removal directly on river, eg. Voyager Point and the land between Voyager Point and Pleasure Point as trees reduce runoff.
177	Pleasure Point	The mangroves slow the water on the reserve and around the properties. The mangroves and other trees are slowly being removed by some residents and I fear the water speed near the houses will be much higher next time. We may need a deflecting levee in the next few years.
199	Sandy Point	The mandatory installation of rainwater tanks to be installed on all existing and new developments. Retention tanks installed for slow release of stormwater. No development below the 1:100 year flood line. Existing development below the 1:100 year flood line should contribute to evacuation programs.

APPENDIX B

FREQUENTLY ASKED QUESTIONS

(The questions included in this Appendix are typical of those that were raised during the public workshops, or in response to the short questionnaire that was distributed to residents in the study area. Answers to each question are included.)

FLOODPLAIN MANAGEMENT STUDIES

FREQUENTLY ASKED QUESTIONS

Why do flood levels change over time?

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

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

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

How are these studies funded?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

How have the flood risk maps been prepared?

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

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

What is the probable maximum flood (PMF)?

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

What is the 100 year flood?

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

Why do councils prepare floodplain management studies and plans?

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

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

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

Will the Flood Risk Precinct maps be changed?

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

APPENDIX C

Summary of Submissions received from the Public Exhibition of Draft Reports

(Draft Reports and other information about the study were placed on public exhibition from 21st January to 5th March, 2004.)

Summary of Submissions received from the Public Exhibition

1. Liverpool Council

1.1 Submission concerning the draft Liverpool Flood Risk Management DCP

This submission concerned the list of flood compatible materials that were included in Schedule 1 of the draft Liverpool DCP. The respondent did not believe that a prescriptive list of building materials should be provided. In addition, some technical matters concerning the names of products were raised.

Schedule 1 provides a list of flood compatible materials to be considered for new building applications that are sited below the 100 year flood. It attempts to limit the potential for flood damage and only applies to that part of the building that is below the 100 year flood (or the PMF in the case of sensitive uses and facilities). Schedule 1 is not intended to be a prescriptive list, but rather to provide guidance on the range of building materials that will limit potential flood damage.

1.2 Submission from CARE Engineering Pty Ltd in relation to future development

This submission was lodged on behalf of a commercial property owner on the Georges River Floodplain. Some concern was expressed that the proposed flood risk management DCP would unnecessarily prohibit all development identified within the high flood risk precinct, without the provision for merit based considerations that might facilitate development in some situations.

The development control matrix specified in Schedule 3 of the draft DCP does prohibit most land uses other than *recreation & non-urban*, and *concessional development* within the high flood risk precinct. However, there is provision for a change in the flood risk precinct of an area by filling or other means, provided that such activity does not increase flooding elsewhere.

There has been some further discussion with CARE Engineering on the above, and there are no longer concerns over this issue.

1.3 Email from resident concerning the Liverpool Voluntary Purchase Scheme

A Liverpool resident emailed the consultant seeking more information on the recommendation for the Liverpool Voluntary Purchase Scheme, that self funding initiatives involving the private sector be investigated with a view to completing the scheme. A response was issued to the resident providing further clarification of the proposed measure.

1.4 Letter concerning illegal filling on a particular site

This company raised concerns over the impact of illegal filling that had occurred on a particular site on flood levels at their property. Whilst the study has attempted to quantify the impact of all major filling activities within the floodplain, it has not been possible to include every instance where fill has been placed on individual

properties. The site in question was not flagged by Council as being a major activity, nor was this evident from an assessment of aerial photography. Consequently, an assessment of this particular site was not undertaken. The issue has been brought to the attention of staff from Liverpool Council, for further action if appropriate.

2. Fairfield Council

Fairfield Council advised that there had been a number of general phone calls and enquiries at the counter on the draft floodplain management study and plan. Most of these concerned development issues in Lansvale, the proposed planning and development controls, and the Floodplain Risk Management Maps. No formal submissions were made to Council in relation to the study and plan.

One feedback form was received by the consultant from a resident in Knight Street, Lansvale. The resident indicated support for the floodplain management study and plan, and for the proposed planning and development controls. It was also suggested that Prospect Creek needed to be dredged from the Georges River up to the Hume Highway, and that overhanging trees and other debris needed to be cleared from the Creek. Specific works on Prospect Creek are covered by the Lower Prospect Creek Floodplain Management Study. Fairfield Council has proposed that a review of this study be undertaken, which will consider such options.

Council officers requested that the study reference other studies that have been undertaken on Lower Prospect Creek and Cabramatta Creek.

3. Bankstown Council

3.1 Letter from the Insurance Council of Australia

The Insurance Council of Australia strongly endorsed the draft Study and Plan, and the joint cooperation of each of the four participating councils.

The acceleration of the Liverpool Voluntary Purchase Scheme, through potential funding from private sector development, was particularly noted as these properties have little chance of obtaining any form of insurance coverage for flood damage.

Also strongly endorsed was the Study recommendation in relation to public awareness, and the concept of providing flood certificates for flood-affected properties.

In relation to insurance cover for riverine flooding, it was noted that *"the position has not changed very much to that which is outlined in the Study. For Insurance Companies to accept the transfer of the risk of flood damage they must be able to assess the risk and rate appropriately. Much of the concerns in the past, which influenced their decisions not to offer cover, were due to inappropriate development on floodplains"*.

It was also noted that *"Implementation of the Plan would be a significant step in addressing the major concerns of insurers in the area of development controls, data*

collection and availability, transparency around planning issues and the absolute imperative of public education about flood risk and mitigation measures".

3.2 Submission to Bankstown Council

This submission raises two issues. The first deals with the accuracy of the delineation of the different flood risk precincts; the second with flood insurance.

The submission proposes that the flood risk precincts need to be accurately defined prior to any notifications such as those contained on Section 149 Certificates. Also noted are difficulties that occur when only a small portion of a property is affected by flooding and that in some cases site plans may need to be prepared showing the actual portion of a property affected by the different flood risks.

It is a recommendation of the floodplain management study that airborne laser scanning be undertaken to provide improved topographic data to allow further refinement of the flood risk precincts. This survey was recently completed within both the Bankstown and Fairfield Council areas. Refinement of the flood risk precinct maps for these two Council areas could therefore commence relatively soon.

The issue on flood insurance refers to anomalies that exist for instances where insurance companies may or may not pay insurance claims. This is beyond the scope of the current study, and largely an issue for the Insurance Companies and the State Government.

3.3 Feedback form from resident of Henry Lawson Drive, Picnic Point

Support was indicated for the floodplain management study and plan, and the proposed development controls. However, it was suggested that further clarification of the flood risk for waterfront properties along Henry Lawson Drive was warranted. The extent of the flood risk was also questioned, based on the resident's experience of flooding at this property. Some concern was also expressed on the amount of stormwater now entering the river as a result of recent development. It was suggested that dredging the river should be considered.

The study has recommended that additional information on flood risks for individual properties be communicated through the regular issue of flood certificates. The option for dredging was also considered as part of the floodplain management study, but was not recommended due to high capital costs and relatively low flood benefits.

3.4 Letter from resident of Carinya Road

This resident believes that the existing flood controls on buildings in Carinya Road are both onerous and unnecessary, and should be removed. In particular, controls relating to walkways, breezeways and hard stands and garages above the 100 year flood level. He believes that the required walkways are dangerous, provide a false sense of security, and are an unnecessary cost.

One of the recommendations of the floodplain management study is that a review of the Carinya Road flood mitigation measures be undertaken. This would include a detailed review of flood conditions using a 2-dimensional computer model. A review

of the existing requirements for walkways and other flood related provisions would logically form part of this review.

4. Sutherland Council

Residents of Sandy Point in Sutherland Shire requested a public meeting to discuss the draft floodplain management study and plan. The meeting was held on 8th March 2004 at the Sandy Point Community Centre. The meeting was attended by approximately 30 residents, Bewsher Consulting, and staff from Sutherland Shire Council and the Department of Infrastructure, Planning and Natural Resources.

A presentation on the floodplain management study and plan was provided by Bewsher Consulting. This was followed by a general question period. At the conclusion of the meeting, residents were asked to forward any outstanding concerns or issues on the study to Council. No submissions were received.

APPENDIX D

Flood Level Contours from the 1991 Georges River Flood Study Report [PWD 1991]

No changes are proposed to the design flood levels
previously determined from the 1991 Flood Study report.
The relevant figures from that report are included in this Appendix.

0 200 400 600 800 1000 m

N

PROSPECT

CABRAMATTA CK.

CREEK

RIVER

GEORGES RIVER

LIVERPOOL

BANKSTOWN AIRPORT

weir

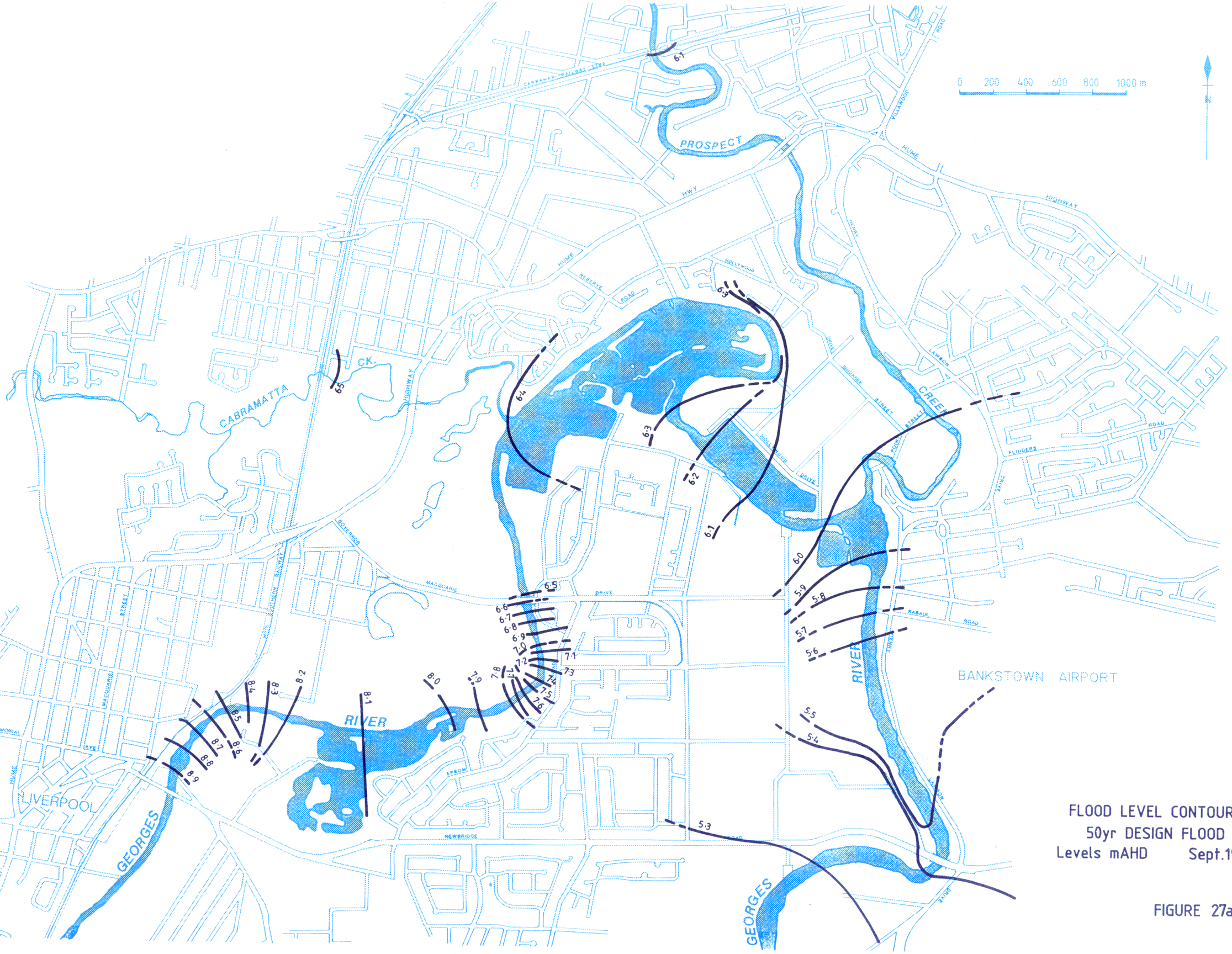
5.5 5.9 5.9 5.8 5.7 5.6 6.0 6.0 6.1 5.5 5.4 5.3 5.2 5.1 5.0 4.9 4.8 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 7.0 7.1 7.2 7.3 7.4 7.5 7.6 7.7 7.8 7.9 8.0 8.1 8.2 8.3 8.4

FLOOD LEVEL CONTOURS
20yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 26a

FLOOD LEVEL CONTOURS
20yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 26b



FLOOD LEVEL CONTOURS
50yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 27a

FLOOD LEVEL CONTOURS
50yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 27b

0 200 400 600 800 1000 m

N

PROSPECT

CABRAMATTA CK.

CREEK

RIVER

GEORGES

BANKSTOWN AIRPORT

LIVERPOOL

6·5 6·6 6·7 6·8 6·9 7·0 7·1 7·2 7·3 7·4 7·5 7·6 7·7 7·8 7·9 8·0 8·1 8·2 8·3 8·4 8·5 8·6 8·7 8·8 8·9 9·0 9·1 9·2 9·3

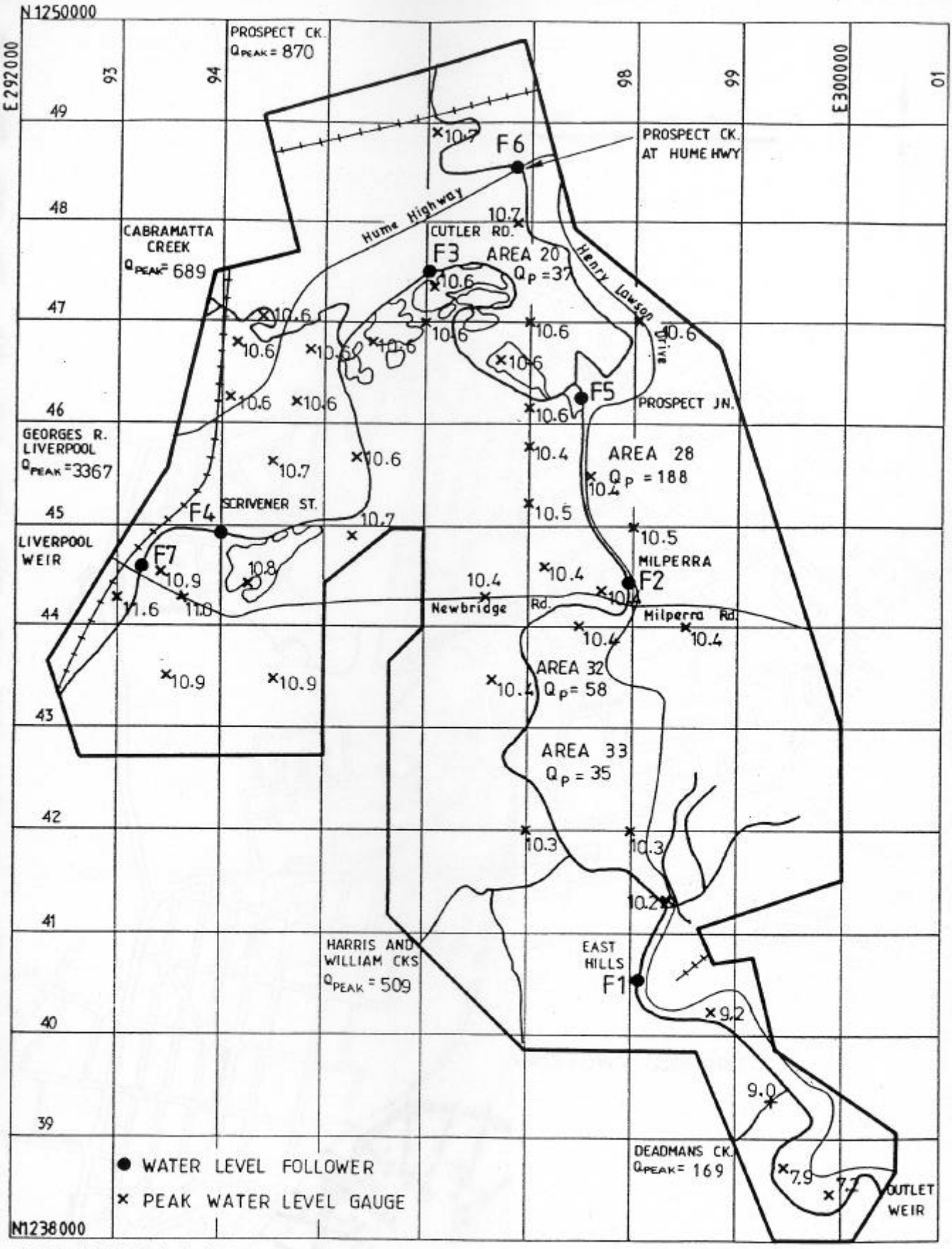
6·4 6·3 6·2 6·1 6·0 5·9 5·8 5·7

FLOOD LEVEL CONTOURS
100yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 28a

FLOOD LEVEL CONTOURS
100yr DESIGN FLOOD
Levels mAHD Sept.1990

FIGURE 28b



WATER LEVELS (m) A.H.D.

Q_{PEAK} = (m^3/s)

36hr storm extreme flood estimate

PEAK FLOOD LEVELS

FIGURE 25