Sutherland Shire COUNCIL

Lower Georges River Floodplain Risk Management Study & Plan

Lower Georges River at Como Marina

Final Report

March 2011

Bewsher

SUTHERLAND SHIRE COUNCIL

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Prepared with the assistance of Sutherland Shire Council's Floodplain Management Committee

Prepared by:
Bewsher Consulting Pty Ltd
6/28 Langston Place, Epping NSW 2121 Australia
P O Box 352, Epping NSW 1710 Australia
Telephone: (02) 9868 1966. Facsimile: (02) 9868 5759
Web: www.bewsher.com.au E-mail: postmaster@bewsher.com.au
ACN 003137068. ABN 24 312 540 210

FOREWORD

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

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood hazard and does not create additional flood problems. The Policy sets out four sequential stages in the process of floodplain management:

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

A Flood Study was prepared for the Georges River in PWD (1991), and extended to cover the Lower Georges River in Bewsher Consulting (2004).

A comprehensive Floodplain Risk Management Study was prepared for the Georges River as far downstream as its junction with the Woronora River (Bewsher Consulting, 2004). The current study extends the *Georges River FRMS&P*, to cover the area of the Lower Georges River floodplain within the Sutherland Shire downstream of the Woronora River junction.

Bewsher Consulting has prepared this Floodplain Risk Management Study & Plan with the assistance of Sutherland's Floodplain Management Committee, Council officers and the Department of Environment, Climate Change and Water (DECCW). Council has received technical and financial support from the Government's Floodplain Management Program administered by DECCW.

In broad terms, the report investigates what can be done to minimise the effects of flooding in the Lower Georges River floodplain and has recommended a strategy in the form of a Floodplain Risk Management Plan.

Lower Georges River Floodplain Risk Management Study And Plan

ADDENDUM TO RESIDENTIAL FLOOD PLANNING LEVELS

The Lower Georges River Floodplain Risk Management Study and Plan was prepared in November 2009, and placed on public exhibition during 2010.

One of the recommendations from the draft Study and Plan was to increase the freeboard applied to the 100 year flood when specifying flood planning levels for new residential development from 0.5m to 0.8m throughout the study area, to cater for uncertainties of future sea level rise.

Subsequent to the preparation of the draft report, the NSW Government released a *NSW Sea Level Rise Policy Statement*, which sets planning benchmarks for sea level rise (relative to 1990 levels) of 40cm by 2050 and 90cm by 2100 for the NSW coast. An accompanying *Flood Risk Management Guide* notes that freeboard should not be used to allow for sea level rise impacts.

The matter was discussed at a floodplain management committee meeting on 28 October 2010, where it was recommended that a separate sea level rise allowance be provided additional to the normal 0.5m freeboard. A sea level rise allowance of 0.4m (based on the 2050 planning benchmark) was deemed appropriate for the majority of new (infill) residential development along the Lower Georges River. It was also recommended that the sea level rise allowance be reviewed as additional information becomes available.

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LIST OF ABBREVIATIONS

AEP	Annual Exceedence Probability
AHD	Australian Height Datum
ALS	Airborne Laser Scanning
ARI	Average Recurrence Interval
DECCW	Department of Environment, Climate Change and Water
DEM	Digital Elevation Model
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
LGA	Local Government Area
PMF	Probable Maximum Flood

EXECUTIVE SUMMARY

Bewsher Consulting Pty Ltd was commissioned by Sutherland Shire Council, with financial assistance from the Department of Environment, Climate Change and Water (DECCW), to prepare a Floodplain Risk Management Study and Plan (FRMS&P) for the floodplain of the Lower Georges River.

A major FRMS&P was completed for the Georges River upstream from the Woronora River junction in May 2004. The *Lower Georges River FRMS&P* was initiated to assess and manage flood risks along the Georges River floodplain downstream of its junction with the Woronora River, within the Sutherland Shire Local Government Area. Its study area includes the foreshores of Oyster Bay, Gwawley Bay and Woolooware Bay, but only flooding originating from the Georges River is considered. Other studies are being pursued to investigate local catchment flooding (e.g. Oyster Creek FRMS&P; Gwawley Bay FRMS&P).

The *Lower Georges River FRMS&P* has been overseen by the Lower Georges River and Gwawley Bay Catchment Floodplain Management Committee, which comprises Councillors, officers from DECCW and the State Emergency Service (SES) and several community representatives.

Principal Outcomes

The principal outcomes of this study include:

- Community consultation to identify flood problems and possible solutions (**Chapter 2**);
- Mapping of the high, medium and low flood risk precincts for the Georges River floodplain downstream of Deadmans Creek, using Council's airborne laser scanning (ALS) elevation data (**Chapter 3**);
- Assessment of buildings and roads potentially at risk from flooding under existing conditions (**Chapter 3**);
- Assessment of the potential impacts of climate change on flood behaviour (**Chapter 4**);
- An evaluation of potential floodplain management measures to reduce flood damages (**Chapter 5**); and
- A recommended Floodplain Risk Management Plan (FRMP) for the Lower Georges River floodplain (**Chapter 6**).

The Floodplain Risk Management Plan

A range of structural flood mitigation measures were considered, including a flood mitigation dam in the upper catchment and river dredging. These measures are not supported due to: 1) limited effects on flood levels in the Lower Georges River where the Botany Bay storm tide level is the dominant control; 2) high and in the case of dredging ongoing capital costs; and 3) environmental issues. Embankments to protect houses were also considered but generally these are not recommended due to the relatively small number of buildings exposed to Georges River flooding and their dispersed nature, which makes levees uneconomic. One possible exception could be at Woodlands Road, where several houses and yards could be affected by flooding. Here, however, issues of economic merit, environmental impact, aesthetic impact and internal drainage count against support of this option.

A recommended *Lower Georges River Floodplain Risk Management Plan* is presented in **Table 6.1**, at a capital cost of $82K plus $5K for annual maintenance. The recommended measures have been selected from a range of available measures, after an assessment of the impacts of flooding, as well as environmental, social and economic considerations. These measures comprise:

<u>High Priority</u> (within 2 years)

- Assess flooding problems and solutions at Kareela Creek near Morna Place;
- Capture building floor survey for approx. 20 buildings identified as within the medium flood risk precinct;
- Review the flood risk management provisions in the amended Sutherland Shire DCP 2006;
- Revise Sutherland Shire DCP 2006 to include a freeboard of 800mm (where 500mm currently applies) for the Lower Georges River study area (i.e. downstream of the Como Railway Bridge); **See Addendum**
- Continue to monitor climate change projections and Government policy/guidelines regarding appropriate response measures to these projections;
- Revise Sutherland Local Flood Plan with information from this study; and
- Increase and sustain public flood readiness by issuing certificates, preparing a FloodSafe brochure; and preparing a floodplain management web-site.

<u>Medium Priority</u> (within 4 years)

- Prepare a brochure outlining potential flood-proofing techniques.

<u>Low Priority</u> (within 7-10 years)

- Give further consideration to a levee at 58-64 Woodlands Road if sea level rise is pronounced.

1. INTRODUCTION

1.1 BACKGROUND

In May 2004, Bewsher Consulting Pty Ltd completed a major Floodplain Risk Management Study and Plan (FRMS&P) for the Georges River floodplain upstream from its junction with the Woronora River. It documented the behaviour of flooding, the damages that could arise from flooding, and the preferred floodplain risk management measures to be implemented across the catchment.

The *Lower Georges River FRMS&P* was initiated to assess and manage flood risks along the Lower Georges River floodplain downstream of its junction with the Woronora River, within the Sutherland Shire Local Government Area. The study area includes the foreshores of Oyster Bay, Gwawley Bay and Woolooware Bay, but only flooding originating from the Georges River is considered. Flooding of tributaries and waterways could also result from local catchment flooding, for example in Oyster Creek and Sylvania Waters. Separate studies are being pursued to investigate flooding problems in these areas, including the *Oyster Creek FRMS&P* (WM&A, 2005) and the *Gwawley Bay FRMS&P* (Bewsher Consulting, 2009).

An important goal of this study is to take advantage of Council's recently acquired Airborne Laser Scanning (ALS) survey data to update the flood risk maps prepared in the 2004 Georges River FRMS&P. At Council's request, the flood risk maps have been updated for the entire Georges River floodplain within Sutherland Shire Council, even though the area upstream of the Woronora River junction is not within the study area for this FRMS&P.

Another important component of this study is a climate change sensitivity test. This assesses the potential impact of sea level rise and increased rainfall intensity on flood levels.

A rigorous assessment of potential floodplain management options and valley-wide measures has already been undertaken as part of the *Georges River FRMS&P* (Bewsher Consulting, 2004; Don Fox Planning, 2004). Recommendations included the adoption of consistent planning and development controls, flood warning enhancements, improved emergency management operations and improved public awareness. A large flood mitigation dam in the upper catchment and dredging of the river were considered but not recommended due to high capital costs, low economic benefits and/or significant environmental issues. Because the current study is designed to be read as an extension to the earlier work, the reader is directed to the *Georges River FRMS&P* for a full discussion of valley-wide measures. Nevertheless, a variety of measures relevant to the Lower Georges River study area are considered in this report.

1.2 THE STUDY AREA

Figure 1.1 shows the *Lower Georges River FRMS&P* study area. It extends along the Georges River from the Como Railway Bridge to Towra Point near the entrance to Botany Bay, but it excludes areas where flood behaviour is influenced by local catchment flooding, which are considered under separate studies. Flooding along Oyster Creek was considered under the *Oyster Creek FRMS&P* (WM&A, 2005) and flooding in the Gwawley Bay catchment (including Sylvania Waters) is currently being considered under the *Gwawley Bay FRMS&P* (Bewsher Consulting, 2009). Some issues rising from the community consultation conducted for this study more properly fall under the ambit of other proposed studies, including studies at Carina Creek and Kareela Creek.

Flood risk maps based on the new ALS survey data are presented for the entire Georges River floodplain within the area of Sutherland Shire Council, from Sandy Point to Towra Point. The extent of Georges River inundation is also mapped for Deadmans Creek downstream of Heathcote Road and for Mill Creek, but not for the Woronora River which is the subject of a separate study (ACER Wargon Chapman, 1995).

FIGURE 1.1
STUDY AREA

0 1 2km
Scale

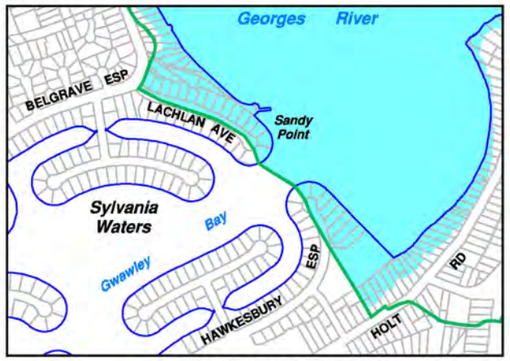
LEGEND

- Limit of Study Area (Probable Maximum Flood Extent)
- Edge of Waterway within Study Area
- Local Catchment FRMS&P Study Areas
- Sutherland Shire Council Boundary

N

INSET A

INSET B



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LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

1.3 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The main responsibility for managing 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 these studies.

A Flood Prone Land Policy and a *Floodplain Development Manual* (NSW Government, 2005) form the basis of floodplain management in New South Wales.

The objectives of the Policy include:

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

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

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

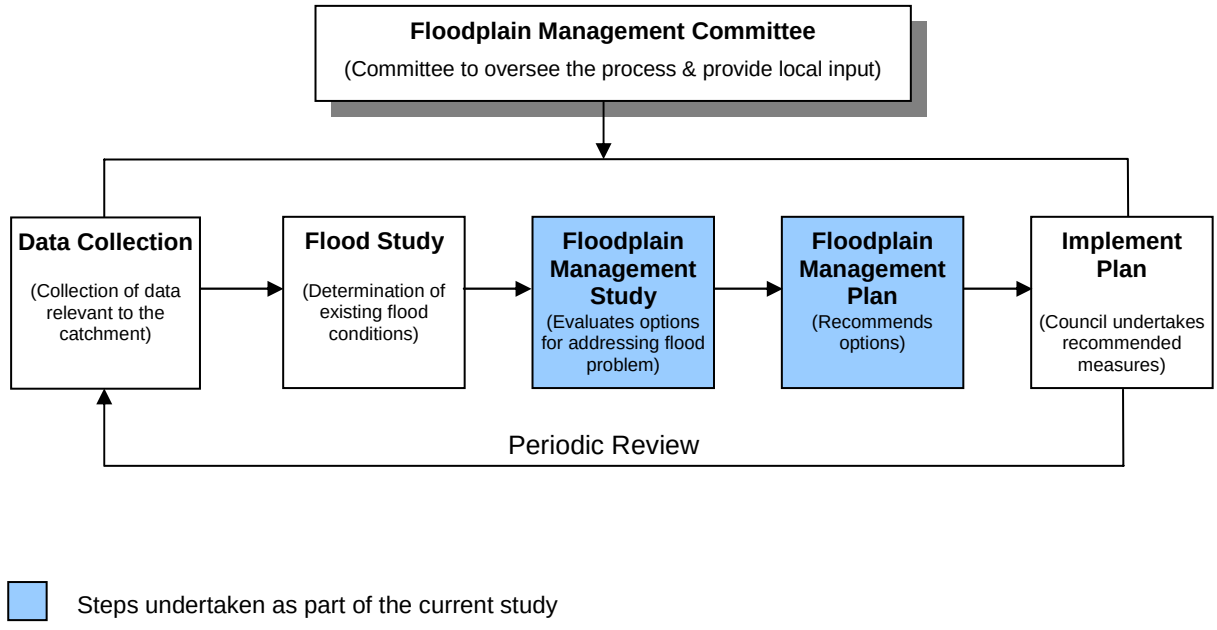

FIGURE 1.2 – The Floodplain Management Process

2. COMMUNITY CONSULTATION

2.1 CONSULATION PROCESS

The success of any floodplain management plan hinges on its acceptance by the local community and other stakeholders. This can only be achieved by involving the local community at all stages of the decision-making process.

Community consultation has been an important component of the current study, through meetings of the Floodplain Management Committee, questionnaires and public exhibition of the draft report. The consultation has aimed to inform the community about the development of the floodplain management study and its likely outcomes, and provided an opportunity to collect feedback and ideas on potential floodplain management measures.

2.2 FLOODPLAIN MANAGEMENT COMMITTEE

The study has been overseen by the Lower Georges River and Gwawley Bay Catchment Floodplain Management Committee. This committee comprises representatives from:

- Sutherland Shire Council;
- Department of Environment, Climate Change and Water (DECCW);
- State Emergency Service;
- Department of Primary Industries;
- NSW Maritime; and
- the community of the Shire.

The Committee has met regularly to hear progress reports by the consultant, and to provide direction as the study progressed. The Committee has provided a valuable mechanism for the views of many interested parties to be represented. The main agenda items at each meeting are summarised in **Table 2.1**.

TABLE 2.1 – Meetings of the Sutherland Floodplain Management Committee

DATE OF MEETING	MAIN AGENDA ITEMS
20 August 2008	Introduction to study
16 December 2008	Flood risk mapping; climate change considerations
28 April2009	Potential floodplain management measures
10 November 2009	Review of draft report
28 October 2010	Review of public exhibition

2.3 QUESTIONNAIRE

In May 2009, a community questionnaire was prepared and sent to the owners of 1,548 properties located or partly located within the PMF extent (see **Section 3.2**). Some 250 responses were received (216 residential, 33 commercial), yielding a response rate of 16%. A copy of the questionnaire is included at **Appendix A**.

One question asked respondents to record their previous experiences of flooding in the Lower Georges River study area. The results are shown in **Table 2.2**. It is clear that the vast majority of respondents had no experience of flooding. Very few (four) had experienced above floor flooding and close inspection shows that the flooding at two of the four properties was not related to flooding of the Georges River – one was associated with overland flow and the other was related to flooding from the creek running through Kareela Golf Course (which we refer to as "Kareela Creek"). Indeed, many of the flood problems identified in the questionnaire are located outside of the study area and are covered in other studies including the *Georges River Flood Study*, *Oyster Creek Flood Study*, *Gwawley Bay Catchment Flood Study* and *Kurnell Township Flood Study*. One submission referred to flooding of Carina Creek. Seven submissions referred to frequent flooding of properties in Morna Place, which is next to Kareela Creek, after local rain (see **Figure 2.1**). The residents there attributed the flooding to siltation of the drain and a policy that encourages mangrove growth. Investigation of local catchment flooding problems such as these is beyond the scope of the current study, which is focussed on flooding from the Georges River. Nevertheless, it is noted that both Carina Creek and Kareela Creek were identified as warranting further flood investigations in the *Initial Subjective Assessment of Major Flooding* in Sutherland Shire (Bewsher Consulting, 2004). In view of the frequency of flooding and level of community concern, it is recommended that the Kareela Creek Flood Study be given a high priority.

Locations within the Lower Georges River study area that were identified as having flood issues are discussed in **Section 3.3.1** and **Appendix B**.

TABLE 2.2 – Flood Experience at Property

FLOOD EXPERIENCE	PROPORTION OF RESPONDENTS
Above floor flooding	2%
Below floor flooding	3%
Minor flooding within property only	8%
No flooding within property	85%
Not answered	3%

FIGURE 2.1 – Flood Photos of Kareela Creek Supplied by Residents of Morna Place

a. May 2003, looking east

b. December 2007, looking north-east

c. February 2008, looking south-east

d. Looking towards Morna Place

A particular goal of the questionnaires was to canvass residents' ideas about how to solve the flood problem. Using "open" questions, several very detailed responses were received. Common answers have been grouped, and are ranked in descending order of the frequency of the suggestion in **Table 2.3**. Dredging of the Lower Georges River to remove recently deposited mud and silt was a popular suggestion. (Six of the 20 suggestions relate to dredging of Kareela Creek near Morna Place). Many respondents called for the construction, preservation or raising of embankments to guard against flooding and shoreline erosion. There was some concern about Council's intended removal of the seawall and regrading to provide habitat for endangered birds at the Taren Point Shorebird Reserve. Fourteen respondents called for various improvements to drainage infrastructure (e.g. bigger pipes) and 12 called for more frequent clearing of the drains. These two suggestions – as well as calls for silt and litter traps, and stormwater harvesting – go to the issue of improved conveyance of local stormwater, which is not directly related to the Georges River flooding which is the subject of this study. Several people expressed interest in the possible impacts of sea level rise associated with climate change, which is considered in **Chapter 4** of this study. There were also several calls for appropriate development controls, including a foreshore exclusion zone and higher minimum floor levels to account for future sea level rise. A few people blamed the flooding problems on the growth of mangroves, and called for their removal. Others called for the preservation of mangroves and other riparian flora and fauna.

TABLE 2.3 – Management Measures Suggested by Community

MANAGEMENT MEASURE	NUMBER OF TIMES SUGGESTED
Dredge silted bays and river	20
Construct levees/seawalls/retaining walls	20
Improve drainage infrastructure	14
Clear drains	12
Investigate effects of climate change and sea level rise	11
Apply development control	8
Remove mangroves	6
Ensure adequate silt and litter traps	4
Stormwater harvesting/recycling	3
Filling low-lying land	3

2.4 PUBLIC EXHIBITION

The draft report of the *Lower Georges River FRMS&P* was placed on public exhibition for eight months from November 2009 to June 2010. The received submissions were considered at a meeting of the Floodplain Management Committee on 28 October 2010, and some changes were incorporated.

3. EXISTING FLOOD BEHAVIOUR

3.1 DESIGN FLOOD LEVELS

Design flood levels for this study have been taken from maps presented in the *Georges River Floodplain Risk Management Study & Plan* (Bewsher Consulting, 2004). That study developed a computer model known as MIKE-11 to simulate flood conditions in the Georges River. No previous studies had defined design flood levels on the Georges River for the reach of the river within Sutherland Shire Council.

An important influence on flood levels within the study area is the adopted Botany Bay tailwater levels. 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 waves within the bay.

A detailed record of flood heights is available for Sydney Harbour. Whilst less information is available for Botany Bay, the results are likely to be similar. On this basis, the tailwater levels recorded in **Table 3.1** have been used consistently for Botany Bay since 1991.

TABLE 3.1 – Adopted Botany Bay Tailwater Levels (m AHD) in Previous Studies
Note: Fort Denison Datum approximately 0.9m lower than m AHD.

	Georges River Flood Study (PWD, 1991)	**Woronora River Flood Study** (PWD, 1991, p.22)	**Georges River FRMS&P** (Bewsher Consulting, 2004, p.56)	**Kurnell Flood Study** (WMA Water, 2009)
Mean high water	0.6		0.6	0.6
5 year storm tide				1.4
20 year storm tide		1.5	1.5	1.5
50 year storm tide		1.6		
100 year storm tide		1.7	1.7	1.7
PMF storm tide			2.0	2.0

In the absence of any storm tide modelling studies for Botany Bay, and in order to achieve consistency with other studies, this study adopts the same Botany Bay tailwater levels used previously. The design flood levels for flood risk mapping are based on the *higher* of the levels from:

(1) modelling of river flood flows with a mean high water level in Botany Bay; and

(2) estimated storm tide levels for Botany Bay with no river flow in the Georges River.

3.2 FLOOD RISK MAPPING

Floodplain management is all about managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of flood risk.

It is important not to confuse "flood risk" with "flood hazard" or "provisional flood hazard". The terms "hazard" and "provisional hazard" are defined in the 2005 *Floodplain Development Manual* and relate to the magnitude of a *specific* flood. For example, a site may experience high hazard conditions in a 100 year ARI flood and low hazard conditions in a 5 year ARI flood. On the other hand, flood risks (as used to define land use planning precincts) do not relate to a single flood, but rather to all floods.

Flood risk precincts consider the probabilities and consequences of flooding over the full spectrum of flood frequencies that might occur at a site. When expressed in mathematical notation:

$$\textit{Flood Risk} = \int_{\textit{all floods}} \textit{Probability} * \textit{Consequence}$$

where ***probability*** is the chance of a flood occurring, and ***consequence*** is the property damage and personal danger resulting from the site's flood characteristics. Note that in carrying out this assessment, the existing land uses and any private warning/evacuation plans at the site are ignored, and typical residential land uses and the normal public warning/evacuation plans are assumed.

The system adopted by Council for Flood Risk Management in the *Sutherland Development Control Plan 2006* has been to classify floodplains into three flood risk precincts: "high", "medium" and "low". This is the same classification that was adopted by the four participating Councils in the *Georges River Floodplain Risk Management Plan*.

After a review of the probabilities and consequence of flooding over all flood frequencies, the "high", "medium" and "low" flood risk precincts were mapped as described below:

- **High flood risk precinct** includes all areas of the floodplain which would be provisionally high hazard in a 100 year flood (based on Figure L2 of the *Floodplain Development Manual*). In addition to including the 100 year provisionally high hazard areas in the high flood risk precinct, other parts of the floodplain are also included where:
  - (a) in a 100 year event, significant evacuation difficulties exist (e.g. islands surrounded by provisionally high hazard conditions);
  - (b) in floods rarer than a 100 year event, the potential for significant or extreme consequences exist which are not otherwise apparent from consideration of only the 100 year flood or more frequent flood events. Some events that may result in these consequences (depending on their scale) include catchment diversions, areas subject to overtopping of levees and embankments, areas subject to severe bank or bed erosion, or other conditions that can lead to unusually high depths, velocities or otherwise produce very dangerous flood conditions. Whilst the probabilities of these events might be low, the consequences can in some cases be extreme and thus produce a high risk.

- **Medium flood risk precinct** is the remaining area inundated in a 100 year flood event, not defined as the "high" flood risk precinct. For reasons similar to those discussed above under (a) and (b), it is possible for some otherwise "low" flood risk areas to be elevated to "medium", when the flood conditions warrant it, though this is rarely required.

- **Low flood risk precinct** comprises all remaining areas of the floodplain (defined as the limit of inundation in a PMF) but not identified as either a high flood risk or medium flood risk precinct, and where the risk of damages is low for most land uses.

The method employed for mapping flood risks in the Lower Georges River study area is described below:

- A Digital Elevation Model (DEM) was constructed from Airborne Laser Scanning (ALS) survey points (flown March 2006).
- Flood grid surfaces for the 100 year flood and Probable Maximum Flood (PMF) were constructed by extending the cross sections shown in Figures 4.5 and 4.6 of the *Georges River FRMS&P*.
- Flood extents for the 100 year flood and PMF were calculated by subtracting the DEM from the respective flood grid surface, and removing minor irregularities.
- The provisional high hazard area for the 100 year flood was assessed using the approach set out in the *Floodplain Development Manual*, Figure L2 (NSW Government, 2005).

The mapped flood risk precincts are plotted on **Figure 3.1**. Flood risk precincts have not been mapped in areas known to be included in local catchment studies, including Oyster Creek and Gwawley Bay. Whilst flood risk precincts are mapped at the lower end of Carina Creek, Kareela Creek and other waterways which may be the subject of future floodplain management studies, the mapping only reflects flooding from the Georges River – no account is taken of additional flows from local catchments.

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.

FIGURE 3.1
FLOOD RISK MANAGEMENT PRECINCTS
SHEET 1 - INDEX PLAN

0 1 2km
Scale

N

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 being in either a high flood risk or medium flood risk precinct

Normal Waterway Area
Area included in high flood risk precinct

Local Catchment FRMS&P Study Area

Sutherland Shire Council Boundary

IMPORTANT NOTES
1. The extent of flood inundation shown is based on results provided in existing flood study reports and available Council ALS data
2. Mapping is for Georges River flooding only and does not include local catchment flooding or stormwater flooding

SEE FIGURE 3.1 - Sheet 2

SEE FIGURE 3.1 - Sheet 3

SEE FIGURE 3.1 - Sheet 4

Limit of Flood Mapping

Oyster Creek FRMS&P Study Area

Gwawley Bay FRMS&P Study Area

Sandy Point
Alfords Point Bridge
Alfords Point
Deadmans Creek
Mill Creek
Georges River
Menai
Illawong
Woronora River
Como Bridge
Como
Carina Creek
Oyster Bay
Kangaroo Point
Tom Ugly's Bridge
Captain Cook Bridge
Georges River
Bonnet Bay
Menai
Bangor
Jannali
Oyster Creek
Kareela Creek
Sylvania
Kareela
Sylvania Waters
Taren Point
Woronora
Sutherland
Miranda
Barden Ridge
Woronora
Kirrawee
Gymea
Gymea Bay
Yowie Bay
Caringbah
Wooloowara
Cronulla
Wooloowara Bay
Kurnell

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LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FIGURE 3.1
FLOOD RISK MANAGEMENT PRECINCTS
SHEET 2

0 — 1km
Scale

N

Sandy Point

Limit of Flood Mapping

Deadmans Creek

HEATHCOTE ROAD

Menai

Alfords Point Bridge

Alfords Point

ROAD

Creek

Mill

POINT

ALFORDS

Georges River

FOWLER

ROAD

Illawong

Menai

Bangor

Woronora

Como Bridge

River

Como

RAILWAY

Jannali

JOINS FIGURE 3.1 - Sheet 3

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 being in either a high flood risk or medium flood risk precinct

Normal Waterway Area
Area included in high flood risk precinct

Sutherland Shire Council Boundary

IMPORTANT NOTES

1. The extent of flood inundation shown is based on results provided in existing flood study reports and available Council ALS data
2. Mapping is for Georges River flooding only and does not include local catchment flooding or stormwater flooding

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LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FIGURE 3.1
FLOOD RISK MANAGEMENT PRECINCTS
SHEET 3

0 — 1km
Scale

N

Georges River

Woronora River

Limit of Flood Mapping

Como Bridge

Como

RAILWAY

Carina Creek

Oyster Bay

OYSTER BAY ROAD

Oyster Bay

Kangaroo Point

Tom Ugly's Bridge

Captain Cook Bridge

HWY

Sylvania

ROAD

Creek

Oyster

Kareela Creek

Jannali

Kareela

PRINCES

BATES DRIVE

Oyster Creek FRMS&P Study Area

SEE FLOOD RISK MANAGEMENT MAPS FOR OYSTER CREEK

Gwawley Bay FRMS&P Study Area

SEE FLOOD RISK MANAGEMENT MAPS FOR GWAWLEY BAY (IN PREPARATION)

Sylvania Waters

BOX ROAD

HACKING

PORT

TARREN POINT ROAD

Taren Point

Wooloowara Bay

JOINS FIGURE 3.1 - Sheet 2

JOINS FIGURE 3.1 - Sheet 4

RAILWAY

Sutherland

THE BOULEVARDE

KINGSWAY

Kirrawee

Gymea

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 being in either a high flood risk or medium flood risk precinct

Normal Waterway Area
Area included in high flood risk precinct

Local Catchment FRMS&P Study Area

Sutherland Shire Council Boundary

IMPORTANT NOTES

1. The extent of flood inundation shown is based on results provided in existing flood study reports and available Council ALS data
2. Mapping is for Georges River flooding only and does not include local catchment flooding or stormwater flooding

Bewsher

File name : J1644-fig3.1 sheet 3
Plot scale : 20 (1:20000 @ a3)
Date : 01 October 2009

LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FIGURE 3.1
FLOOD RISK MANAGEMENT PRECINCTS
SHEET 4

0 1km
Scale

N

Botany Bay

Captain Cook Bridge

Towra Point

Limit of Flood Mapping

JOINS FIGURE 3.1 - Sheet 3

Taren Point

Woolooware Bay

CAWARRA RD

CAPTAIN COOK DRIVE

Kurnell Peninsula

Kurnell

Bate Bay

Cronulla

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 being in either a high flood risk or medium flood risk precinct

Normal Waterway Area
Area included in high flood risk precinct

Gwawley Bay FRMS&P Study Area

Sutherland Shire Council Boundary

IMPORTANT NOTES

1. The extent of flood inundation shown is based on results provided in existing flood study reports and available Council ALS data
2. Mapping is for Georges River flooding only and does not include local catchment flooding or stormwater flooding

Bewsher

File name : J1644-fig3.1 sheet 4
Plot scale : 20 (1:20000 @ a3)
Date : 01 October 2009

LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

3.3 EXISTING FLOOD PROBLEMS

3.3.1 Historical Flooding

Responses to the community questionnaire indicated some properties in the Lower Georges River study area which had experienced mostly very minor flooding in the past. These properties are listed in **Appendix B**. Areas that were mentioned by several respondents are summarised here. A number of people mentioned problems in properties bordering the canal on the southern side of Oyster Bay Oval, especially during king tides. Serious flooding, including shallow over-floor inundation, has been experienced at a few properties in the vicinity of The Promenade and Moray Place, Sylvania, including in 1974. A number of properties in the area of Marra Place and Belgrave Esplanade, Sylvania, have been inundated, including in 1974. Several residents of Woodlands Road, Taren Point, noted flooding problems. Another area with multiple responses was at Sturt Road, Cronulla.

3.3.2 Potential Flooding

The extent of potential flood problems attributable to Georges River flooding was also estimated by counting the number of building footprints in the Lower Georges River study area located within each flood risk precinct (note that no surveyed building floor levels are currently available to facilitate a more precise assessment, though a survey to capture floor levels for the buildings identified here as within the medium flood risk precinct is recommended). This was assessed in a GIS system using a layer of building polygons. **Table 3.2** records the number of buildings, the *centroid* of which is located within each flood risk precinct. The land use was estimated from aerial photography.

No significant buildings are located within the mapped high flood risk precinct. Only 14 houses and 8 commercial/industrial buildings are located within the medium flood risk precinct (100 year flood extent). **Appendix B** provides a list of these addresses with photos where available. The bulk of the buildings exposed to flood risks in the high and medium flood risk precincts are categorised as “other” land uses, including a few “converted boatsheds” for habitable use, though most buildings seem to be boat sheds, pool sheds and garages, which often are located on the waterfront. Many more houses and commercial/industrial buildings are located within the low flood risk precinct (PMF extent).

TABLE 3.2 – Number of Buildings in the Lower Georges River Study Area located within each Flood Risk Precinct

LAND USE	FLOOD RISK PRECINCT		
	HIGH	MEDIUM	LOW
Residential	0	14	160
Commercial/industrial	0	8	48
Other	18	70	144
TOTAL	18	92	352

As judged by the number of houses and businesses located within the 100 year flood extent, the scale of the existing flood problem within the study area is minor compared to many other areas of the State. This reflects the topographic character of the area, with mostly steep river banks that confine the extent of flooding. Exceptions are the foreshore of Woolooware Bay, and where local catchments drain into the river, though the latter areas are often reserved for recreational uses.

Figure 3.2 indicates the buildings located within the medium flood risk precinct, and also indicates the *average* 100 year flood depth *above a ground level* (estimated from the Digital Elevation Model) for the residential and commercial/industrial building polygon footprints at those sites. It is noted that some average "depths" are particularly low, which indicates that flooding is shallow and could be below *building floor* levels, which are not known.[1]

A selection of photos to convey the nature of the flood problem in the Lower Georges River study area is provided in **Figure 3.3**.

3.3.3 Road Inundation

A number of roads within the Lower Georges River study area could be partly inundated by flooding (see **Figure 3.1**). The list below arranges flood-liable roads from upstream (Como) to downstream (Woolooware). Few of these roads are significant routes, and most of these roads would be flooded only in events rarer than the 100 year event. Two important traffic routes that would be affected in the 100 year event are The Promenade at Sylvania and Captain Cook Drive at Woolooware.

- Cremona Road, Como;
- Verona Range, Como;
- Tivoli Esplanade, Como;
- Glenhaven Place, Oyster Bay;
- The Promenade, Sylvania;
- Moray Place, Sylvania;
- Clare Street, Sylvania;
- Koorooma Place, Sylvania;
- Princes Highway exit ramp near Tom Uglys Bridge, Sylvania;
- Marra Place, Sylvania;
- Holts Point Place, Sylvania Waters;
- Lachlan Avenue, Sylvania Waters;
- Hawkesbury Esplanade, Sylvania Waters;
- Alexander Avenue, Taren Point;
- Atkinson Road, Taren Point;
- Mangrove Lane, Taren Point;
- Parraweena Road, Caringbah;
- Northumberland Drive, Caringbah;
- Adventure Place, Caringbah;
- Resolution Drive, Caringbah;
- Endeavour Road, Caringbah;
- Captain Cook Drive, Woolooware (near Toyota Park and Cronulla Golf Course);
- Woolooware Road, Woolooware; and
- Restormel Street, Woolooware.

[1] A negative average "depth" means that although the ground level at the centroid of the building polygon is below the 100 year flood level, elsewhere below the building polygon, the ground level is higher than the flood level.

FIGURE 3.2
BUILDING INUNDATION PATTERNS IN THE 100 YEAR ARI FLOOD

0 1 2km
Scale

N

LEGEND
- 100 year ARI Flood Extent
- Normal Waterway Area
- Local Catchment FRMS&P Study Areas
- Sutherland Shire Council Boundary
- Residential buildings
- Commercial/Industrial buildings
- Other buildings
- 0.24 Average 100yr ARI flood depth over ALS ground at building (m)

Limit of Study Area
Limit of Flood Mapping
Botany Bay
Woronora River
Como Bridge
0.26
Como
Oyster Bay
Kangaroo Point
Georges River
Tom Ugly's Bridge
Captain Cook Bridge
0.30
0.24
-0.05
0.23
0.21
0.22
0.21
0.17
0.04
0.04
0.09
-0.08
0.42
0.17
0.07
0.46
0.52
0.32
0.00
-0.05
Oyster Creek
Kareela Creek
Jannali
Kareela
Sylvania
Sylvania Waters
Taren Point
Woolooware Bay
Miranda
Kirrawee
Gymea
Gymea Bay
Yowie Bay
Caringbah
Woolooware
Cronulla
Bate Bay
-0.22
Oyster Creek FRMS&P Study Area
Gwawley Bay FRMS&P Study Area

Bewsher

File name : J1644-fig3.2
Plot scale : 30 (1:30000 @ a3)
Date : 01 October 2009

LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FIGURE 3.3 – A Selection of Flood-Liable Buildings in the Lower Georges River

a. Café and other businesses at Como Marina

b. Boatshed converted for habitable use, Oyster Bay

c. House and utility, Sylvania

4. CLIMATE CHANGE FLOOD RISK

4.1 BACKGROUND

There is increasing evidence that the temperature of the earth's atmosphere and oceans has increased over the last century, and that the accumulation of greenhouse gases in the earth's environment will accelerate this process in future years. Current estimates indicate that the annual average temperature for Australia could increase by about 1.0°C by 2030 (relative to 1990) and by between 1.8°C to 3.4°C by 2070 (*Climate Change in Australia*, CSIRO/BOM, 2007).

Climate change can potentially affect flood behaviour through:

(1) increased sea levels;

(2) increased severity of flood producing storms or other weather systems; and

(3) increased evaporation (for inland rivers where volumes are important).

The IPCC (2007) reported that the average global sea level may rise between 0.18m and 0.59m by 2100, excluding future rapid dynamical changes in ice flow and uncertainties in climate-carbon cycle feedbacks. The Floodplain Risk Management Guideline on climate change prepared by DECC (2007) added up to 0.2m for ice flow melt uncertainty. Modelling by CSIRO reported in DECC (2007) indicated that mean sea level along the NSW coast could rise by 0.12m more than the global average, meaning that the total sea level could rise by 0.18m to 0.91m by 2100. In addition to these "low level" and "high level" ocean impacts, DECC (2007) also recommended a sea level sensitivity test based on an increase of 0.55m ("mid level" ocean impacts).

A sea level rise policy statement was recently released (NSW Government, October 2009) which notes sea level rise planning benchmarks of 40 cm by 2050 and 90 cm by 2100 (over 1990 sea levels). These projections are subject to further monitoring and review as more data becomes available.

The impact of climate change on rainfall is a topic of greater uncertainty. Evidence to date suggests that whilst mean annual rainfall over much of Australia is likely to decrease, the intensity of extreme daily rainfall could increase. Of interest for flooding is that the La Niña events often associated with flooding in eastern Australia may tend to become wetter (CSIRO/BOM, 2007). A study of rainfall intensity in the Sydney Metropolitan Catchments projected changes of -7% to +10% (for the 1 in 40 year 1 day rainfall event) by 2070 (CSIRO, 2007), although a footnote stated that "given strong rainfall gradients in extreme rainfall projections, these results may not be applicable for Sydney". It is understood that at the time the climate change sensitivity test for this study was conducted (December 2008), CSIRO was in the process of finalising more detailed estimates for the Sydney region. In the absence of more precise estimates of changes in rainfall intensity for the 100 year event, this study adopted a figure of +10% as per the upper limit for the Sydney Metropolitan Catchments recorded in CSIRO's 2007 report.[2]

[2] Another reason for adopting a 10% increase in rainfall intensities for the climate change sensitivity test was that this was the only event for which flow data was readily available from earlier studies (PWD, 1991). Other sensitivity tests would have required detailed hydrological modelling, which is beyond the scope of the current study.

4.2 CLIMATE CHANGE SENSITIVTY MODEL RUN

As reported in **Section 3.1**, the design flood levels for the Georges River floodplain are based on the higher of the levels from (1) modelling of river flood flows, and (2) estimated storm tide levels for Botany Bay. **Figure 4.1** plots a profile of the 100 year flood from Deadmans Creek (at the LGA boundary) to Botany Bay. It shows that the design 100 year profile is set by the river flood flows from Deadmans Creek to the Como Railway Bridge near the Woronora River junction, and by the estimated storm tide levels from Como Bridge downstream. Thus, under existing conditions, the 100 year design flood levels for the Lower Georges River study area are dominated by ocean storm tide levels in Botany Bay.[3]

The MIKE-11 computer model used to simulate flood conditions in the Georges River was used to test the sensitivity of the 100 year flood levels to climate change. Two aspects of climate change were tested – increased sea levels and increased rainfall intensities, as discussed in the previous section.

Figure 4.2 shows the influence of raising the Botany Bay tailwater level on the 100 year flood level for the Georges River upstream to Deadmans Creek. The upper bound is for the high sea level rise scenario and the lower bound is for the low sea level rise scenario. Given the dominance of the ocean on flood levels in the Lower Georges River study area, the flood levels would rise by the same amount as the sea level rise.

Figure 4.3 shows the influence of sea level rise, *and* increasing the rainfall intensities in the flood model by 10%, on the 100 year flood level for the Georges River upstream to Deadmans Creek. It shows that the influence of increased rainfall dominates the influence of increased sea levels only upstream of the 29 km chainage. Increased rainfall intensity has no impact on the 100 year design flood profile throughout the Lower Georges River study area (i.e. downstream of Como Railway Bridge), which is dominated by oceanographic conditions.

The magnitude of the increases in 100 year flood levels as a result of the three sea level rise scenarios (low, medium and high) and the increased rainfall intensity (by 10%) is summarised in **Table 4.1** for six cross section sites in the model.

The areal extent of the additional land in the Lower Georges River study area that would be inundated in the 100 year flood under each of the three sea level rise scenarios is mapped in **Figure 4.4**. The most affected area would be the foreshore of Woolooware Bay.

[3] Of the modelled design floods, only in the PMF are flood levels in the Lower Georges River study dominated by river flood flows (see the *Georges River FRMS&P*, Figure 4.6).

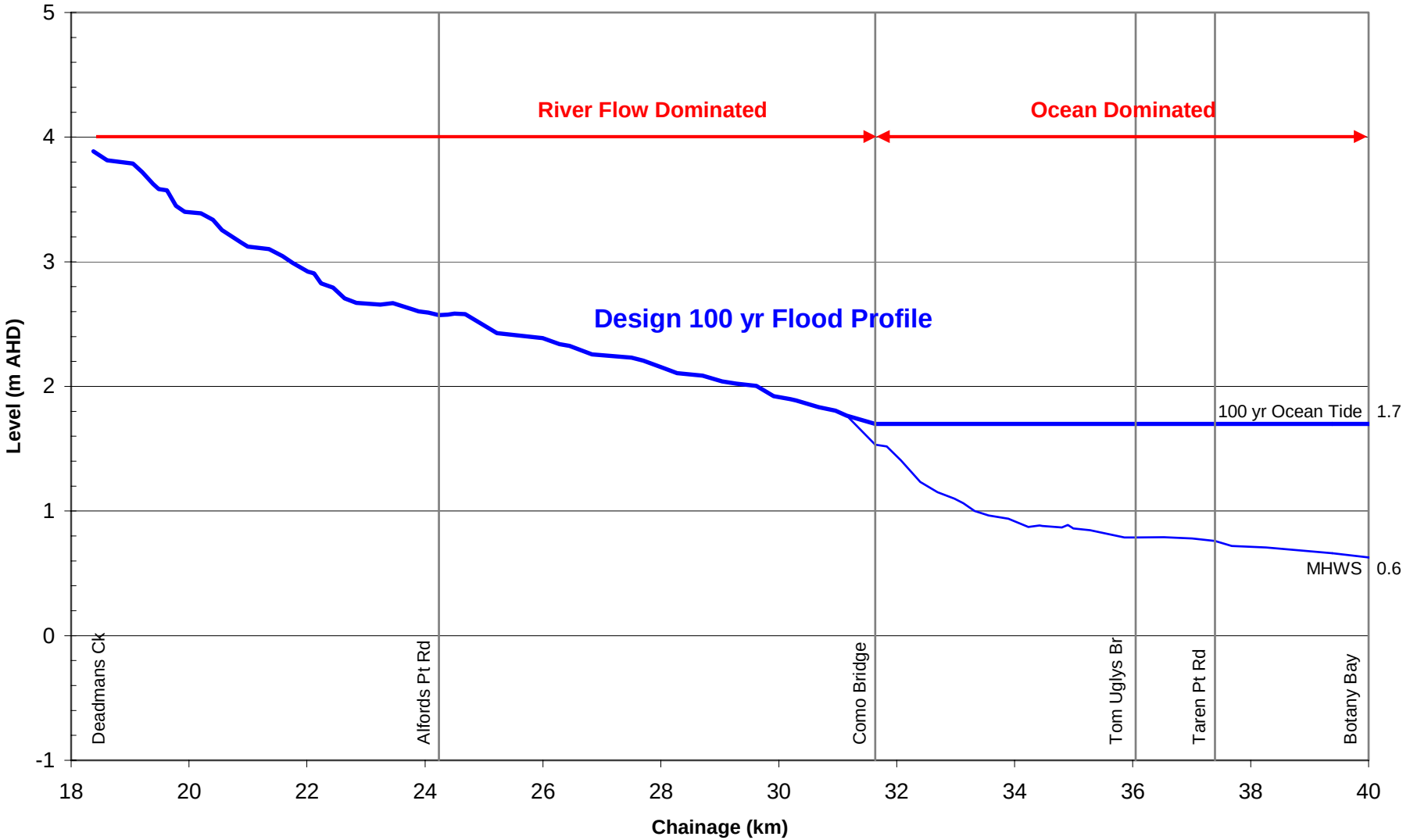

FIGURE 4.1 – Flooding Mechanisms on the Georges River

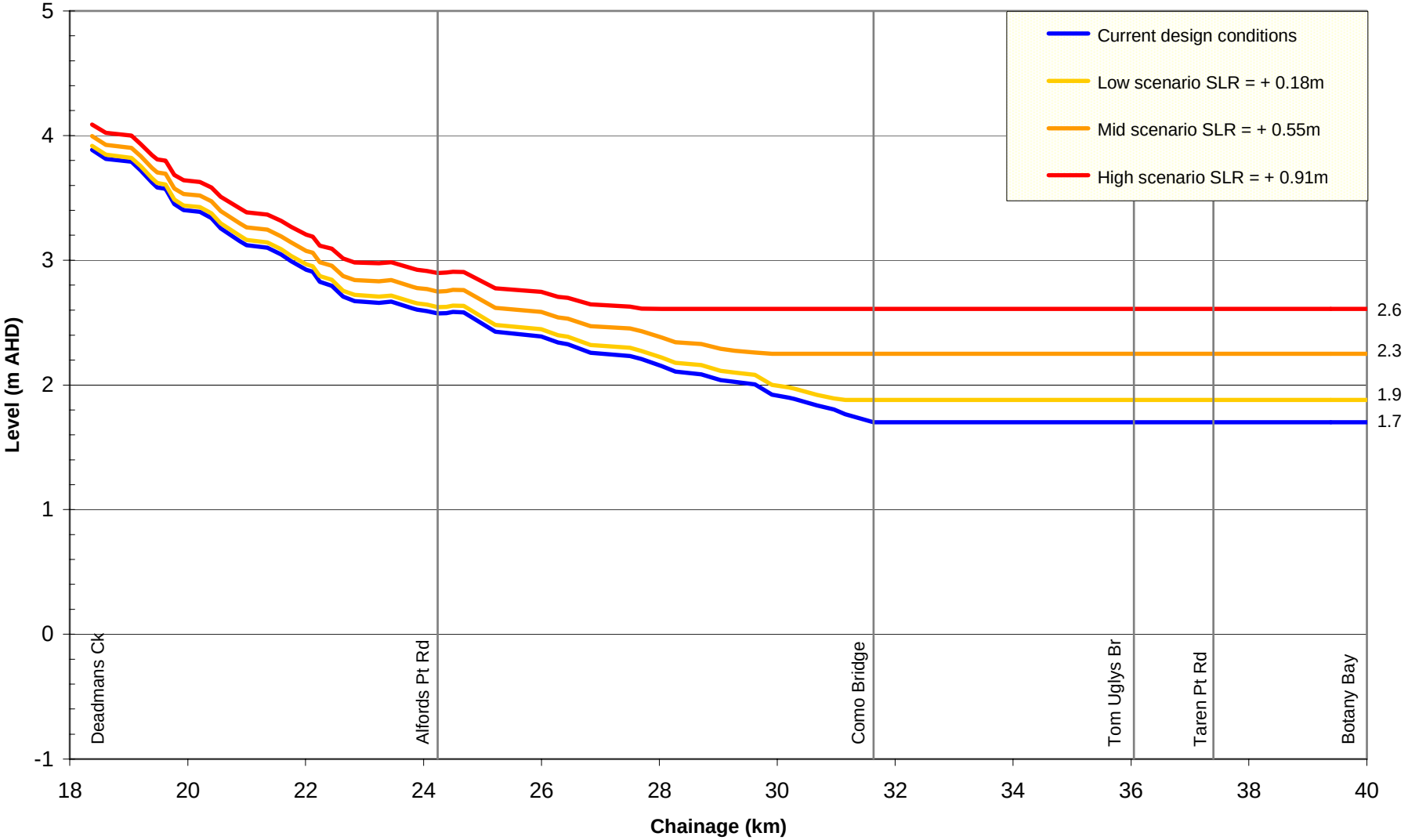

FIGURE 4.2 – Influence of Sea Level Rise on 100 Year ARI Flood Levels, Georges River

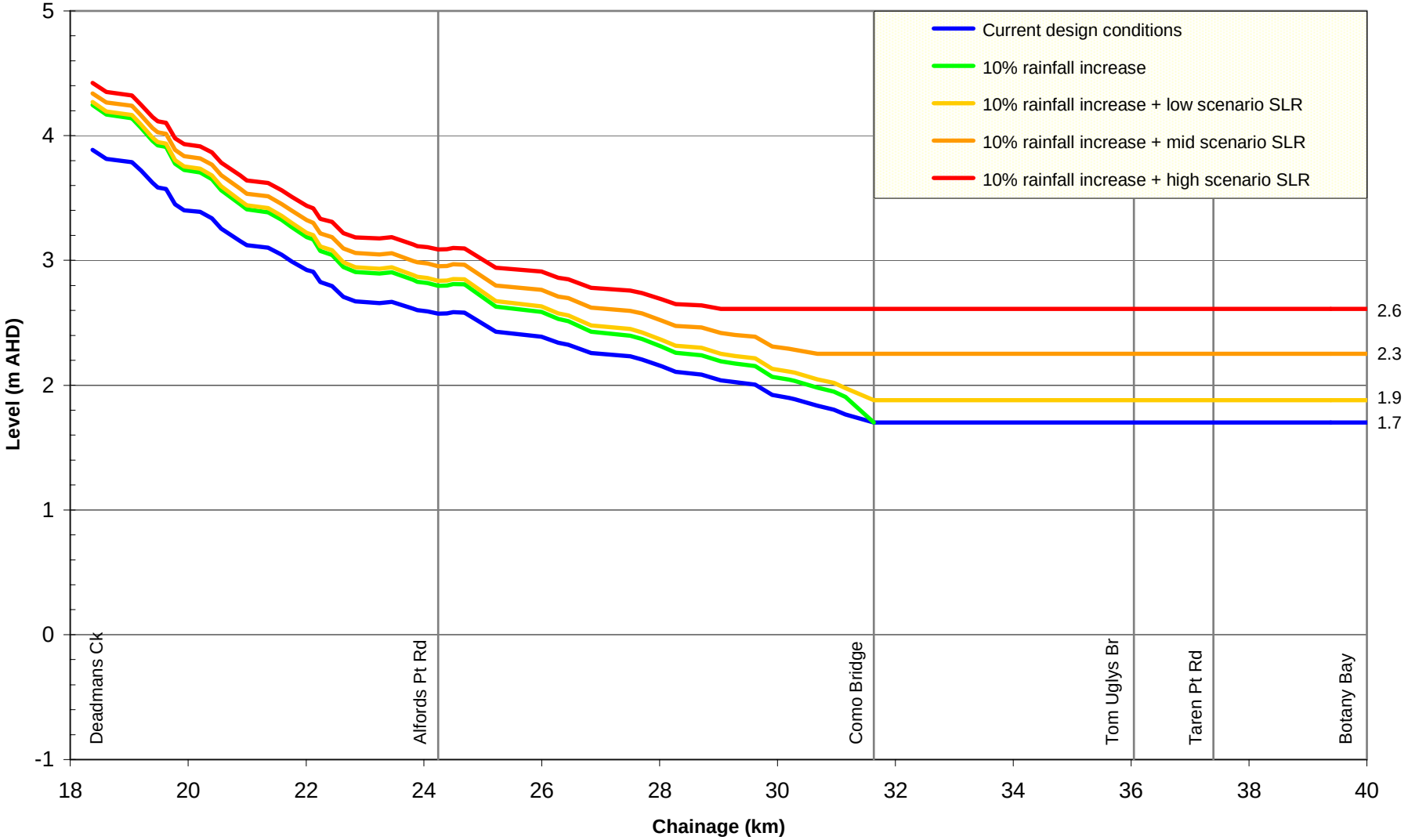

FIGURE 4.3 – Influence of Sea Level Rise and Increased Rainfall Intensity on 100 Year ARI Flood Levels, Georges River

TABLE 4.1 – Increases in 100 Year ARI Flood Levels due to Sea Level Rise and Increased Rainfall Intensity, Georges River (m)

		Georges R. Study Area		Lower Georges R. Study Area			
	Location	**Deadmans Creek**	**Alfords Point**	**Como Bridge**	**Tom Uglys Bridge**	**Taren Point**	**Botany Bay**
	Chainage in model	18380	24240	31635	35050	37395	40515
Sea level rise	Low SLR	0.03	0.05	0.18	0.18	0.18	0.18
	Mid SLR	0.11	0.18	0.55	0.55	0.55	0.55
	High SLR	0.20	0.33	0.91	0.91	0.91	0.91
Additional increase with 10% rainfall ↑	Low SLR	0.35	0.21	0	0	0	0
	Mid SLR	0.35	0.20	0	0	0	0
	High SLR	0.33	0.19	0	0	0	0
Total increase	Low SLR	0.38	0.26	0.18	0.18	0.18	0.18
	Mid SLR	0.46	0.38	0.55	0.55	0.55	0.55
	High SLR	0.53	0.52	0.91	0.91	0.91	0.91

FIGURE 4.4
POTENTIAL INFLUENCE OF CLIMATE CHANGE ON 100 YEAR ARI FLOOD LEVELS

0 1 2km
Scale

IMPORTANT NOTES

1. The extent of flood inundation is based on available Council ALS data
2. Mapping is for Georges River flooding only and does not include local catchment flooding or stormwater flooding

N

LEGEND

- Normal Waterway Area
- Local Catchment FRMS&P Study Areas
- Sutherland Shire Council Boundary

100 year Flood Extent

- Existing conditions
- Additional area inundated by Low Sea Level Rise (+0.18m)
- Additional area inundated by Medium Sea Level Rise (+0.55m)
- Additional area inundated by High Sea Level Rise (+0.91m)

Limit of Study Area

Limit of Flood Mapping

Woronora River
Como Bridge
Como
Oyster Bay
Carina Creek
Kangaroo Point
Oyster Bay
Georges River
Tom Ugly's Bridge
Captain Cook Bridge
Botany Bay
Jannali
Oyster Creek
Kareela
Kareela Creek
Sylvania
Sylvania Waters
Taren Point
Oyster Creek FRMS&P Study Area
Gwawley Bay FRMS&P Study Area
Miranda
Kirrawee
Gymea
Gymea Bay
Yowie Bay
Caringbah
Wooloowa
Wooloowa Bay
Cronulla
Kurnell
Bate Bay

Bewsher

File name : J1644-fig4.4
Plot scale : 30 (1:30000 @ a3)
Date : 07 October 2009

LOWER GEORGES RIVER FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

5. FLOODPLAIN RISK MANAGEMENT MEASURES

Floodplain management measures can be divided into three general groups:

(1) those that modify flood behaviour;

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

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

Measures that modify flood behaviour usually include structural works that attempt to lower flood levels, or to protect properties from flooding. These type of measures are those most favoured by the community (see **Table 2.3**), including dredging the bays and river, and enhancing protection through higher seawalls.

Measures that modify property in order to minimise flood damage include voluntary house purchase, voluntary house raising, "flood-proofing" and planning controls.

Measures that modify people's response to flooding include flood warning systems, emergency management planning and public awareness of the flood risk.

A range of assessment criteria have been used for evaluating potential floodplain management measures within the study area. These are described below.

- *Number of buildings protected in the 100 year flood*

  A prime indicator of the effectiveness of a measure in reducing the potential for flood damage and the risk to life is the reduction in the number of buildings that are affected by significant floods. Compared to many areas of NSW, few houses seem to be at risk of flooding (**Section 3.3.2**) in the Lower Georges River study area, though this is likely to increase with sea level rise.

- *Financial feasibility*

  Measures proposed within the FRMP must be capable of being funded. There are various sources of funding that may be utilised, including funding related to the development of new release areas (Section 94 Contributions) and funding from Council, often with assistance from the Government's Floodplain Management Program administered by DECCW, for the alleviation of existing flood problems.

- *Economic merit*

  The ratio of the benefit divided by the cost (i.e. the benefit/cost ratio) is a common measure of assessing economic feasibility. Theoretically, no investment should be made on a measure if the benefit/cost ratio does not exceed one (i.e. if the benefits do not exceed the costs). However, traditionally many floodplain risk management measures have been undertaken where this is not the case because the intangible benefits (i.e. social benefits and reduced risks to life, which are not readily quantified) are considerable.

- *Community acceptance*

  An understanding of community attitudes towards any proposed floodplain management measures is essential. Strongly negative community attitudes often would be enough to deter the implementation of a proposal which otherwise had merit. Community ideas on potential floodplain management measures were collected through distribution of the community questionnaire. These results were discussed in **Section 2.3**. Further opportunity for comment was provided during public exhibition of the draft Lower Georges River FRMP (**Section 2.4**).

- *Environmental impact*

  Floodplain management measures involving structural works may often have significant environmental impacts. Impacts such as those on vegetation, habitat, biodiversity, Aboriginal heritage, visual amenity and soil erosion/sedimentation must be considered when evaluating works within floodplains.

- *Impact on flood behaviour*

  The impact on flood behaviour caused by any measure needs to be considered for upstream and downstream locations. These impacts can include changes in flood levels, changes in velocities or alteration of flow directions. Reducing impacts in one location can lead to adverse impacts elsewhere (e.g. clearing riparian vegetation in upper catchment areas or filling significant flood storage areas is – in the absence of compensatory measures – expected to increase downstream flows).

- *Performance during large floods*

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

- *Technical feasibility*

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

- *Political/administrative feasibility*

  Any recommended measure will have more chance of success if it involves little if any disruption to current political and administrative structures, attitudes and responsibilities. Council and other authorities also have various strategic objectives concerning development within the study area.

The *Lower Georges River FRMS&P* is viewed as an addendum to the Georges River FRMS&P (Bewsher Consulting, 2004). A detailed discussion of valley-wide floodplain management measures is provided in the 2004 report. Some measures of particular relevance to the study area are described below.

5.1 FLOOD MITIGATION DAM IN THE UPPER CATCHMENT

Findings: Not recommended due to negligible benefits, high capital costs and environmental concerns.

A flood mitigation dam could temporarily store floodwater in the upper catchment area during floods, releasing water at a controlled rate, thereby reducing flood levels downstream. However, in the Lower Georges River study area, reduced river flows would only be of benefit in an event without influence from storm tides – the entire study area (i.e. downstream of Como Railway Bridge) is dominated by the elevated ocean level up to and including the 100 year event (**Figure 4.1**). Even further up the river where a flood mitigation dam was found to have significant benefits, the high capital costs and environmental concerns were sufficient to exclude the option of a flood mitigation dam from the recommended *Georges River FRMP* (Bewsher Consulting, 2004, pp.94-97).

5.2 DREDGING

Findings: Not recommended due to negligible benefits, high and ongoing costs and significant environmental concerns.

Dredging of the Lower Georges River (including bays such as Oyster Bay) to increase the capacity to carry floodwater was a popular option suggested by the community (**Table 2.3**). While there may be merit in dredging watercourses for improved navigability, its benefits for flood mitigation would be negligible in the study area, where flooding up to and including the 100 year event is predominately influenced by Botany Bay storm tide levels (**Figure 4.1**). Even further up the river where dredging was found to have some benefits, the low benefit-cost ratio, the need for repeated dredging and significant environmental concerns were sufficient to exclude the option of river dredging from the recommended *Georges River FRMP* (Bewsher Consulting, 2004, pp.97-99).

5.3 LEVEES

Findings: Not recommended due to low economic merit, aesthetic impacts and complications with internal drainage. Review if sea level rise pronounced.

A number of respondents to the questionnaire suggested some form of embankments to combat flooding and the potential for higher floods and shoreline erosion with sea level rise (**Table 2.3**). Indeed, some respondents described how they were in the process of raising their sandstone seawalls.[4]

Several points may be made about the merits of a levee strategy to address flooding problems in the Lower Georges River study area:

[4] Initial advice from Council is that the construction, replacement or repair of seawalls is prohibited with the exceptions of: (1) Sylvania Waters; (2) Zones 1,2,3,4,12,13 or 15; (3) in Zones 13,14 and 16 (with consent), where beach and foreshore protection works (including seawalls) are proposed by a *public authority* and authorised by a *plan of management*; and (4) where seawalls have the benefit of existing use rights. The Zones are defined in *Sutherland Shire Local Environmental Plan (SSLEP) 2006*.

- Existing flood problems are on the whole relatively minor (**Section 3.3**), meaning that the economic merit of State funded levee schemes would be low;
- The houses exposed to flood risks are for the most part widely distributed (**Figure 3.2**), reinforcing the point about the low economic merit of State funded levee schemes;
- Levees or seawalls constructed on an ad hoc basis by individual property owners can cause adverse erosion and flood effects on any unprotected adjacent properties;
- Such ad hoc efforts may also have adverse aesthetic impacts, including the appearance from the waterway, and the possible loss of views to the waterway; and
- Levees need to be designed with pumps to remove any local overland flow trapped behind the levee, which could also make their construction impractical.

In summary, then, a levee strategy to manage flooding problems in the Lower Georges River study area is generally not recommended due to the low economic merit, effects on visual amenity and complications in addressing internal drainage issues. One exception could be in the area of Woodlands Road, Taren Point, where four residents reported minor flooding in the historical record (**Table B1**), and three (other) houses were identified as being located within the medium flood risk precinct (**Table B2**). A digital elevation model for the area, derived from Council's ALS survey, is shown in **Figure 5.1**. It shows that several properties have areas of low-lying ground, from about 1.4–1.6m AHD (green colour). A photograph at the northern end of the Taren Point Shorebird Reserve during a king tide event also conveys the low-lying nature of this area (**Figure 5.2**).

Several levee options for this area have been considered. The three waterfront properties immediately north of the Taren Point Shorebird Reserve could potentially be protected from river flooding by a wall extending along the Georges River boundary and along the southern boundary of No. 64 Woodlands Road. A simple damages database was prepared using:

(1) the design flood levels reported in the *Georges River FRMS&P* (Bewsher Consulting, 2004) with a 5 year flood level of 1.4m AHD taken from **Table 3.1**,

(2) estimated ground and floor levels derived from the ALS survey and photography (**Table B2**); and

(3) the DECC (2007) *Residential Flood Damages* guideline, tailored to the Lower Georges River study area.

This suggests that the present value of actual damages for these three houses is only $29,000. A low flood wall (up to about 0.7m over ground to provide 500mm freeboard over the existing 100 year flood level) would likely cost considerably more than the sum total of property at risk, so the benefit-cost ratio would be unfavourable. However, with a mid range sea level rise of 0.55m (**Table 4.1**), the design flood levels would rise, increasing the present value of actual damages to $627,000. In such a scenario, a flood wall would be a more economically attractive option, though it would need to be raised higher (up to about 1.3m over ground) to provide the same level of protection. Such a height would probably be unappealing to the owners of these waterfront properties. A levee at this site is not recommended at the current time, but this option could be given further consideration at the next review of the *Lower Georges River FRMS&P* when better estimates of sea level rise may be available.

Flooding problems at Nos. 66 to 94 Woodlands Road could potentially be mitigated by an earthen embankment either within the Taren Point Shorebird Reserve or at their rear fence lines. The first option may be incompatible with the environmental objectives contained in the Masterplan prepared for the Reserve (Environmental Partnership, 2009). In particular, the Reserve is home to an endangered ecological community listed in the *NSW Threatened Species Conservation Act 1995*. The second option may be unacceptable because of the

FIGURE 5.1 – Digital Elevation Model, Woodlands Road, Taren Point

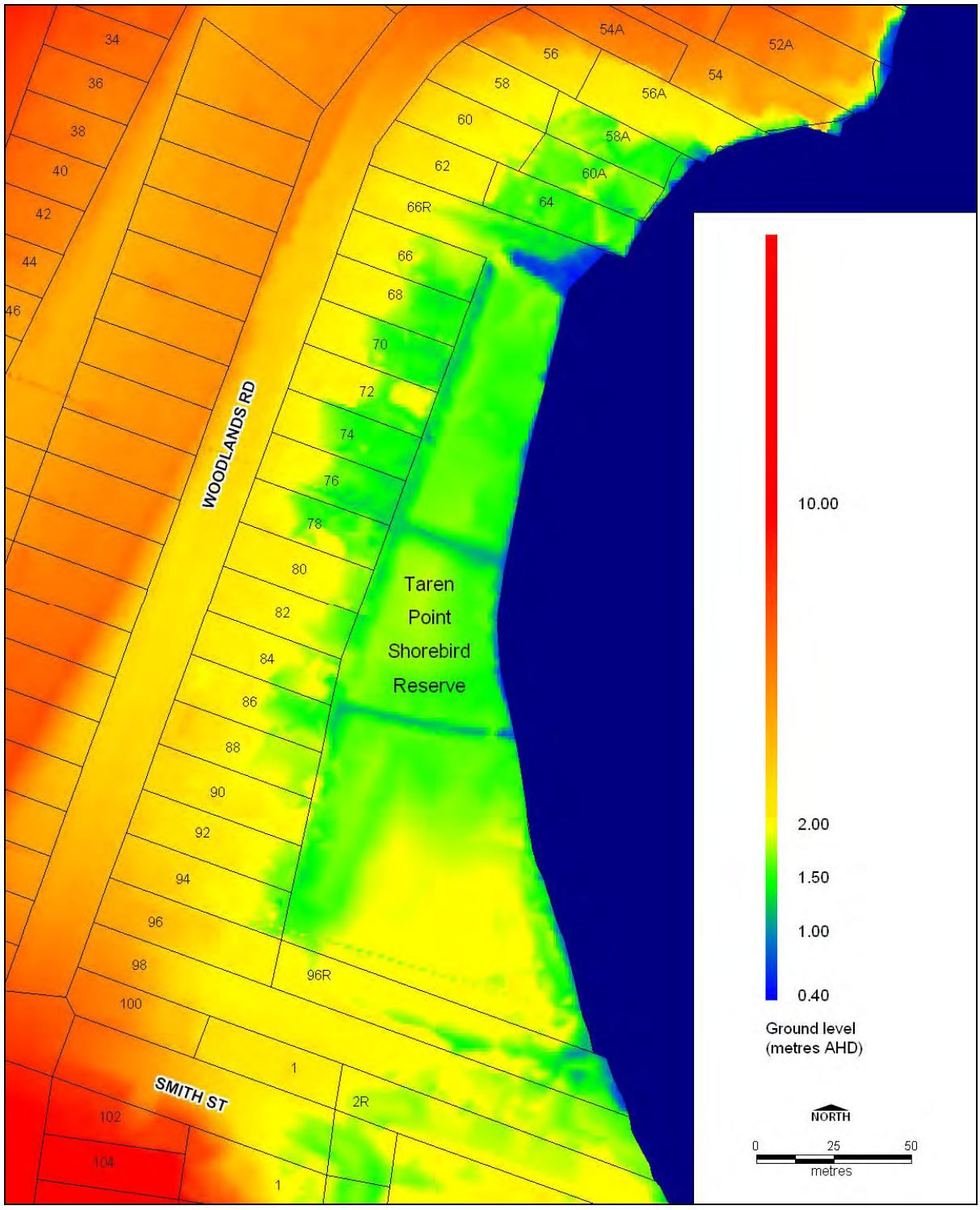

FIGURE 5.2 – King Tide at 64 Woodlands Road, 9.46 a.m., Monday 12th January 2009
(Source: Council)

loss of residents' views[5] and the difficulties of dealing with internal drainage i.e. runoff trapped behind the levees. Accordingly, an embankment is not recommended.

From residents' descriptions of the problem, the issues at Nos. 66 to 94 Woodlands Road have more to do with local drainage following heavy rain than with flooding from the Georges River, and as such are beyond the scope of this study. Nevertheless, the issues of concern to the residents are noted here:

- Possible uncontrolled runoff from Taren Point Road through their properties;
- The effect of some individual residents filling the swale on stormwater drainage;
- The effect of works associated with the proposed Taren Point Shorebird Reserve on water levels.

It is noted that the Masterplan prepared for the Reserve proposes to retain the swale that runs along the rear of the residences in Woodlands Road, but to pipe the southernmost swale outfall (Environmental Partnership, 2009). We also note that at the meeting of 2 February 2009, Council resolved to endorse the Taren Point Reserve Masterplan subject to various amendments, including "repairs to the drainage system, in particular stormwater pipes in the Reserve" and "[consideration of] tidal movements and flooding issues".

[5] It is noted that some properties have rear fences while others open directly onto the Reserve. With an existing ground level low-point of about 1.3m AHD, an embankment along the fence line would need to be up to 0.9m high to protect against the existing 100 year flood plus 500mm freeboard, and 1.5m high to protect against the 100 year flood with mid range sea level rise scenario.

5.4 FLOOD PROOFING

Recommendation: Prepare a brochure outlining potential flood-proofing techniques.

Individual properties can be modified to reduce the impacts of flooding through flood aware design. *Reducing Vulnerability of Buildings to Flood Damage* (HNFMSC, 2007) details the many ways buildings and building components can be designed to minimise the impact of flooding. Council's Development Control Plan 2006 lists flood compatible building materials to be applied when developing or redeveloping buildings located in the floodplain. For existing buildings, there may still be some opportunity to apply "flood-proofing" techniques. Fairfield City Council provided subsidies of up to $20K for double-brick or two storey houses (i.e. houses unable to be raised) to assist in flood proofing the lower ground floor by raising electrical power points, installing a water sensor device to shut off power, replacing building materials liable to flood damage, and constructing local flood walls (Frost & Rice, 2003).

Given the relatively shallow flooding expected in the Lower Georges River study area, property-modifying strategies such as voluntary house purchase and voluntary house raising are unlikely to be justifiable economically. Some support for flood-proofing may be more appropriate. One strategy would be for Council to produce a brochure outlining techniques for flood-proofing, at a cost of about $20K. This could be placed on Council's web-site and distributed to properties affected by the 100 year flood.

5.5 PLANNING CONTROLS

Recommendations:

1) *Review the flood risk management provisions in the amended Sutherland Shire DCP 2006.*
2) *Amend Sutherland Shire DCP 2006 to include a freeboard of 800mm (where 500mm currently applies) for the Lower Georges River study area.* **See Addendum**

5.5.1 Review of Planning Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Lower 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.

A comprehensive review of flood risk management policies was undertaken as part of the *Georges River FRMS&P* for Fairfield, Liverpool, Bankstown and Sutherland Councils (Don Fox Planning, 2004). Consistent planning and development controls were recommended for each of the four councils, to be applied through flood risk management Development Control Plans (DCPs). A schedule of planning controls for use in the assessment of individual development applications was formulated specifically for the Georges River floodplain, and an interim schedule was prepared for "All other floodplains including areas affected by local overland flooding" pending the completion of flood risk management studies in these other areas.

The schedules provided a graded set of planning controls tailored to the proposed land use and flood risk, and which recognise flood risks up to and including the probable maximum flood. Three different categories of flood risk were adopted – namely the *High*, *Medium* and *Low* flood risk precincts. These same flood risk precincts have been defined for the Lower Georges River study area, as detailed in **Section 3.2**.

Council endorsed the floodplain risk management provisions recommended in the *Georges River FRMS&P* (Don Fox Planning, 2004), and with some modifications, incorporated these into the *Sutherland Shire Development Control Plan (SSDCP) 2006*. The flood risk management provisions of the DCP were subsequently modified by Amendment 3 to SSDCP 2006, which came into effect on 9 January 2009. A preliminary review of the amended SSDCP 2006 indicates that some significant changes have been made to the original DCP:

- An additional flood risk category has been added, namely land mapped with an "Initial Assessment of Potential Flood Risk";
- In response to the Department of Planning's 2007 Flood Planning Guideline, flood-related development controls are not imposed on residential development above the Flood Planning Level (FPL) (refer to **Section 5.5.3**);
- Instead of a capacity for schedules to be attached to the DCP for individual catchment areas, the format is more text-based;
- The controls in the amended DCP appear to be more conservative than previously (e.g., in requiring open car parking spaces to be no lower than the 100 year flood, rather than the 20 year flood).

A thorough review of the flood risk management component of SSDCP 2006 is beyond the scope of the current study, but is recommended for future action. As well as considering the issues identified above, a review could incorporate climate change flood risk.

For the purposes of the current study, our interest is whether the current DCP provisions appropriately manage flood risks in the Lower Georges River study area.

5.5.2 Freeboard

Freeboard is defined as a factor of safety typically used in relation to the setting of floor levels above the design flood level. It 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 (NSW Government, 2001).

Habitable floor level controls for residential, commercial/industrial and tourist related development are set to the 1% AEP (100 year) flood plus 500mm freeboard in the current DCP. The same level including 500mm freeboard is used for the provisions relating to flood compatible building components, structural soundness and the storage of goods. An assessment of the potential impacts of climate change on flood levels in the Lower Georges River study area found that 100 year levels might increase by between 0.18 and 0.91m depending on the magnitude of sea level rise (**Table 4.1**). While the range of sea level rise points to a good deal of uncertainty, it appears that the existing freeboard allowance of 500mm may be inadequate, recalling that climate change is only one of the uncertainties for which a freeboard is intended to provide a factor of safety. As a precautionary step, and subject to (upwards or downwards) revision as better information becomes available, it is recommended that the current 500mm freeboard be increased to 800mm for the Lower Georges River study area. This additional factor of safety can be implemented for new buildings with relative ease. **See Addendum**

Flood levels upstream of Como Bridge are less influenced by sea level rise and more dominated by rainfall (**Figure 4.1**), the changes to which under a warmer climate are still highly uncertain (**Section 4.1**). In addition, the rainfall intensity-frequency-duration (IFD) data is currently under review, so improved information is expected in the next few years. For these reasons, it is recommended that the current freeboard of 500mm be retained in these areas until a later review can take advantage of improved IFD data and improved rainfall projections with climate change.

Adoption of varied freeboards for different areas of the Sutherland Local Government Area will require amendments to the DCP development controls and additional clauses relating uniquely to the Lower Georges River study area.

5.5.3 Flood Planning Guidelines

On 31st January 2007 the NSW Planning Minister announced a new guideline for development controls on floodplains (the "2007 Flood Planning Guideline").

An overview of the new guideline and associated changes to the Environmental Planning and Assessment Act and Regulation was issued by the Department of Planning in a Circular dated 31st January, 2007 (Reference PS 07-003). The new guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act and Regulation and the Floodplain Development Manual, the implications of which are summarised as follows:

a) Guideline on Development Controls in Low Flood Risk Areas – Floodplain Development Manual

A discreet Guideline has been issued to provide additional guidance on matters dealt with in the Floodplain Development Manual. This Guideline effectively provides an amendment to the Manual. It confirms that unless there are "exceptional circumstances", Council's are to adopt the 100 year flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstances" justification being agreed to by the Department of Natural Resources (now Department of Environment, Climate Change and Water) and the Department of Planning prior to the exhibition of a Draft LEP or Draft DCP.

The Guideline provides conflicting statements in regard to what is the residential flood planning level for the purpose of applying the directions in the Guideline. Despite noting the flood planning level for typical residential development would generally be based around the 100 year flood plus a freeboard of typically 0.5m, the Guideline "confirms" that "unless there are exceptional circumstances, Councils should adopt the 100 year flood as the flood planning level for residential development." Senior officers of the Department of Planning have subsequently advised that the flood planning level is inclusive of freeboard, and this has been included in a draft Q&A document issued to the Floodplain Management Authorities of NSW in a letter dated 28th March 2008 from the Department of Planning.

b) Amendment to Regulation on Section 149 Certificates

Schedule 4 of the Environmental Planning and Assessment Regulation was amended, commencing on 16th February, 2007, to specify flood related information that can be shown on Section 149(2) Certificates. The amendment will require Councils to distinguish between the situation where there are flood related development controls on nominated types of "residential development" and all other development. More sensitive land uses such as group homes or seniors living are excluded from the limitation of notations for residential development.

Clause 7(A)(1) of the Regulation means that Council should not include a notation for residential development on Section 149(2) Certificates in "low risk areas" if no flood related development controls apply to the land. Under Clause 7(A)(2) Council can include a notation for critical infrastructure or more flood sensitive development on Section 149(2) Certificates in low flood risk areas if flood related development controls apply. Low flood risk areas are undefined, but in the context of the Circular it is assumed to be a reference to that part of the floodplain between the 100 year flood (plus freeboard) and the PMF extents.

c) Section 117 Ministerial Direction No. 4.3 – Flood Prone Land

Section 117 Direction No. 15 – Flood Prone Land was revised on 31st January, 2007 and is now known as Section 117 Direction No. 4.3. The principal implication of the revision of the Direction was to introduce provisions to limit the imposition of LEP controls on residential development within that part of the floodplain above the 100 year flood level. This limitation is specifically set out in Clauses (4) and (5) of the Direction as follows:

"(4) A draft LEP must not impose flood related development controls above the residential flood planning level for residential development on land, unless a council provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

(5) For the purposes of a draft LEP, council must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a council provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General)."

Clause (6) of the Direction specifies circumstances which must be satisfied in order for the Director-General or nominee to allow for a variation to the Direction, as follows:

"(6) A draft LEP may be inconsistent with this Direction only if council can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that any particular provision or area should be varied or excluded having regard to the provisions of section 5 of the Environmental Planning and Assessment Act, and

(a)the rezoning is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual, 2005, or

(b)the rezoning, in the opinion of the Director-General (or an officer of the Department nominated by the Director-General) or minor significance."

Council adopted an amendment to SSDCP 2006 on 9 January 2009 to comply with the above directions, including the directions pertaining to flood notations on S.149 Certificates. It is considered that the amended DCP is consistent with the Guideline, since it does not apply flood related development controls to residential development in the area above the flood planning level. Despite the DCP amendments, Council is mindful of its obligations under the NSW Flood Prone Land Policy as set out in the Floodplain Development Manual. Flood notations will still appear on S.149 Certificates for residential properties in "low" flood risk areas, but only in the non-mandatory S.149(5) part of the certificate.

5.6 FLOOD WARNING SYSTEMS

Findings: Current services adequate for Lower Georges River study area.

According to the NSW State Flood Sub Plan (June 2008), the Bureau of Meteorology provides flood warnings for river gauges at Liverpool Weir, Milperra and East Hills (Picnic Point) on the Georges River, with at least six hours' notice required. The Bureau is also involved in a local flash flood warning system for the Woronora River. A flood warning tool was developed for the NSW State Emergency Service (SES), initially using the property database prepared for the Georges River study area, which translates flood height predictions at river gauge locations into aerial maps and specific property inundation predictions (Gissing et al., 2004; Bewsher Consulting, 2005).

As has been noted, for events up to and including the 100 year event, flood levels in the Lower Georges River study area are expected to be dominated by Botany Bay storm tide conditions rather than flooding from the upper Georges River (**Figure 4.1**). Specific flood warnings are not issued for Botany Bay. However, more general services such as Severe Weather Warnings are provided. These are issued for synoptic scale events such as "east coast lows" when one or more of the following hazardous phenomena are forecast:

- damaging winds (peak wind gusts 90 km/hr or more);
- gale force winds (average 10-minute wind speed of 63 km/hr or more);
- widespread blizzards in Alpine areas;
- heavy rainfall that is conducive to flash flooding;
- abnormally high tides caused by winds (expected to exceed highest astronomical tide);
- unusually large surf waves expected to cause dangerous conditions on the coast.[6]

In the Lower Georges River study area, Severe Weather Warnings are expected to be sufficient to alert the community to dangerous flooding conditions. The large flood storage area in the Lower Georges River estuary should mean a relatively slow rise, though wind-driven waves might rise higher. Given the typically sloping topography in the area, in most cases people will be able to avoid the rising water by driving or walking up hill. The longest distance from a house to land above the existing PMF floodplain is about 300 metres.

[6] www.bom.gov.au/catalogue/warnings/WarningsInformation_SW_Ed.shtml. Low barometric pressure can also raise sea levels.

5.7 EMERGENCY MANAGEMENT PLANNING

Recommendation: Revise Sutherland Local Flood Plan with information from this study.

It is understood that the Sutherland Local Flood Plan (LFP) is currently in the process of being updated (Jim Pullin, Sutherland Unit SES, pers. comm.). We recommend that information developed as part of the *Lower Georges River FRMS&P* be included in the revised LFP. This includes:

- information about historical flood effects at properties (**Section 3.3.1**; **Appendix B**);
- information about design flood effects at properties (**Section 3.3.2**; **Appendix B**);
- information about roads subject to inundation (**Section 3.3.3**); and
- mapping of different flood risk areas (**Figure 3.1**).

These measures can be implemented now at minimal cost, and are therefore recommended as part of the *Lower Georges River Floodplain Risk Management Plan*.

5.8 PUBLIC AWARENESS

Recommendation: Increase and sustain public flood readiness by issuing certificates (Council), preparing a FloodSafe brochure (SES) and preparing a floodplain management web-site (Council).

Actual flood damages can be reduced, and safety increased, where communities are "flood-ready".

> *"People who understand the environmental threats they face and have considered how they will manage them when they arise will cope better than people who lack such comprehension… Many people who live and work in flood liable areas have little idea of what flooding could mean to them – especially in the case of large floods of severities well beyond their experience or if a long period has elapsed since flooding last occurred. It falls to the combat agency, with assistance from councils and other agencies, to raise the level of flood consciousness and to ensure that people are made ready for flooding. In other words, flood-ready communities must be purposefully created. Once created, their flood-readiness must be purposefully maintained and enhanced."* (Keys, 2002, p.52)

> *"The challenge is not in gaining the attention of the community… but in changing the community's attitude and behaviour towards* flooding*."* (FEAC, 2006)

Comments on the community questionnaire give the impression that many people in the Lower Georges River study area are unconcerned about flooding risks. Indeed, the assessment of flood problems in this report indicates that compared with many areas of the State, the magnitude of the problem is relatively minor. However, this is no grounds for complacency, and Council along with the SES is mandated in the *Floodplain Development Manual* (NSW Government, 2005) to promote flood awareness and readiness. This section explores measures for promoting community flood readiness in the Lower Georges River floodplain.

5.8.1 Certificates

In the Consultant's view, perhaps the key measure for raising a community's awareness of flooding is via the *regular* issuing of flood certificates to all occupiers of the floodplain. These flood certificates would inform individual property owners of the flood situation at their *particular property*. It is the site-specific nature of this advice (cf. a generic brochure) that offers the best chance of overcoming the scepticism typical of a community that has not experienced serious flooding for some years. Only after floodplain occupants accept that *they* could have a problem are they ready to take on board ideas about addressing that problem. A certificate would contain information such as the expected flood levels in a range of design floods. It could also provide information on ground and floor levels where this information is available.

Flood certificates, such as the sample included as **Figure 5.3**, could be attached to Section 149 certificates. They could also be delivered with Council's rates notices every two years, along with advice about what people can do to prepare for flooding (e.g. an SES FloodSafe brochure).

5.8.2 Brochures

Following the *Georges River FRMS&P*, the SES prepared two FloodSafe brochures for residential and business land uses located in the Georges River floodplain as far downstream as the Woronora River junction. It would now be timely to prepare a separate brochure for the Lower Georges River, where storm tide levels may exert a greater influence. Possibly this could be combined with a brochure for Sylvania Waters, when the *Gwawley Bay FRMS&P* is complete.

5.8.3 Web-site

A number of Councils are providing a wealth of useful flood information available on their web-sites. For example, Wollongong City Council includes a summary of the floodplain management process, a history of flooding in Wollongong, details about how to obtain flood information, answers to frequently asked questions (FAQs), and advice on being flood prepared.[7] Flood resources are also available for school geography programmes. It is recommended that Sutherland Shire Council develop a similar web page.

[7] www.wollongong.nsw.gov.au/environment/floodplainmanagement.asp

FIGURE 5.3 – Sample Flood Certificate

Sutherland Shire Council

Flood Certificate

Certificate Issued for Property at: 25 Example Crescent, Taren Point
Lot 25, DP 25252

Owners Name: Mr D. & Mrs I. Citizen

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 known as "Managing our Flood Risks" that provides details of flood related development controls that may be applicable.

2. Known Floor and Ground Levels

The lowest habitable floor level of the main building on this property is : 1.65m AHD
Source of information : Estimate

The lowest ground level on this property is : 1.6m AHD
Source of information : Estimate

If the floor level and/or ground level are currently unknown and you would like to know what the levels are; this can be surveyed by a registered surveyor. Alternatively, Council can arrange this for a fee of $100.

3. Estimated Flood Levels

Flood levels in the vicinity of the above property have been extracted from the Lower Georges River Floodplain Risk Management Study & Plan (Bewsher Consulting, 2010).

Size of Flood*	Flood Level	Depth over Lowest Floor Level	Depth over Lowest Ground Level
Probable Maximum Flood	2.4m AHD	0.75m	0.8m
100 Year ARI Flood	1.7m AHD	0.05m	0.1m
20 Year ARI Flood	1.5m AHD	Not flooded	Not flooded

**The Probable Maximum Flood (or PMF) is extremely rare.*
A 100 year ARI flood is a large flood. It has a 1 in 100 (ie 1%) chance of occurring in any year.
A 20 year ARI flood has a 1 in 20 (ie 5%) chance of occurring in any year.

Issued by Sutherland Shire Council
1st January 2010.

6. RECOMMENDED FLOODPLAIN RISK MANAGEMENT PLAN

A Floodplain Risk Management Plan (FRMP) showing the preferred floodplain risk management measures for the Lower Georges River floodplain is presented in this chapter. The recommended measures have been selected from the range of measures discussed in **Chapter 5**, after an assessment of each measure's impact on flood risk, as well as consideration of environmental, social, and economic factors. The recommended measures are presented in **Table 6.1**.

In general, the potential flood problems in the Lower Georges River study area are not serious when compared to many other areas of the State. Several structural flood management options have been considered, but none have been recommended for inclusion in the FRMP. A flood wall or other form of embankment at Woodlands Road may become a more attractive option if the sea level rises anticipated in DECC's *Climate Change Guideline* are realised, so a recommendation is included to prompt a review. Several non-structural options are recommended. Many of these are given a "high" priority (implementation sought within 2 years), including a review and an amendment to SSDCP 2006, updating the Local Flood Plan, and measures to generate and maintain public flood readiness. The preparation of a brochure outlining potential flood-proofing techniques is given a "medium" priority (implementation within 4 years). Given the extent of concern expressed in the community consultation conducted for this study, there is also a recommendation to address flooding issues in the Kareela Creek floodplain, which is located beyond the Lower Georges River study area.

The cost of implementing the Lower Georges River FRMP is approximately $82,000, with $5,000 annual maintenance cost. Potential funding sources include Council funds, SES funds, and State funding for flood risk management measures through DECCW (which usually provides assistance on a 2:1 basis).

The next steps in progressing the Lower Georges River floodplain risk management process are:

- Council determines a programme of works based on overall priorities, available Council funds and any other constraints;
- Council submits an application for funding assistance to DECCW; and
- Council implements the FRMP as funds become available.

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

TABLE 6.1 – Recommended Lower Georges River Floodplain Risk Management Plan

Report Section	Description	Capital Expenditure		Maintenance		Principal Responsibility	Priority
		Est. Cost ($)	Funding Sources	Est. Cost ($ pa)	Funding Sources		
2.3	Assess flooding problems and solutions at Kareela Creek near Morna Place	Already recommended in Bewsher Consulting (2004) for a nominal fee of $60K		N/a		Council	High
3.3.2	Capture building floor survey for approx. 20 buildings identified as within the medium flood risk precinct	$2,000	DECCW, Council	N/a		Council	High
5.3	Give further consideration to a levee at 58-64 Woodlands Road if sea level rise is pronounced	N/a		N/a		Council	Low
5.4	Prepare a brochure outlining potential flood-proofing techniques	$20,000	DECCW, Council	Nil		Council	Medium
5.5.1	Review the flood risk management provisions in the amended Sutherland Shire DCP 2006, including relating to climate change flood risk	$20,000	DECCW, Council	Nil		Council	High
5.5.2	Amend Sutherland Shire DCP 2006 to include a freeboard of 800mm (where 500mm currently applies) for the Lower Georges River study area **See Addendum**	$10,000	Council	Nil		Council	High
5.7	Revise Sutherland Local Flood Plan with information from this study	Nil		Nil		SES	High
5.8	Increase and sustain public flood readiness by: a) issuing certificates; b) preparing a FloodSafe brochure; and c) preparing a floodplain management web-site	a) Nil b) $10,000 c) $20,000	 Council, SES Council	a) $5,000 b) Nil c) Nil	Council	a) Council b) SES c) Council	High
	TOTAL	**$82,000**		**$5,000**			

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8. 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 or accurately recorded 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 Environment, Climate Change and Water (DECCW) 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?

Flood studies and floodplain risk management studies are often carried out under State Government guidelines and are funded on a 1:1:1 basis among the Federal and State Governments, 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 ARI flood but still has a very slight chance 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. Often it means that your property is inundated in a 100 year ARI flood, however conditions are not likely to be hazardous during such a flood. 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. Often it means that your property will be inundated in a 100 year ARI 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 ARI 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 ARI 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 January 1998 flood in Katherine, the August 1998 flood in the northern suburbs of Wollongong, the 2002 floods in Europe, Hurricane Katrina in 2005, 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 has generally not been available in Australia for residential property. Following the disastrous floods in Coffs Harbour in November 1996 and in Wollongong in August 1998, very limited flood cover began to be offered by some insurance companies. From 2008, many insurance companies started offering wider cover although the extent of the cover particularly for very flood prone properties is still not well known and may differ between insurers. The most likely situation is that your insurer will now offer you some flood cover although this will be dependent on the flood level information that the insurer has for your property. (This may not necessarily be the same as that available from Council). If flood cover is offered, the classification of your property within a Flood Risk Precinct per se, 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 could have identified the nature of the flood risk 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 or accurately recorded 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's Floodplain Development Manual (2005), councils must consider all flood risks, even these potentially small ones, when managing floodplains. As part of the State Government's Manual, the definitions of the terms 'flood liable', flood prone' and 'floodplain' 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 risk management study. The outcome of the study is the floodplain risk management plan, which details how best to manage flood risks in the floodplain for the foreseeable future.

Floodplain risk 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 to ten years. This is the likely frequency at which the maps may be amended.

9. GLOSSARY

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

1% AEP flood	A **flood** that occurs (or is exceeded) on average once every 100 years. Also known as a 100 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
2% AEP flood	A **flood** that occurs (or is exceeded) on average once every 50 years. Also known as a 50 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
5% AEP flood	A **flood** that occurs (or is exceeded) on average once every 20 years. Also known as a 20 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
10% AEP flood	A **flood** that occurs (or is exceeded) on average once every 10 years. Also known as a 10 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20% AEP flood	A **flood** that occurs (or is exceeded) on average once every 5 years. Also known as a 5 year flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
100 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 100 years. Also known as a 1% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
50 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 50 years. Also known as a 2% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
20 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 20 years. Also known as a 5% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
10 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 10 years. Also known as a 10% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
5 year ARI flood	A **flood** that occurs (or is exceeded) on average once every 5 years. Also known as a 20% flood. See **annual exceedance probability (AEP)** and **average recurrence interval (ARI)**.
acid sulphate soils	Sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by the Acid Sulfate Soil Management Advisory Committee.
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 the frequency or probability of floods occurring. Large floods occur rarely, whereas small floods occur more frequently. For example, a 1% AEP flood occurs (or is exceeded) on average once every 100 years. It is also referred to as the '100 year flood' or the '1 in 100 year flood'.
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 are normally provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in an area over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe the frequency or probability of floods occurring. Large floods occur rarely, whereas small floods occur more frequently. For example, a 100 year ARI flood is a flood that occurs (or is exceeded) on average once every 100 years. See also **annual exceedance probability (AEP)**.
BoM	The Australian Bureau of Meteorology.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site.
DECCW	NSW Department of Environment, Climate Change and Water. Previously the State Government's Flooding Unit was part of the Department of Natural Resources (DNR), and prior to that was part of the Department of Infrastructure, Planning and Natural Resources (DIPNR).
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (**m^3/s**). Discharge is different from the speed or **velocity** of flow, which is a measure of how fast the water is moving.
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. In NSW, the State Emergency Service (SES) is the principal agency involved in emergency management during floods.

flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam. It includes local overland flooding associated with major drainage before entering a watercourse. In addition, it includes coastal inundation resulting from raised sea levels, or waves overtopping the coastline.
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 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 100 year flood level.
flood planning levels (FPLs)	The combination of flood levels and **freeboards** selected for planning purposes, as determined in **floodplain risk management studies** and incorporated in **floodplain risk management plans**. 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 risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a council to manage the flood **risk**. (The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses). Usually the floodplain is categorised into three flood risk precincts — 'low', 'medium' and 'high' — although other classifications can sometimes be used. (See also **risk**).
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** (PMF) event, that is, **flood prone land** or **flood liable land**.
Floodplain Risk Management Plan	The outcome of a **Floodplain Risk Management Study**. (Note that the term 'risk' is often dropped in common usage and 'Floodplain Risk Management Studies or Plans' are referred to as 'Floodplain Management Studies and Plans'.)
Floodplain Risk Management Study	These studies are carried out in accordance with the *Floodplain Development Manual* (NSW Government, 2005) and assess options for minimising the danger to life and property during **floods**. These 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	Floodways are those parts of a floodplain where a significant discharge of water occurs during **floods**. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
flow	See **discharge**
freeboard	A factor of safety expressed as the height above the flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the **floodplain**, such and wave action, localised **hydraulic** behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change.
geographical information system (GIS)	A system of software designed to support the management, manipulation, analysis and display of spatially referenced data.
geomorphology	The study of landforms.
high flood hazard	For a particular size **flood**, there may be a possible danger to personal safety, able-bodied adults may have difficulty wading to safety, evacuation by trucks may be difficult and/or there may be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow; in particular, the assessment of flow parameters such as water level and **velocity**.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the estimation of **peak discharges**, flow volumes and the derivation of hydrographs (graphs that show how the discharge at any particular location varies with time during a flood).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, 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 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^3/s	Cubic metres per second or 'cumecs'. A unit of measurement for flows or **discharges**. It is the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different **flood prone** areas together with flood damage, **hazard** and behaviour implications, and environmental protection and well being of the State's rivers and **floodplains**.

overland flow path	The path that floodwaters can follow when not confined within a flow channel. Overland flow paths can occur through private property or along roads.
peak discharge	The maximum **flow** or **discharge** during a flood.
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. It has a very rare chance of occurring. The PMF defines the extent of **flood prone land** or **flood liable land**, that is, the **floodplain**.
reliable access	During a **flood**, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within the **effective warning time**, having regard to the depth and **velocity** of floodwaters, the suitability of the evacuation route and other relevant factors.
risk	Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sportsground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk. (See also **flood risk precinct**).
risk management	The process of identifying, analysing, evaluating, treating, monitoring and communicating risks. A generic framework for risk management in Australia is provided in the joint Australian and New Zealand Standard AS/NZS 4360;1999.
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.
Section 149 Certificates	In NSW, councils issue these certificates to potential property purchasers under Section 149 of the NSW Environmental Planning and Assessment Act. It is compulsory to attach S149(2) certificates to contracts for sale of land and these certificates generally identify policies affecting development of the land. Other information and risks concerning the property are generally provided on S149(5) certificates (which are not compulsory in contracts for sale of land).
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 = 2.8m/s.

APPENDIX A

COMMUNITY QUESTIONNAIRE

Lower Georges River Floodplain Management Study
Questionnaire for Residents and Business Owners

The information provided from this questionnaire will help us to identify any flooding problems within the study area, and to consider measures that may reduce these problems. It would help us if you could indicate the location of your property, or other problem areas, on the map on the back.

The questionnaire is voluntary. No names or addresses will be included in any published material.

---

1. Your Address? _____

2. Within the study area, do you own:
   - ☐ A residential house
   - ☐ A residential unit or apartment
   - ☐ A business premises

3. Has your property previously flooded? When did this happen? _____
   - ☐ Yes, above floor level — Depth above floor? _____m.
   - ☐ Yes, but floor level of building was not flooded
   - ☐ Minor flooding within property only
   - ☐ No flooding within this property

4. Are there any flood problems on the Georges River that you are aware of beyond your property?
   _____
   _____
   _____

5. Are there any flooding issues you would like the study to consider?
   _____
   _____
   _____

6. Do you have any ideas on reducing or managing the flood risk?
   _____
   _____
   _____

7. Other comments
   _____
   _____
   _____

8. Your Contact Details (in case we need to ask you anything further)
   Name: _____
   Email: _____ Phone: _____

Please return your completed questionnaire by <u>FRIDAY 26th JUNE 2009.</u>
Questionnaires should be returned to the following address **(no postage stamp is required).**

Bewsher Consulting Pty Ltd
Reply Paid 352,
Epping NSW 1710

Thank you for your participation

Sutherland Shire COUNCIL

Bewsher Consulting

APPENDIX B

LIST OF PROPERTIES WITH REPORTED HISTORICAL FLOODING INCIDENCE AND WITHIN MEDIUM FLOOD RISK PRECINCT

TABLE B1 – Historical Flooding Incidences from Community Questionnaire

Note: arranged upstream to downstream; street numbers not shown

Address	Description of Flood Issue
Verona Range, Como	Minor flooding within property experienced
Green Point Road, Oyster Bay	Minor flooding within property experienced
Glenhaven Place, Oyster Bay	Minor flooding within property experienced
Caravan Head Road, Oyster Bay	Minor flooding within bottom of property experienced
Como Road, Oyster Bay	Minor flooding within property experienced at various times since 1986
Como Road, Oyster Bay	Adjoining properties have had land covered by king tides
Canal on southern side Oyster Bay oval, Oyster Bay	
Oyster Bay Road, Oyster Bay	Minor flooding of yard during king tides via canal next to Oyster Bay oval
Oyster Bay Road, Oyster Bay	Minor flooding within property experienced
Siandra Drive, Kareela	Minor flooding of lower rear corner of property prior to 1985
The Promenade and Moray Place, Sylvania	Houses affected on the king tide in 1974
The Promenade, Sylvania	Flooded over floor to depth of 150mm about 20 years ago
The Promenade, Sylvania	Flooded over floor to depth of 100mm in 1975 and six times altogether
Kangaroo Point Road, Kangaroo Point	Backyard flooded prior to 1980
Clare Street, Sylvania	Minor flooding common during king tides
Marra Pl, Sylvania	Flooded below floor in 1974
Belgrave Esplanade, Sylvania	Water exceeds height of retaining wall for a few feet during the Christmas high tides
Belgrave Esplanade, Sylvania	Flooded below floor in 1974
Lachlan Avenue, Sylvania Waters	Some minor street flooding during king tides
Holt Road, Taren Point	Minor flooding within property experienced in 2002 or 2003
Woodlands Road, Taren Point	Minor flooding within property experienced
Woodlands Road, Taren Point	Flooded below floor at various times
Woodlands Road, Taren Point	Flooded over garage flood to depth of 300mm in early 1980s
Woodlands Road, Taren Point	Minor flooding within property experienced after heavy rain
Resolution Drive, Caringbah	Major flooding in carpark
Sturt Road, Cronulla	Minor flooding within property experienced in 2009
Sturt Road, Cronulla	Minor flooding within property experienced on 19-20 May 2009

TABLE B2 – Residential and Commercial/Industrial Buildings within the Medium Flood Risk Precinct (arranged upstream to downstream)

Address	Land Use	Average 100 Year ARI Flood Depth over ALS Ground Level	Photo
2 Cremona Road, Como	Commercial (Como Marina – boat sales, marine mechanic, upholsterer, welder, coffee shop, restaurant)	0.26m	
14 The Promenade, Sylvania	Residential	-0.05m	Not available
10 The Promenade, Sylvania	Residential	0.00m	
25 Harrow Street, Sylvania	Commercial (Sylvania Marina)	0.30m	
16 Clare Street, Sylvania	Residential	0.23m	

Address	Land Use	Average 100 Year ARI Flood Depth over ALS Ground Level	Photo
19 Clare Street, Sylvania	Residential (unit blocks)	-0.05m	
4A Belgrave Esplanade, Sylvania	Residential	0.24m	
2 Marra Place, Sylvania	Residential	0.21m	
3 Holts Point Place, Sylvania	Residential	0.22m	Not available
1 Lachlan Avenue, Sylvania Waters	Residential	0.21m	

Address	Land Use	Average 100 Year ARI Flood Depth over ALS Ground Level	Photo
105A Holt Road, Taren Point	Residential	-0.08m	
73 Holt Road, Taren Point	Residential	0.17m	
58A Woodlands Road, Taren Point	Residential	0.04m	
60A Woodlands Road, Taren Point	Residential	0.04m	See above (centre)
64 Woodlands Road, Taren Point	Residential	0.09m	 Source: Sutherland Shire Council, 12 Jan 2009, at king tide

Address	Land Use	Average 100 Year ARI Flood Depth over ALS Ground Level	Photo
Unknown (adjacent to 2-28 Alexander Avenue, Taren Point)	Commercial?	0.42m	
17-21 Mangrove Lane, Taren Point	Commercial (boat manufacture/ repair) (5 buildings)	0.07-0.52m	
13 Sturt Road, Cronulla	Residential	-0.22	Not available