

**WARRINGAH COUNCIL
PITTWATER COUNCIL
DEPARTMENT OF LAND AND WATER CONSERVATION**

***NARRABEEN LAGOON
FLOODPLAIN RISK MANAGEMENT PLAN***

VOLUME 2



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Table of Contents
VOLUME 2 – Floodplain Risk Management Plan Review

1	INTRODUCTION.....	3
1.1	PURPOSE OF THE REVIEW	3
1.2	STRUCTURE OF THE PLAN	3
1.3	THE FLOOD SITUATION.....	3
2	COMMUNITY CONSULTATION.....	9
2.1	CONSULTATION WITH THE NLJE/FMC.....	9
2.2	CONSULTATION WITH THE WIDER COMMUNITY	9
2.3	CONSULTATION WITH KEY STAKEHOLDERS	11
3	DOCUMENT REVIEWS	13
3.1	TECHNICAL REPORTS AND STUDIES.....	20
3.2	MANAGEMENT PLANS.....	33
3.3	LOCAL PLANNING INSTRUMENTS AND POLICIES.....	39
3.4	STATE AND REGIONAL PLANNING INSTRUMENTS AND POLICIES	57
4	ECONOMIC IMPACTS OF FLOODING.....	62
4.1	INTRODUCTION	62
4.2	METHODOLOGY	63
4.3	RESIDENTIAL DAMAGES	63
4.4	COMMERCIAL/INDUSTRIAL DAMAGES.....	66
4.5	GOVERNMENT INFRASTRUCTURE AND RECREATIONAL FACILITIES	68
4.6	TRAFFIC DISRUPTION.....	68
4.7	AVERAGE ANNUAL POTENTIAL DAMAGES	69
5	FLOOD MANAGEMENT MEASURES REVIEW	70
5.1	SUMMARY OF OPTIONS.....	70
5.2	GENERAL MANAGEMENT MEASURES	71
5.3	FLOOD MODIFICATION MEASURES	71
5.4	PROPERTY MODIFICATION MEASURES	78
5.5	RESPONSE MODIFICATION MEASURES.....	92
6	ASSESSMENT OF MANAGEMENT MEASURES	98
6.1	ECONOMIC IMPACTS	99
6.2	DISCUSSION OF ASSESSMENT FOR OPTIONS	99
6.3	OUTCOMES OF ASSESSMENT.....	107
 APPENDIX A		
APPENDIX B		
APPENDIX C		

1 INTRODUCTION

1.1 Purpose of the Review

Council has prepared a Floodplain Risk Management Plan as detailed in Volume 1 of this report that provides a plan of management for the floodplain, discussing implementation strategies for assessed mitigation options. A separate Plan for each Council area has been developed that provides management actions that each Council is to individually and jointly address.

Floodplain management options were identified through previous studies, recent community consultation and floodplain management review that includes two options aimed at increasing the flood immunity of Wakehurst Parkway. This was required to ensure all nominated options were assessed and those recommended developed and prioritised. Specific investigation was also requested into the area of entrance management for flood mitigation, development controls within the floodplain and SEPP5 influence on floodplain management options. This Volume provides the detailed discussion on these issues.

1.2 Structure of the Plan

This review has been structured as follows:

- Introduction
- Community consultation program
- Document Review
- Economic Impacts of Flooding for Narrabeen Lagoon Floodplain
- Flood Management Measures Review
- Assessment of Management Measures

1.3 The Flood Situation

Within the Narrabeen Lagoon catchment flooding can occur from either short duration rainfall bursts, typically along the tributary creeks, or longer duration rainfall events that result in flooding of the low-lying areas of the lagoon floodplain. A combination of these effects can accentuate flooding in the downstream parts of the tributary creeks. Floods in the tributary creeks generally have critical storm duration to around 2 hours. The Flood Study (PWD, 1990) reported that the critical storm duration for the lagoon was the 36 hour event.

1.3.1 Lagoon Flooding

Flooding of the low-lying areas surrounding the lagoon was identified in the Flood Study as being caused by three mechanisms:

- Lagoon entrance closed, combined with heavy rain;
- Lagoon entrance open, combined with ocean level rise; and
- Lagoon entrance open, combined with heavy rain.

In past flood events the most significant flooding has occurred when the first mechanism prevails (for example the 1942 flood).

During a flood maximum water levels in the lagoon are subject to the state of the lagoon entrance. Under natural forces, the lagoon entrance tends to close by accumulation of sand resulting in an entrance plug. It re-opens during flood events when the plug is overtopped.

Discharge of floodwaters is also a function of the difference between lagoon and ocean water levels.

The Flood Study determined design flood levels in the lagoon assuming mechanical entrance opening. The generalised design flood levels and the critical storm duration for each event, from the Flood Study, are reproduced in **Table 1.1**. The extreme event modelled in the Flood Study was derived using probable maximum precipitation and an inshore ocean level of 2.7m AHD (estimated using the 1974 event). The extreme event has not been designated as a PMF, but approaches that event in impact. This was adjusted slightly in the FMS taking into account alterations to creek and bridge cross sections.

Table 1.1 : Design Flood Levels for Narrabeen Lagoon

Event	Ocean Level adopted	Water Level (m AHD)	Critical storm duration
5 % AEP	1.8m AHD	2.54	36 hour
1 % AEP	2m AHD	2.92	36 hour
Extreme	2.7m AHD	4.61 (upper limit)	12 hour

Flood levels taken from the Flood Study (PWD, 1990)

1.3.2 Tributary flooding

Flooding in tributaries to Narrabeen Lagoon is caused from one or a combination of two factors:

- local catchment flooding from typically short duration intense rainfall events; and
- backwater flooding from elevated water levels in Narrabeen Lagoon.

The latter effect produces higher water levels in the lower lying areas of the tributary creeks and can vary from a distance of 0.5km to 1km up the creeks from the lagoon.

The Plan addresses local catchment flooding for:

- Mullet Creek from Narrabeen Lagoon to the crossing at Garden Street (a distance of approximately 1.5km),
- Narrabeen Creek from its confluence with Mullet Creek to the first crossing by Boondah Road, approximately 0.8km
- Middle Creek in the vicinity where flooding of Wakehurst Parkway occurs, approximately 2.7km upstream of Narrabeen Lagoon.

Flooding impacts for these reaches are presented in the following sections.

Nareen and South Creek tributaries do not form part of this Plan. These tributaries will be subject to individual flood risk management plans. There is no future Plan proposed at this time for Deep Creek and the remainder of Middle Creek, as the floodplains do not have residential or commercial development.

1.3.3 Mullet Creek

Mullet Creek is a tributary of Narrabeen Lagoon; it has a catchment of 9.7 km². The local catchment flows are attenuated in the lower sections of the creek at Warriewood Wetland and in Progress Park (downstream of Jacksons Road). It has two tributaries namely Narrabeen and Fern Creeks, Narrabeen Creek joins downstream of Jacksons Road and Fern Creek flows into the wetland.

From the results of the Flood Study the lower reaches of Mullet Creek was found to be inundated by lagoon flooding alone. In the upper reaches flooding is dominated by local catchment runoff.

The critical storm duration of 2 hours produced the highest water levels. Results for Mullet Creek are presented in **Table 1.2**.

Table 1.2 : Design flood information along Mullet Creek

Cross section reference number	Location	1% AEP Water level (m AHD)	Extreme event Water Level (m AHD)
CS10.2	Pittwater Road bridge	2.71	3.98
CS18		2.82	4.21
CS19		2.83	4.22
CS20		2.84	4.23
CS21		2.85	4.24
CS43.2	Downstream of Jacksons Road	2.85	4.24
CS44	Upstream of Jacksons Road / wetlands	2.96	4.26
CS32.2		2.96	4.26
CS33		2.98	4.27
CS34	Garden Street	3.88	Not available
MU10		4.5	Not available
MU11		5.14	Not available
MU12		6.25	Not available

Information is sourced from Narrabeen Lagoon Flood Study

1.3.4 Narrabeen Creek

Narrabeen Creek is a tributary of Mullet Creek and has a catchment of 3.2km² upstream of Warriewood Shopping Centre (WSC). The creek passes under WSC in a 300m long triple cell culvert and joins Mullet Creek some 100m downstream. Upstream of WSC the creek passes under Boondah Road to Macpherson Street via Warriewood STP. There are extensive areas of the catchment that are being developed to commercial/light industrial and residential areas as part of the Warriewood Valley Urban Land Release.

At the creek's confluence design flood levels in Mullet Creek are dominated by elevated lagoon levels. Flooding in Narrabeen Creek catchment is largely controlled by tailwater levels from Mullet Creek and the capacity of the culvert under WSC. Previous reports indicate the capacity of these culverts to be in the order of the 20 year ARI event.

In major storms, secondary overland flowpaths occur across Boondah Road between Macpherson Street and the crossing of Narrabeen Creek, which is directed to the wetlands. The Pilot Stormwater Management System Report (Patterson Britton, 1997) reports that these secondary overland flowpaths occur for floods greater than about 10 to 20 year ARI.

Pittwater Council has developed a quasi two-dimensional hydraulic model (MIKE-11) for Narrabeen Creek from Ponderosa Road to its confluence with Mullet Creek. Results from this model are given in **Table 1.3** for the local catchment storm (2 hour duration) with a 0.6m tailwater in Narrabeen Lagoon.

Table 1.3 has flood levels from the 36 hour duration storm over the lagoon catchment taken from the Pilot Stormwater Management System Report. Studies that have been done for the Warriewood Release Area reference results from the MIKE-11 hydraulic model developed by Pittwater Council. These studies are generally limited in reporting design flood information for

both local catchment flood events and backwater flooding from Narrabeen Lagoon from Pittwater Road Bridge to Boondah Road.

Table 1.3 : Flood Information for Narrabeen Creek

Location	Model reference (km)	1% AEP local catchment event (2 hour duration)		1% AEP flood for Narrabeen Lagoon catchment (36 hour duration) *	
		Water level (m AHD)	Peak velocity (m/s)	Water level (m AHD)	Velocity (m/s)
Mullet Creek at Pittwater Road		Not available		2.8	0.4
Upstream of Warriewood Shopping Centre	3.05	1.7	1.1	3.1	0.6
Boondah Road – downstream	2.90	2.4	0.6	3.2	0.4

Results from Pilot Stormwater Management System Report (1996)

1.3.5 Middle Creek - Wakehurst Parkway

Wakehurst Parkway is subject to frequent inundation from Middle Creek. The road was closed 11 times between October 1999 and March 2002. The nature and extent of flooding of Middle Creek for a length of 5.5km upstream of Narrabeen Lagoon was investigated as part of the Statement of Environmental Effects (SEE) for the Rehabilitation of Middle Creek (Patterson Britton, 1993). This discussion on flooding is drawn from that previous study.

Flooding of Wakehurst Parkway is initiated some 2.7 km upstream of the lagoon, where water surcharging the channel of Middle Creek inundates Wakehurst Parkway. The RTA considers this to be due to a number of factors:

- constriction of flow due to a steep escarpment on the northern bank and the road on the southern bank;
- the low road level;
- sedimentation of the creek channel and blockage by weeds such as lantana and privet; and
- restricted performance of piped culverts due to vegetation overgrowth.

A one-dimensional hydraulic model, based on HEC2, was established for a 5.5km length of Middle Creek during the SEE. The model was used to assess the impact of flooding on the proposed water quality improvement works. Summaries of modelling results relevant to Wakehurst Parkway inundation for existing conditions are presented in **Local Drainage - Mactier Street**

During the preparation of the FRMP an issue was raised with respect to local drainage along Mactier Street Narrabeen. There is a local low point associated with a roundabout that has in the past been inundated during rainfall events, particularly worsened when lagoon levels are elevated.

Table 1.4.

1.3.6 Local Drainage - Mactier Street

During the preparation of the FRMP an issue was raised with respect to local drainage along Mactier Street Narrabeen. There is a local low point associated with a roundabout that has in the past been inundated during rainfall events, particularly worsened when lagoon levels are elevated.

Table 1.4: Maximum water depth (m) on Wakehurst Parkway for existing conditions

Distance from lagoon along creek (m)	HEC2 Cross-Section	AEP				
		50%	20%	10%	5%	1%
1624	CS35	-	-	-	-	<i>0.14</i>
2037	CS30	-	-	-	-	<i>0.35</i>
2714	CS18	0.27	0.48	0.60	0.71	1.00
2889	CS17	0.20	0.40	0.51	0.62	0.87

Source: SEE (Patterson Britton, 1993), 3 hour critical storm duration

Italics indicate maximum water depth is for right hand road edge (looking downstream)

Non-italics indicate maximum water depth is for left hand road edge (looking downstream)

1.3.7 Flood affected areas

There are a significant number of flood affected commercial, light industrial and residential properties within the Narrabeen Lagoon floodplain. Flooding varies from water above habitable floors to the inundation of gardens and secondary buildings. **Figure 3** shows the extent of inundation for the 1% AEP and extreme flood event for Narrabeen Lagoon Floodplain.

The primary flood affected areas are:

- The eastern side of the entrance channel;
- Lakeside Caravan Park and the surrounding residential area north of the lagoon entrance;
- The Mullet Creek area, from Pittwater Road to Jacksons Road;
- Narrabeen Creek floodplain including Warriewood Shopping Centre;
- The Wimbledon Avenue peninsula;
- NSW Academy of Sport; and
- The southern foreshore of the Central Basin .

The FMS identified that overfloor flooding would occur for 320 residential and 102 commercial dwellings at the 1% AEP event, which included properties in the lower reaches of Nareen Creek catchment. During the preparation of the FRMP these estimates were revised (refer to **Table 1.5**) to reflect developments between 1992 and 2000, to include Narrabeen Creek floodplain and to exclude properties in the Nareen Creek catchment.

Table 1.5: Number dwellings flooded above floor level

Flood Event (AEP)	Number of dwellings flooded above floor level	
	Residential	Commercial*
5%	162	87
1%	208	113
Extreme	434	241

* These figures include shops in Warriewood Shopping Centre

2 COMMUNITY CONSULTATION

A Consultation Plan was used as a guide for community involvement in the development of the Flood Risk Management Plan. The aims of the consultation plan were to:

- clearly articulate the plan's aims and objectives to the community;
- establish and maintain the interest and enthusiasm of the community in the plan;
- ensure that the community has ownership of the plan by involving them in the decision making process;
- ensure that views of all target audiences are heard and there is clear lines of communication between the community and the consultants at the outset of the project;
- utilise established community networks and links to disseminate information to the wider community; and
- ensure that all material presented is in a clear and concise plain English manner.

Consultation with the community was primarily through meetings with the Narrabeen Lagoon Joint Estuary/Floodplain Management Committee (NLJE/FMC). These meetings were supplemented by consultation with the wider community and key stakeholders.

2.1 Consultation with the NLJE/FMC

Progress Reports

Two progress reports were forwarded to the members of the NLJE/FMC, on the 4 January and 12 February 2001.

Meetings and workshops

A presentation to the NLJE/FMC was given on 8 March 2001. The purpose of this presentation was to provide progress on the preparation of the Plan and approve presentation material for the upcoming Open Shop Day planned to be held on 10 March 2001.

A workshop was held with the NLJE/FMC on 24 March 2001 in order to review technical aspects of the Plan and assess each of the proposed management options against a range of environmental, economic, social and flooding issues. Representatives attended the workshop from Warringah and Pittwater Councils, DLWC and one community member. As there was not a good representation from the NLJE/FMC those present requested that assessment of management measures not be done during the workshop. Assessment sheets (copy attached) were forwarded to the Committee members and requested to be completed within two weeks. Seven of these forms had been completed and forwarded to Warringah Council. These responses were used in multi-criteria assessment of the flood mitigation measures.

2.2 Consultation with the wider community

The aim of consultation with the wider community was to advise the community of the ongoing work for the floodplain management strategy being developed by Councils and receives feedback. Consultation included distribution of a newsletter and an Information Day held at Warriewood Square. Details of the consultation information and responses are provided in **Appendix A**.

Information Newsletter

Shortly after commencement of this project, a newsletter was distributed to all affected residents and businesses in the study area as well as owners of affected property. Approximately 1200 were distributed by hand or by mail. The newsletter provided information regarding the floodplain management process; a brief background of flooding issues in the study area; and welcomed comment or questions.

Ten community members contacted either Warringah Council or SMEC following distribution of the newsletter. Issues raised are presented in **Table 2.1**.

Table 2.1: Summary of responses from newsletter – March 2001

Response	Issues raised
1	<ul style="list-style-type: none"> • general enquires about study
2	<ul style="list-style-type: none"> • when did flooding recently occur and to what extent • effects of Lake Park Road levee • reasoning behind minimum floor levels • unsatisfied with resident input during Flood Study
3	<ul style="list-style-type: none"> • knows little about the floodplain management process and wants more information
4	<ul style="list-style-type: none"> • information regarding house raising • confused about different development controls in Pittwater and Warringah Council • Concerned about entrance management
5	<ul style="list-style-type: none"> • offered photos of the Lagoon in flood
6	<ul style="list-style-type: none"> • requested more information on the floodplain management process
7	<ul style="list-style-type: none"> • provides historical information on flooding • discusses importance of keeping entrance open to avoid flooding • is opposed to levee along Pittwater Road
8	<ul style="list-style-type: none"> • is against raising levee • asked who is responsible for opening entrance • offered photos of the Lagoon • is concerned about dredging
9	<ul style="list-style-type: none"> • concerned about the effects of a levee
10	<ul style="list-style-type: none"> • notes the danger of flooding of roundabout at Mactier St

Open Shop Day – 10 March 2001

An Open Shop Day/Information Day was held on Saturday 10 March, 2001 at Warriewood Square shopping centre from 8:30am to 5pm. The Open Shop Day/Information Day was advertised on two days in the Manly Daily (a local paper) during the preceding week.

During the first half of the day, several residents came into the centre with photographs from past floods. One of note was a photograph that showed the Ocean Street Bridge in the 1930s. At this time it was a wooden bridge on piles that appeared higher than the present bridge. It also appeared that the line of the bank on the northern side was back at about the present caravan park boundary.

Anecdotal evidence from several residents who have been in the area since before the present Ocean Street Bridge was built, suggests that problems with the flooding and other problems in the estuary are due to the present configuration of the Ocean Street Bridge. They note that the entrance was straight before the existing bridge was constructed and that the Birdwood Pk dune did not exist.

Other issues raised by residents included:

- A perception that in past years, concerns expressed over flooding issues have not been dealt with by Council;
- The management of drains needs to be improved, particularly with respect to keeping them cleared;
- The flooding in 1942 was exacerbated by the Army actually refusing to open the entrance, due to a concern that the lagoon would be invaded;
- When the entrance was cleared annually, floods were not experienced during that time; and
- Permanently opening the entrance was suggested as a flood mitigation strategy.

An assessment sheet of floodplain management options was distributed on the day. A total of 11 forms were completed to varying degrees. Some assessed all measures against all issues whereas others only filled in selected sections. See **Appendix A**

2.3 Consultation with Key Stakeholders

Key stakeholders identified for the Narrabeen Lagoon floodplain included:

- | | |
|---|--|
| ▪ Department of Land and Water Conservation | ▪ Department of Urban Affairs and Planning |
| ▪ Waterways Authority | ▪ NSW Academy of Sport |
| ▪ NSW Bureau of Meteorology | ▪ NSW Environment Protection Authority |
| ▪ National Parks and Wildlife Service | ▪ NSW Fisheries |
| ▪ Sydney Water | ▪ Cromer Golf Club Ltd |
| ▪ Lakeside Caravan Park | ▪ Coastal Environment Centre |
| ▪ Narrabeen Chamber of Commerce | ▪ Manly Warringah Kayak Club |
| ▪ Wakehurst Touring Canoeists | ▪ Pittwater Natural Heritage Association |
| ▪ Warringah Environmental Action Group | ▪ Sydney Northern Beaches Catchment Management Committee |
| ▪ Narrabeen Lakes Sailing Club Inc | ▪ Berry Reserve Markets |

These groups and organisations were contacted inviting their input during the preparation of the Plan.

Responses were received from the NSW Environment Protection Authority and NSW Fisheries, giving advice on documentation to be included in the literature review undertaken.

2.4 Public Exhibition of Final Draft

The public exhibition period of the final report was undertaken from 4 October 2002 to 15 November 2002. This involved advertisements in both Council's Mayor's message and displays of the Report in both Councils local libraries, Customer Service Centres, web pages.

Additionally, a mail out was sent to residents and property owners in the Floodplain, approximately 600 in Pittwater and 850 in Warringah, informing them of the public exhibition

and providing them with a summary of the report and the management options to be implemented.

Five written responses were received, raising the following issues:

- Objections to flood risk management development controls
- Costs related to implementing flood risk management controls
- Resident indemnification of Council from flooding
- Mismanagement of the lagoon entrance
- Past flood experience never flooding individual's houses

Open Shop Day – 9 November 2002

An open shop day was also held between 10 am and 4 pm on Saturday 9 November 2002, at the Coastal Environment Centre. This was to afford interested community members the opportunity to obtain further information and to discuss any issues they had with the report.

12 people attended throughout the day, raising similar issues to those of the open shop day held on 10 March 2001, as well questions and comment in relation to flood risk management development controls.

3 DOCUMENT REVIEWS

Included in this Section are the summaries for each of the documents reviewed during the preparation of the Narrabeen Lagoon Flood Risk Management Plan. Table 3.1 contains a synopsis of all the documents. This is followed by the summaries, divided into the following categories:

- 3.1 Technical Reports and Studies
- 3.2 Management Plans
- 3.3 Local Planning Instruments and Policies
- 3.4 State and Regional Planning Instruments and Policies

Table 3.1: Document review summary

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
Technical Reports and Studies					
3.1.1	Narrabeen Lagoon Flood Study	PWD	January 1990	Describes the nature of flooding and the hydrologic & hydraulic modelling for Narrabeen Lagoon and the lower reaches of its tributaries.	Reference to the reported design flood levels
3.1.2	Narrabeen Lagoon Floodplain Management Study	Narrabeen Lagoon Floodplain Management Committee	December 1992	Describes areas of flooding, assesses flood damages and investigates and makes recommendations on flood mitigation options	Findings from this report form the basis of the FMP.
3.1.3	Narrabeen Lagoon Floodplain Management Study ANUFLOOD Data File	Mitchell McCotter	1992	Database of information relating to flood damages for residential and commercial premises in the study area	Used to establish potential flood damage estimates for economic assessment of mitigation options.
3.1.4	Narrabeen Lagoon Entrance Study	PWD	August 1989	Reports on the detailed investigation of four entrance management strategies for Narrabeen Lagoon	Reference to the entrance behaviour and its impacts on lagoon water levels; details on various management strategies
3.1.5	Narrabeen Lagoon Maintenance Dredging – Assessment of Benefits Derived from Different Dredging Frequencies	Warringah Shire Council	1982	Reports on monitoring of entrance dredging activities in 1979 and an assessment of the impacts of variation in the frequency of dredging.	Information on the impacts of dredging of the entrance on flood behaviour
3.1.6	Narrabeen Lagoon Floodplain Property Appraisal	Pittwater Council	2000	Summary of new developments in the Narrabeen Lagoon floodplain since the FMS was completed (1992).	Used to establish potential flood damage estimates for economic assessment of mitigation options. Used to assess the impact of filling within the floodplain.
3.1.7	Nareen Creek Flood Study	Manly Hydraulics Laboratory	June 1995	Describes the nature of flooding and the hydrologic & hydraulic modelling for Nareen Creek.	
3.1.8	Nareen Creek Floodplain Management Study	Hyder Australia	July 2000	Describes areas of flooding, assesses flood damages and investigates and makes recommendations on flood mitigation options	
3.1.9	Narrabeen Lagoon Estuary Processes Study – Draft	WBM Oceanics Australia	October 2000	Assembles all relevant data and assesses the estuarine processes for use in the development of estuary management plan.	Referenced during assessment of flood mitigation options.
3.1.10	Narrabeen Lagoon Aquatic Ecology Review and Community Consultation	Nelson Consulting, The Ecology Lab and Patterson Britton	1999	Assessment of community values and awareness with respect to the management of Narrabeen Lagoon.	Provides information on social values.
3.1.11	Narrabeen Lagoon Dredging EIS	Don Fox Planning Pty Ltd, Patterson Britton & Partners	1989	Reports on the development and assessment of a dredging proposal for the lagoon	As there is little impact on flooding, this report was only used as an environmental reference
3.1.12	Statement of Environmental Effects for the Rehabilitation of Middle Creek	Patterson Britton & Partners	1993	Reports on the assessment of the environmental impacts of rehabilitation of Middle Creek, a cause of flooding of Wakehurst Parkway	Sourced for information for the development and assessment of mitigation options

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
3.1.13	Narrabeen Lagoon Data Compilation Study	Patterson Britton & Partners	February 1998	Documents the assembly and review of all existing information relevant to the management of Narrabeen Lagoon for use in the Estuary Process Study and Estuary Management Study	Discussion papers referenced for information on the processes affecting Narrabeen Lagoon
3.1.14	Be Prepared For Your Next Flood	Narrabeen Lagoon Joint Floodplain Committee		Advisory brochure to the community	Reviewed as a flood awareness tool
3.1.15	Ingleside Warriewood Urban Release Area Water Cycle Management Study	Patterson Britton & Partners	June 1994	Examines and recommends the optimum means of integrating water, wastewater and sewage services within the Ingleside Warriewood urban development release area; estimated peak runoff discharges were also calculated for existing and post development phases	Provided information for the assessment of mitigation measures for Narrabeen Creek
3.1.16	Narrabeen Creek Model Calibration 10 th April 1998 Flood Event – Draft	Lawson and Treloar Pty Ltd	July 1998	Review of flood data collected for the April 1998 flood	Provides background data for a recent flood event
3.1.17	Review of Tailwater Conditions for Flood Modelling for Warriewood Valley	Lawson and Treloar Pty Ltd	October 1999	Reports on a review of tailwater conditions for flood modelling of creeks in Warriewood Valley; Ocean and lake levels were also reviewed	This report provided background information on modelling undertaken for the Narrabeen catchment, as well as ocean and water levels for the area
3.1.18	Conceptual Plan for the Restoration of Creekline Corridor (Jubilee Ave to Prosperity Parade).	Lawson and Treloar Pty Ltd	August 1999	This study addresses the requirements for Stage 1 works for the Urban Release Area in Narrabeen Creek catchment - design and construction of creekline corridor and retention/water quality basin.	Used for background information
3.1.19	Narrabeen Lagoon Entrance Channel Survey Data Compilation Report	DLWC	June 2000	Compiles historical survey data for the entrance channel and costs of dredging; indicated that there is a need for ongoing monitoring and clearance works for the Narrabeen Lagoon entrance	This report provided information for the evaluation of mitigation options involving entrance management
3.1.20	Hydraulic Review of Warriewood Square Culvert	Bewsher Consulting Pty Ltd	December 1996	Investigates the operation of three box culverts under the Warriewood Square shopping complex car park, carrying flow from Narrabeen Creek. Potential modifications which decrease entry and exit losses are assessed to quantify the increase in flow capacity.	Calculations of the effectiveness of culvert modifications assisted with the assessment of this measure as flood management option.
3.1.21	Flood Characteristics of Narrabeen Creek	Unisearch Ltd	June 1990	The report reviews existing flood studies on Narrabeen Creek and its receiving waters and determines the impact of flooding on the proposed re-development of Warriewood Square shopping centre.	Provided information used in developing and assessing options for managing flooding at Warriewood Square shopping complex.
3.1.22	Pilot Stormwater Management System – Narrabeen Creek Catchment, Warriewood Valley	Patterson Britton & Partners Pty Ltd	March 1997	This document examines the effectiveness of the proposed stormwater management control facilities for both runoff quantity and quality, developed for Warriewood Valley Stage 1 Release Area.	The report was referenced when examining the effects of flooding at Narrabeen Creek.

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
3.1.23	Revised Water Management Documentation – Boondah Road Works Depot Development Application	Lawson and Treloar Pty Ltd	September 2000	The report is an assessment of all aspects of water management for the development of the site. Runoff from the site, flooding and water quality issues are addressed.	The FRMP references the flood models used in this report.
3.1.24	Management Objectives and Options Discussion Paper, Narrabeen Lagoon Estuary Management Study	Narrabeen Lagoon EMS Committee Workshop	November 2000	This study summarises the key management issues and objectives from various studies and reports done on Narrabeen Lagoon Estuary	This paper was not be an important source of information for the FMP as flooding was not considered within the objectives

Management plans

3.2.1	Northern Beaches Stormwater Management Plan	Patterson Britton & Partners Pty Ltd	July 1999	Documents the plan which aims to facilitate coordinated management of stormwater within the Northern Beaches to protect and improve riparian vegetation, aquatic habitats and water quality	Referenced for background information on the environment for the Narrabeen catchment
3.2.2	Jamieson Park, Narrabeen – Plan of Management	LandArc	2000	Documents the plan which aims to provide a framework for managing Jamieson Park	Referenced for information on flood issues in Jamieson Park
3.2.3	Berry Reserve & Adjoining Foreshores, Narrabeen – Plan of Management	LandArc	2000	Documents the plan which aims to provide a framework for managing Berry Reserve and adjoining foreshores	Information on social, heritage and environmental issues in Jamieson Park
3.2.4	Dee Why Valley and South Creek Open Space Corridor – Geographic Plan of Management		1996	Outlines the plan, that aims is to introduce an approach that will reverse or stop the negative pressures of urbanisation, pollution and managerial neglect	Flooding is not considered as a major issue, therefore the plan was referenced for information on South Creek where necessary
3.2.5	Management Policy for Narrabeen Lagoon Entrance, Narrabeen Lagoon Joint Estuary	Narrabeen Lagoon Floodplain Management Committee	November 1996	Describes the procedures and responsibilities for management of Narrabeen Lagoon Entrance based on past works and investigations	Referenced and reviewed during the assessment of flood management measures in the FMP
3.2.6	New South Wales State Storm Plan	SES	Aug 2000	Describes the type of storms that may affect NSW and the measures that should be taken	Referenced and reviewed during the assessment of emergency planning measures in the Narrabeen Lagoon FMP
3.2.7	Manly Warringah Pittwater Local Disaster Plan	SES	Dec 1999	Documents planning, preparation, response and recovery aspects of dealing with disasters that may occur in the Manly, Warringah and Pittwater areas. Does not include Flood Plans	Referenced and reviewed during the assessment of emergency planning measures.
3.2.8	Integrated Water Management Strategy – Warriewood Valley	Lawson and Treloar Pty Ltd	November 1997	Reports on a hydrologic and hydraulic analysis was undertaken, flood levels determined, and waterway designs were developed; detention requirements for development were reviewed	Used for background information
3.2.9	Warriewood Valley Water Management Specification: OSD Specification Review – After Calibration to August 1998 Event	Lawson and Treloar Pty Ltd	December 1999	Updates previous assessment of the OSD requirements for new developments based on flood data from August 1998	This report was not referenced during the preparation of the FMP

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
3.2.10	Warriewood Valley Urban Land Release Water Management Specification Revised Version – Draft	Lawson and Treloar Pty Ltd	August 2000	Describes the documentation requirements for the application and certification of developments in Warriewood Valley; and provides guidance in relation to water management	The recommended flood planning levels for the Valley given here were considered in the preparation of the FMP
3.2.11	Warriewood Square Flood Plan	Lyll & Associates Consulting Engineers	September 2001	Addresses the issue of flooding with relation to the re-developed Warriewood Shopping Centre. The report outlines monitoring of flood waters, evacuation procedures, and existing flood proofing measures.	The document provided information used for assessing the extent of possible flood damage to Warriewood Shopping Centre.

Local Planning Instruments and Policies

3.3.1	Warringah Council Local Environmental Plan	Warringah Council	2000	Guides development for Warringah LGA, with five sections relevant to flood management: exempt and complying development, environmental protection of waterways, on-site detention of stormwater, housing for older people or people with disabilities, and development on flood prone land	Used in the assessment of future development and in the assessment of property modification measures in the Narrabeen catchment
3.3.3	Interim Warringah Design Guidelines	Warringah Council	December 2000	Outlines the appropriate guidelines for development on flood affected land	Information was referenced in the review and assessment of property modification measures in the preparation of the FMP
3.3.4	Pittwater Council Local Environmental Plan	Pittwater Council	1993	Guides development for all land within the Pittwater LGA. No specific information on flood prone land	Used in the assessment of future development and in the assessment of property modification measures in the Narrabeen catchment.
3.3.5	Interim Policy and Guidelines for Development and Use of Land likely to be affected by the Designated Flood Event	Narrabeen Lagoon Floodplain Management Committee	1991	Outlines design requirements for development on flood prone land. Superseded during the development of the FMP	Used in the assessment of future development and in the assessment of property modification measures in the Narrabeen catchment
3.3.6	Flood Risk Management Policy for Pittwater	Pittwater Council,	2001	This policy detailed controls for development on flood affected land, and accompanies Pittwater LEP.	This Policy has been reviewed, and recommended inclusions are in Section 5.2
3.3.7	On-Site Stormwater Detention Technical Specifications	Warringah Council	2000	Specifies design guidelines for OSD systems that aim to reduce the impact of urbanisation on stormwater runoff	Used as background information in the development of the FMP
3.3.8	Development Control Plans	Pittwater Council	various	Outline guidelines that aim to ensure that new developments do not increase flooding or stormwater flows. Also includes relevant drainage design requirements and allowances in case of a flood	Reviewed in the assessment of future development and in the assessment of property modification measures in the Narrabeen catchment
1.3.8.1	Pittwater Council Development Control Plan No. LP23 – Narrabeen Valley Locality Plan	Pittwater Council		This plan applies to residential areas in the valley to the north of Narrabeen lagoon, to all development permissible within the residential zones. It includes on-site detention and other provisions for flooding which apply to certain properties identified by council	The properties identified by Council within the Narrabeen Lagoon – Nareen Creek Floodplain on a map were taken into account during the preparation of the FMP
3.3.9	Warringah Section 94 Contributions Plan	Warringah Council	1997	Objective is for the developer to make a contribution in connection with a development scheme	No specific contributions are required for the management of Narrabeen Lagoon floodplain

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
3.3.10	Warriewood Valley Section 94 Contributions Plan	Pittwater Council		Outlines the requirements that the increased demand for public amenities and services (eg. water management facilities) as a result of development will be met by various developer contributions	This paper was not an important source of information for the FMP

State and Regional Planning Instruments and Policies

3.4.1	Sydney Regional Coastal Management Strategy	Sydney Coastal Councils Group and the Regional Steering Committee	1998	Outlines the strategy to implement sustainable coastal planning and management practices through protecting and conserving terrestrial and marine ecosystems	Used for background information
3.4.2	The Urban Storm Water Initiative			Aims to encourage integrated catchment management approaches to stormwater management works. Federal funding is available to stakeholders who have formed a consortium	Referenced during the consideration of funding sources, as funding is available under this Plan for the management of the Narrabeen Lagoon catchment.
3.4.3	State Government Flood Prone Land Policy	NSW Government	1984	Sets out the policy that aims to reduce the impact of flooding and identifies local government responsibilities for management of flood prone land	Used for background information
3.4.4	NSW Floodplain Management Manual	NSW Government	2001	Sets out policy and gives technical guidance for flood management in NSW, including information on hazards, flood planning levels etc.	FMP will be prepared in accordance with this manual
3.4.5	Section 117 Direction – No G25	Minister for Urban Affairs and Planning	1979	Sets out provisions to regulate Local Environmental Plans (LEPs). Flood liable land must not be rezoned for development	Provides information used in the development of property modification measures in the FMP
3.4.6	Circular C9 – Floodplain Development Manual		March 1989	Provides assistance to councils by relating the Floodplain Development Manual to the Environmental Planning and Assessment Act 1979. It identifies matters that should be considered in the preparation of a draft LEP	Provides information used in the review of LEPs applicable for Narrabeen Lagoon.
3.4.7	Circular C31			Aims to remove urban development from flood prone lands	Principles taken in account during the development of the FMP
3.4.8	Rivers and Foreshores Improvement Act	NSW Government	1948	Outlines the permit requirement for any actions affecting a river and connected lakes, and any land within 40m of the riverbank	Used as background information in the development of the FMP
3.4.9	State Environmental Planning Policy (SEPP) No 5 – Housing for Older People or People with a Disability	NSW Government	February 1998	Sets out the policy, which aims to increase the supply of housing to meet the needs of older people or people with a disability within NSW, but does not apply to environmentally sensitive land	Reviewed in the assessment of future development and in the assessment of property modification measures in the Narrabeen catchment
3.4.10	State Environmental Planning Policy (SEPP) No 44 – Koala Habitat Protection	NSW Government	February 1995	The Pittwater and Warringah LGAs are covered by this policy; Before a development consent is granted, the land must be examined to determine if it is “potential koala habitat”	Referenced in the development of the FMP
3.4.11	Total Catchment Management (TCM) and Planning	DUAP	August 1995	This document highlights specific land use planning issues relating to flooding, and identifies ways in which legislation can accommodate them	Referenced in the development of the FMP

Reference number	Document	Author	Publication Date	Synopsis	Relevance to Narrabeen Lagoon Floodplain Management Plan
3.4.12	NSW State Rivers and Estuaries Policy	NSW Government		Outlines a framework for the consideration of issues affecting rivers, estuaries, and adjacent riverine plains; This policy aims to encourage the sustainable use of rivers and estuaries	Referenced in the development of the FMP
3.4.13	Fisheries Management Act	NSW Fisheries	1994	Objective is to conserve, develop and share the fisheries resources of the State; The act incorporates the following: marine protected areas (MPAs), habitat protection, dredging and excavation, threatened species conservation, and aquaculture lease areas, all of which have relevance to flood mitigation work in Narrabeen Lagoon.	The issues outlined in the Fisheries Management Act – e.g. the sensitivity of Long Reef Aquatic Reserve (MPA) south of the study area will be considered in determining the environmental impact of any proposed flood mitigation works.
3.4.14	Policy and Guidelines for Bridges, Roads, Causeways, Culverts and Similar Structures	NSW Fisheries	1999	Summarises the requirements of NSW Fisheries in relation to roads and watercourse crossings	The requirements outlined in the Policy and Guidelines should be taken into account if any mitigation structures or watercourse crossings are recommended.
3.4.15	Policy and Guidelines for Aquatic Habitat Management and Fish Conservation	NSW Fisheries	1999	Highlights the need to obtain a permit under the Fisheries Management Act 1994 for any activity that will cause environmental damage. This document provides the policy framework for dredging and reclamation works, and other regulations in relation to waterfront developments, structural mitigation works, water pollution, snag management, and management of intermittently opening coastal lagoons	The FMP should comply with the regulations set out in the Policy and Guidelines; A preference for non-structural flood mitigation works should be maintained throughout the FMP; Narrabeen Lagoon, which is intermittently open to the sea, is particularly susceptible to water pollution
3.4.16	Fish Habitat Protection Plan No. 1 – General	NSW Fisheries		It protects all waterways in NSW that include habitat areas, and notice to or written consent of the Minister of Fisheries is required for any activities that may interfere with these areas	Any mitigation works recommended in the FMP should only be carried out after obtaining a written consent from the Minister of Fisheries
3.4.17	Fish Habitat Protection Plan No. 2 – Seagrasses	NSW Fisheries		This plan applies to all coastal and estuarine waters of NSW, and a permit is required for dredging of any area containing seagrasses	A permit must be obtained before dredging of any area in Narrabeen Lagoon

3.1 Technical Reports and Studies

3.1.1 Narrabeen Lagoon Flood Study, PWD, January 1990

The objective of the Flood Study undertaken by the Public Works Department for Narrabeen Lagoon was to determine the nature and extent of the existing flood problem. The subcatchments contributing to the Lagoon are:

Catchment	Area (km ²)	% of Total
Mullet Creek	9.7	18
Deep Creek	15.6	28
Middle Creek	14.2	26
South Creek	7.9	14
Nareen Creek	1.6	3
Narrabeen Lagoon (normal water level)	2.1	4
Other areas	3.6	7
Total	54.7	100

Historically, it was seen that the flooding mechanism varies for different flood events. Flood behaviour in Narrabeen Lagoon is determined by changes in ocean level as well as runoff from the lagoon catchment. Thus the study undertook a joint probability of storm runoff events and ocean storm events to assess design flood levels for the lagoon system.

Several different methods of hydrological modelling were assessed and the Boyd runoff model adopted. The study considered the effects of future urbanisation within the catchment.

Hydraulic analysis of the lagoon levels was undertaken using a combination of different models. The main tributaries, away from the influence of the main lagoon, were modelled using a one-dimensional model - HEC2. Flooding in the lagoon and in the Mullet Creek wetland was simulated using a quasi two-dimensional cell model.

Calibration of the models was done using the floods of March 1977 (some data), November 1961, March 1975, May 1974 (limited data), and August 1986.

Council's Entrance Management Plan, at the time of production of the Flood Study, required the entrance to be opened when water levels in the lagoon reached 1.3m AHD. A design run of the hydraulic model adopted parameters that reflect the policy, i.e. a partially closed entrance with water levels inside of 0.8m AHD and the entrance berm at 1.3 m AHD. After the internal water level reached 1.3 m, the entrance was assumed to be open. This was in line with recommendations of the Narrabeen Lagoon Entrance Study, 1989.

For Narrabeen Lagoon and the lower reaches of its tributary creeks the design flood levels for the 5%, 1% and extreme events were determined. Upstream of Pittwater Road Bridge, the design flood levels determined were:

Event	Water Level (m AHD)	Critical storm duration
5 % AEP	2.54	36 hour
1 % AEP	2.92	36 hour
Extreme	4.61 (upper limit)	12 hour

In the tributaries, two conditions were modelled and an envelope drawn to determine the design water level:

- a starting water level equal to the peak design level in the lagoon and a 36 hour peak flow
- a starting water level of 0.6 m AHD in the lagoon and the critical duration flow in the creek.

This study provides information regarding the nature of the flooding and design flood levels for the preparation of the Floodplain Management Plan.

3.1.2 Narrabeen Lagoon Floodplain Management Study, 1992

The objective of the study was to identify flood mitigation options to reduce the impact of flooding. A range of options were proposed and investigated based on their economic, environmental and social impacts. The study area covers the limit of lagoon dominated flooding, which generally extends 0.5 to 1.0 km upstream of the confluence with the tributaries. Specific areas affected by flooding include:

- Eastern side of the outlet channel,
- Lakeside Caravan Park and the adjacent residential areas,
- Mullet Creek area,
- Wimbledon Avenue,
- Narrabeen Academy of Sport,
- southern foreshores of the Central Basin, and
- area around Mullet and Narrabeen Creeks above Jackson's Road.

The study drew on information and modelling done for the Flood Study (1990). The Study found that for a 1% AEP event over-floor flooding occurred in 320 houses and 102 commercial properties, and there was significant impacts on public utilities and recreational facilities.

The FMS estimated potential flood damages that were reduced to account for community preparedness and flood warning. The reported actual flood damages were:

Damage Type	Flood Damage (\$million)		
	5%	1%	Extreme
Residential	0.14	1.77	10.92
Commercial	0.07	.73	7.8
Recreational Facilities	0.11	0.21	1.7
Government Infrastructure	1.01	2.05	6.05
Traffic Disruption	0.0	0.0	0.22
Total	1.38	4.77	26.69

The annual average damage (AAD) was estimated to be \$330,000.

The specific recommendations from the FMS included:

- A revised management strategy for the lagoon entrance based on a formalised mechanical breakout and entrance clearing strategy supported by a monitoring system to optimise entrance management intervention operations;
- A levee to run between Pittwater Road and Ocean Street to protect the Lake Park Road residential area and the Lakeside Caravan Park;
- A flood response plan and community awareness program
- A flood policy that requires a minimum flood level of 3.5 m AHD and 3.3 m AHD in the areas affected by a 1% AEP flood, upstream and downstream respectively of Pittwater Road bridge, for all new development, redevelopment and major developments of existing property;
- Further analysis for the provisional proposal for a levee along Mullet Creek, and
- local drainage study of Nareen Creek and develop flood mitigation strategies.

This report is the outcome of the phase preceding the preparation of a Floodplain Management Plan, and as such the development of the Plan will draw heavily on the results of investigations undertaken in the Study and the recommendations made.

3.1.3 Narrabeen Lagoon Floodplain Management Study ANUFLOOD Data File, 1992

The ANUFLOOD data file was compiled as a part of the Narrabeen Lagoon FMS (1992). The file contains information pertaining to the residential and commercial establishments within the study area. Information recorded for the residential dwellings under the following categories:

- Address
- Type of dwelling (detached, semi-detached, units or flats)
- Number of storeys
- House raised or unraised
- Height house is raised to
- AMG coordinates (grid reference)
- Construction material
- House size
- Block size
- Condition of dwelling
- Age
- Ground height
- Floor height
- Damage class

Some slightly different categories were used to record information pertaining to commercial properties. These were:

- Business name
- Address
- ASIC code
- Number of storeys
- Property raised or unraised
- Height property is raised to
- AMG grid reference
- Construction material
- Age
- Size
- Ground height
- Floor height
- Value class

The database was used to estimate the economic benefits of mitigation options during the preparation of the FMP.

3.1.4 Narrabeen Lagoon Entrance Study, PWD, August 1989

The Public Works Department was commissioned to develop a management strategy for the Narrabeen Lagoon entrance. The strategy considered both water quality and flood mitigation.

Flooding of the low-lying areas surrounding the lagoon can be caused by three mechanisms:

- Lagoon entrance closed, combined with heavy rain

- Lagoon entrance open, combined with ocean level rise; and
- Lagoon entrance open, combined with heavy rain.

Sand transportation processes in the lagoon entrance channel, surf zone and on the beach, make it difficult to maintain an entrance channel. The operational difficulties with mechanically opening the entrance were identified as:

- Short notice for mechanical openings to prevent flooding after a period of heavy rain
- The inability to successfully open the entrance for flushing purposes after extended dry periods.

The study identified sixteen strategies and investigated four of them in detail. No attempt was made to rank the strategies. The four strategies investigated in detail were:

- Formalised mechanical breakout and entrance clearance operation,
- Ebb tide fluidisation of channel bed,
- Excavated rockshelf entrance and low training wall/s, and
- Extension of Ocean Street Bridge.

This report contains useful information on the entrance morphodynamics and the impacts of the lagoon entrance on water levels and flooding, as well as details on various strategies for management.

3.1.5 Narrabeen Lagoon Maintenance Dredging – Assessment of Benefits Derived from Different Dredging Frequencies

This report documents the observations and findings from dredging undertaken at the Narrabeen Lagoon entrance from December 1979 to September 1982. Works were carried out by Warringah Shire Council. In 1979 the tidal delta below Ocean Street Bridge was removed and by September 1982 the entrance was closed again. The effects on hydrology, water quality, biology and recreation were monitored during and after dredging.

Different maintenance dredging frequencies were assessed for the following criteria:

- Entrance efficiency and lagoon hydrology
- Potential for flooding to occur
- Effect on the ecology of the lagoon
- Effect on the recreational potential of the lagoon.

The study found that maintenance dredging at 1 or 2 year intervals was the most economically suitable frequency and the most desirable from all criteria assessed. A maintenance strategy incorporating this frequency was recommended.

This report will be referenced during the preparation of the FMP.

3.1.6 Narrabeen Lagoon Floodplain Property Survey Appraisal, Zastawny, 2000

The Floodplain Property Appraisal was undertaken in 2000 to assess the impact of new development on the Narrabeen Lagoon floodplain since the FMS was completed (1992). The Appraisal searched development applications, lodged with Pittwater and Warringah Councils, since 1992 that were within the floodplain and were for a value greater than \$10,000. Of the 1000 applications searched, 194 new developments occurred in Pittwater LGA and 60 in Warringah LGA.

The Appraisal recorded information pertaining to new developments including:

- Address
- Date of development or building application
- Value of development
- Development description
- Ground level
- Existing floor level
- Desired or minimum floor level
- Approximate area of development
- Changes (major or minor)
- Noted when a site inspection was undertaken.

The Appraisal found that approximately 50% of new development that has occurred since 1992 might have an adverse impact on the flood level in the 1% AEP flood event. Adverse impact referred to land being filled or filling the gap between the ground level and floor level where piers are used.

The Appraisal concluded that the hydraulic modelling done in the FMS did not need to be revised immediately.

As part of the preparation of the FMP the property database (ANUFLOOD) and damage assessment will be updated with data from this report. Additionally a rudimentary assessment of the impact of filling will be undertaken.

3.1.7 Nareen Creek Flood Study, Manly Hydraulics Laboratory, June 1995

The objective of the flood study was to determine the nature and extent of flooding within the Nareen Creek catchment. The catchment area is 1.6 square kilometres. The lower reaches of Nareen Creek pass through Narroy Park into a 450 m long narrow concrete lined channel to Narrabeen Lagoon.

The first stage of the study was an investigation of the hydrologic regime of the catchment, including the development of a rainfall and runoff model (using WBMN) to determine design discharges in the creek. Water levels were determined using a MIKE11 hydraulic model. The design flood levels for the 5%, 2%, 1% AEP and extreme events were determined.

The study showed that the catchment runoff and tailwater levels in Narrabeen Lagoon control the flood behaviour in the Lower reaches of Nareen Creek. Upstream of Narroy Park the extent of flooding is dominated by the local catchment storm, which are typically shorter duration intense storm events.

Results from this study are being used in the preparation of Nareen Creek FMS and FMP currently being undertaken.

3.1.8 Nareen Creek Floodplain Management Study, Hyder Australia, Draft July 2000

The purpose of the Nareen Creek Floodplain Management Study is to develop and assess flood mitigation options for the catchment. Community consultation was undertaken to assess issues and values.

Flooding in the 1% AEP event was described as:

- Widespread flooding in the lower section of Nareen Creek, from Nareen Parade to near the intersection of Grenfell Avenue and Wakehurst Parkway and between Nareen Parade and Gondola Road, and

- In the upper section of the creek, between the Bowling Club and Narroy Park flood depths of 0.8m deep were estimated.

Flood hazard categorisation was undertaken. The estimated expected flood damages for the catchment were:

Damage Type	Flood Damage (\$1000s)			
	5%	2%	1%	Extreme
Residential	16	58	277	3,535
Commercial	65	129	256	1,033
Infrastructure	386	392	745	1,330
Total	1467	1579	2278	5898

The average annual damage (AAD) was calculated to be \$80,800.

The study assessed various floodplain management options including:

- Flood Modification:
 - Pittwater Road Levee and Flood Gates
 - Pittwater Road Levee and Flood Wall along creek
 - Retarding Basin
 - Duplicating Tatiara Cres Culvert.
- Property modification:
 - Planning controls and public awareness
 - Planning controls and voluntary purchase
 - Planning controls and voluntary house raising
- Response modification:
 - Flood warning

3.1.9 Narrabeen Lagoon Estuary Processes Study - WBM Oceanics Australia, October 2000

The objective of this study is to draw together relevant information and determine the processes that influence the physical, chemical and biological characteristics of the lagoon. Options can then be formed for the long term management plan for Narrabeen Lagoon in an Estuary Management Study, scheduled to be completed at a later stage.

The study included assessment of the following processes:

- Catchment – an assessment of stormwater inflows and sewer overflow inflows, to determine pollutants and the development of an AQUALM-XP model.
- Hydrodynamic – an assessment of the tidal behaviour, daily water variation and a review of the flooding. An RMA-2 model was developed, using inflows from the AQUALM-XP model.
- Sediment – a review and assessment of the substrate and bed sediment characteristics, sediment quality, current and future sedimentation rates. The impacts of dredging and entrance maintenance were considered.
- Water quality – a review of available water quality data, assessment of the flushing times, physical assimilation capacity and impacts of past dredging and entrance maintenance
- Ecological – an assessment of foreshore and aquatic vegetation and marine life.
- Entrance behaviour – a review of the morphodynamic of the entrance and the changes that have occurred, the current entrance management practices and an assessment of the optimum lagoon breakout and closure conditions.

In addition, there was an extensive human user activity review and a discussion of the interaction between the various processes occurring within the lagoon.

This report has a comprehensive amount of data relating to processes in the lagoon, and will provide information when assessing flood mitigation options as part of the FMP.

3.1.10 Narrabeen Lagoon Aquatic Ecology Review and Community Consultation, Nelson Consulting, The Ecology Lab and Patterson Britton & Partners, 1999

The Narrabeen Lagoon Aquatic Ecology Review and Community Consultation was undertaken for Pittwater and Warringah Councils. The Review provides an overview of the previous reports that have been undertaken for the Lagoon, as well as an assessment of the key issues related to aquatic ecology, and the key issues for Lagoon management as perceived by the community.

This study is particularly relevant for the findings of its community consultation program. It was found that the community values Narrabeen Lagoon for its quiet and tranquil atmosphere, scenic values and natural environments. The main concerns of the community regarding the Lagoon were related to:

- stormwater pollution,
- entrance management,
- sedimentation, and
- maintenance and policing of litter and other degrading activities.

The main suggestions put forward by the community for on-going management of the Lagoon were:

- selective dredging,
- improved tidal flushing,
- installation of water quality control measures on stormwater drains and creeks,
- regular removal of litter from lagoons and foreshores, and
- increasing and improving the supply of recreational facilities.

Community consultation highlighted a lack of understanding among the community of the lagoon entrance behaviour and its ecological processes, and also a lack of awareness of Council's flood mitigation and entrance management policies and procedures. It was found that the community thought flooding could be minimised by keeping the entrance open either semi-permanently or more permanently, by measures such as dredging the Lagoon, or widening, deepening or straightening the entrance channel. The study highlighted a lack of public concern for the impact of such measures on the Lagoon's aquatic ecology.

Surveys undertaken for the Study found that 82% of participants thought that stormwater drainage was a problem for Narrabeen Lagoon. A further 13.8% of participants were not sure if this was a problem, and 4.2% said it was not a problem. Similarly, 63.7% of participants thought flooding was a problem for the Lagoon, whilst 18.9% were not sure and 17.4% said no. The Study stated (page 4):

Although flooding rated quite highly as an issue in the set question it did not emerge as a key issue in open ended questions, or on the drop in day unless coupled with entrance management. There seemed to be more concern about entrance management for water quality purposes, than to alleviate flooding. This may, in part, reflect the period of time since major flooding around Narrabeen Lagoon and hence it is not foremost in peoples' minds.

Whilst the Study identified flooding as a key issue for Lagoon management, a detailed discussion was not entered.

The findings from this review and community consultation will be drawn on during the preparation of the Narrabeen Lagoon FMP. In particular the lack of community understanding for flooding issues, identified during the consultation, supports the recommendation from the Narrabeen *Lagoon Floodplain Management Study* to undertake a flood response plan and community awareness program as part of the Floodplain Management Plan.

3.1.11 Narrabeen Lagoon Dredging EIS, Don Fox Planning Pty Ltd, Patterson Britton & Partners, 1989

A dredging proposal was developed and assessed in the study. It was designed to satisfy concerns, which had been expressed over previous operations, in particular, the dredging depth, which was impacting the environment and affecting recreational pursuits.

The revised proposal was driven by a decision to have the Central Basin of the lagoon the focus of recreational activities. In the development of the proposal the following factors were considered:

- Improving water quality
- The increasing number of people using the area for recreational purposes
- Managing flooding and erosion
- Improving tidal flushing and water exchange.

The site investigated in this study was west of the central shallows, between Jamieson Park and Billarong Reserve, linking to the ventilation channel to the east of Wimbledon Island. The proposal was developed assuming that mechanical opening of the lagoon entrance to manage flooding would continue.

The study assessed and reported on the environmental impacts of this proposal. It was determined that the proposal would have a marginal impact on flood levels up to the 50% AEP flood, and even less of an effect for the more significant events.

This report will be referenced for background information relating to environmental factors during the preparation of the FMP.

3.1.12 Statement of Environmental Effects for the Rehabilitation of Middle Creek, 1993, Patterson Britton & Partners

The Statement of Environmental Effects (SEE) was prepared to assess the environmental impacts of the proposed rehabilitation of Middle Creek, which flows into Narrabeen Lagoon. The rehabilitation was proposed to reduce the impacts of water from Middle Creek flowing into the Lagoon and degrading the Lagoon's water quality. This was also leading to degradation of native bushland, loss of habitat and weed infestation in the Lagoon.

The proposed rehabilitation works included construction of a sediment basin and wetland, development of a casual recreation area, and bush regeneration and planting. These were to occur along a section of Middle Creek extending from approximately 5.5km upstream of the Lagoon to a point just upstream of the third bridge on the Wakehurst Parkway. This section of Middle Creek is entirely adjacent to the Wakehurst Parkway.

From a flooding aspect the SEE found that regular flooding of Middle Creek was causing nuisance closure of the Wakehurst Parkway, necessitating the redirection of large volumes of

traffic. Inundation of the Wakehurst Parkway commences approximately 2.7km upstream of the Lagoon. Modelling in the SEE found that the road is inundated up to a depth of about 0.3m in the 50% AEP event.

Inundation of the road in this section of Middle Creek was found to be caused by:

- narrow constriction of the Creek due to its passage between the Wakehurst Parkway and a steep escarpment;
- sedimentation and weed infestation of the channel, obstructing water flow;
- low road level; and
- vegetation overgrowth restricting the performance of culverts.

The SEE assessed the impact of the proposed sediment basin and wetlands on flooding using a HEC2 hydraulic model. Results showed that the proposed works would reduce flood levels up to 800mm in a 1% AEP flood event. The proposed works would also alleviate nuisance flooding along a section of the Wakehurst Parkway, where flooding commences and is deepest, however flooding would continue to occur further upstream. The proposed works would increase flood velocities along the creek, from 1.0 to 1.5 m/s up to 2.5 to 3.0 m/s. It was suggested that the creek bed and banks could be protected using sandstone cobbles and boulders to compensate against the adverse impacts from the increased velocities. The SEE concluded that construction of the sediment basin and wetland would have an overall positive impact on flood levels.

Findings from the SEE will be referenced during the preparation of the FMP. Reported model results were referenced in assessment of flood mitigation options for Wakehurst Parkway.

3.1.13 Narrabeen Lagoon Data Compilation Study, Patterson Britton & Partners, February 1998

The objective of this study was to assemble and review all existing information relevant to the management of Narrabeen Lagoon for use in the Estuary Process Study and Estuary Management Study.

A discussion on the relevant issues was prepared and a database developed to allow relevant information to be easily referenced. Issues addressed were:

- Flooding
- Water Quality
- Sedimentation/Sediments
- Dredging
- Aquatic Ecology
- Terrestrial Flora and Fauna
- Entrance Management
- Recreation
- Catchment Development
- Aboriginal Archaeology
- Bank erosion
- Bridges

With regard to flooding, it was noted that the key documents were the Flood Study and the Floodplain Management Study. No significant gaps were identified during the literature review.

This study will be referenced during the preparation of the FMP as it provides a useful point of reference to identify studies that have been undertaken.

3.1.14 “Be Prepared For Your Next Flood”

This is a colour brochure produced by the Narrabeen Lagoon Joint Floodplain Committee as an advisory to the community. It is a valuable community awareness tool however it does leave some issues unresolved, particularly for a new resident or commercial operator.

This type of document needs to be supported by documents that clearly state the where any evacuation centres are located.

3.1.15 *Ingleside Warriewood Urban Release Area Water Cycle Management Study, Patterson Britton & Partners, June 1994*

This report examines the optimum means of integrating water, wastewater and sewage services within the Ingleside Warriewood urban development release area, while mitigating adverse environmental impacts. Release areas include areas in the Mullet and Narrabeen Creeks catchments.

The study included hydrologic and hydraulic assessment of Mullet Creek reporting:

- a catchment area of 9.7 km² at its confluence with Narrabeen Lagoon,
- the critical storm duration was 2 hours (for a natural - undeveloped - catchment)
- peak discharge for existing development determined to be 146m³/s for the 100 year ARI event and
- attenuation from tailwater conditions produced a discharge of 71m³/s for the 100 year ARI event.

The hydrologic and hydraulic assessment was conducted to assess impacts from the proposed urban release areas. There is limited comment on the combined flooding effects of local tributary flows and elevated tailwater from the lagoon.

The study recommended that runoff flow be controlled in a series of channels and detention systems, with the detention systems consisting of either on-site tanks or more regional basins. The costs for these drainage works were estimated. The Pittwater LEP 1993 designated similar works in the Narrabeen Creek drainage corridor.

Considering the post-development scenarios along Mullet and Narrabeen Creeks it was found that “*there was no significant increase in discharges from Mullet Creek at Pittwater Road or from Narrabeen Creek at the sewage treatment works.*” Post development works include on-site detention, detention basins in two subcatchments of Mullet Creek, detention basin at Macpherson Street on Narrabeen Creek and larger culverts under Macpherson Street.

3.1.16 *Narrabeen Creek Model Calibration 10th April 1998 Flood Event, Lawson and Treloar Pty Ltd, Draft July 1998*

This study was undertaken to review flood data collected for the April 1998 flood and to use it in the calibration of Pittwater Council’s existing RAFTS and Mike 11 models of the Narrabeen Creek catchment.

The April 1998 event rainfall, runoff and flood levels were found to have an AEP between 1% and 5%.

The study concluded that the calibrated model was insensitive to a range of model parameters in all reaches except for an area downstream of Ponderosa Parade. Secondly the calibrated models are a valuable set of tools that can be used with confidence in the management of flooding issues in Narrabeen Creek catchment.

3.1.17 Review of Tailwater Conditions for Flood Modelling for Warriewood Valley, Lawson and Treloar Pty Ltd, October 1999

This report gives detail of the review of tailwater conditions for flood modelling of creeks in Warriewood Valley. This includes Narrabeen, Fern and Mullet Creeks. This review considered previous modelling of these creeks.

One aspect identified was that modelling results and general flood behaviour for Narrabeen Creek were not described or discussed in the original Flood Study (PWD 1990) and that the CELLS model developed has shortcomings in the estuary zone interface. The CELLS model has since been updated to a Rubicon model, and the results were very similar. Rubicon model was recalibrated for the 1986 event using gauging information for Mullet and Narrabeen Creeks.

During consideration of the adopted “high” and “low” tailwater conditions for modelling undertaken, the review notes that *“it is understood that Council is restricted in the opening of the entrance and requires the approval of the DLWC before the entrance can be opened in flood conditions. The consequence of this control may be that Council is unable to maintain an open Lagoon and hence tailwater conditions may be higher than otherwise might be the case.”*

During the review of the entrance configuration adopted during the Flood Study (PWD 1990) it was noted that the formulae used to model scour, the Ackers & White (1973) *“is limited in its application”* and it is suggested that it *“may be prudent to update the modelling procedure to better represent the scour behaviour during flood opening of the entrance”*. A number of suggestions on alternative techniques are made.

Ocean and lake levels over an 8.8 year data set were also reviewed. It was noted that the entrance was open for 68% of the time, with the average water level in the lake during the period of open conditions being 0.43 m AHD. It was also noted that the variation of the ocean and entrance conditions does not significantly affect the peak flood levels in the CELLS model.

This report provides useful background information and discussion on modelling undertaken for the area and ocean and lagoon water levels, which will be referenced where applicable in the preparation of the floodplain management plan.

3.1.18 Conceptual Plan for the Restoration of Creekline Corridor (Jubilee Ave to Prosperity Parade) including retention/water quality basin, Lawson and Treloar Pty Ltd, August 1999

This report supports a development application by Pittwater Council for the design and construction of creekline corridor and retention/water quality basin for Narrabeen Creek. Works proposed are in accordance with the Warriewood Valley Water Management Specification. A design objective for stormwater management is to ensure no worsening of existing flood levels for the study area (downstream limit being Prosperity Parade along Narrabeen Creek).

As part of this study, numerical hydrologic and hydraulic models, that were established during previous investigations, were refined for the purpose of design and assessment of proposed works. A water quality model was established and calibrated.

This study addresses the requirements for Stage 1 works for the Urban Release Area in Narrabeen Creek catchment. To achieve the objective of the existing peak discharges for a 100 year ARI event, a retention basin was proposed and a preliminary sizing done. Reported results from the hydraulic model indicates that the basin alone would not achieve this objective and that a natural channel design and bridge upgrade at Ponderosa Drive (Case 3) would be required.

3.1.19 Narrabeen Lagoon Entrance Channel Survey Data Compilation Report, DLWC, June 2000

This report is a compilation of important historical survey data for the entrance channel and costs of dredging. It was compiled for the Narrabeen Lagoon Estuarine Processes Study and Management Plan.

The types of data collected and generated include:

- Cross section profiles
- Plans of scarps and shoals
- 0.2 m isopachs
- volumetric calculations

The data collected shows that significant changes have occurred to the entrance bathymetry between 1941 and 2000. Since the most recent dredging works, between April and July 1999 the entrance is starting to fill again, indicating a need for ongoing monitoring and clearance works.

This report provides useful information for the evaluation of mitigation options involving entrance maintenance.

3.1.20 Hydraulic Review of Warriewood Square Culvert, Bewsher Consulting, Dec 1996

This report investigates the operation of three box culverts located under the Warriewood Square shopping complex car park, carrying flow from Narrabeen Creek. Potential modifications for improving hydraulic conductivity are evaluated using a HEC-RAS model. The culvert modifications proposed by Lyall Macoun in 1987 are also reviewed. Downstream water levels of 2.83 and 2.52 m AHD were used for the 1% and 5% AEP flood events respectively.

Proposed modifications consisted of construction of a winged headwall to reduce entry losses. A reduction of exit losses was deemed impractical, but was modelled for thoroughness. Results showed that:

- downstream tailwater levels had a significant impact on culvert capacity;
- addition of the winged headwall would increase flow capacity by 3% and 4.1% in the 5% and 1% AEP flood events respectively;
- improvements to the exit conditions resulted in a capacity increase of only 0.3% and 1% in the 5% and 1% AEP flood events respectively; and
- the maximum expected improvement calculated in this study (4.5%) is considerably less than the 19% reported in the 1987 study.

Recommendations are to construct the entrance headwall and clear sediment, debris and aquatic weeds from the culverts.

3.1.21 Flood Characteristics of Narrabeen Creek, Unisearch, June 1990

The report reviews existing flood studies on Narrabeen Creek and its receiving waters and determines the impact of flooding on the proposed re-development of Warriewood Square shopping centre.

The following conclusions were drawn from the document review:

- the Flood Study (PWD, 1990) provides the best available data for assessment of flood conditions around Warriewood Square;
- some reports were in some way deficient for the purposes of flood assessment at Warriewood Square;

- at the time of writing, analysis of the culverts under the shopping centre car park had not been undertaken;
- backwater effects from Narrabeen Lagoon and the wetlands adjacent to Warriewood Square generally control flood levels at the shopping centre;
- the calculated peak water level for the 1% AEP flood event is 3.0 m AHD; and
- surface flows onto the shopping centre site would not cause a flood hazard, but rather general nuisance flooding.

The recommendations arising from the review are that a 1% AEP flood level of 3.0 m AHD be adopted for development purposes and that the operation of the culverts is examined.

3.1.22 Pilot Stormwater Management System - Narrabeen Creek Catchment, Warriewood Valley, Patterson Britton, March 1997

This document forms Pittwater Council's contribution to the Pilot Stormwater Management Systems Program in conjunction with the NSW EPA and their development of a "Stormwater Manual". The report is based on the stormwater management control facilities for both runoff quantity and quality, developed for Warriewood Valley Stage 1 Release Area.

Runoff quantity control measures include a retarding basin near Ponderosa Parade and a channel upgrade between the basin and Jubilee Avenue. These works are designed to accommodate flows from the new development without adverse impacts on flood levels downstream.

Modelling of the control measures revealed that:

- flood levels at the new development would be reduced by up to 2 – 3 m;
- the 1% AEP flood can be contained in the channel;
- the storage volume of the basin is in excess of that required for flood mitigation; and
- channel improvements down to Warriewood Square are not required to mitigate the flooding impacts from the new Stage 1 development.

Appendix A of this document contains the stormwater study of Narrabeen Creek by Lawson and Treloar, which substantiates that the channel improvements and retention basin are adequate for mitigating any adverse flooding impacts following the Stage 1 urban release development.

Photographs of recent flooding are contained at the end of the report.

3.1.23 Water Management Documentation – Boondah Road Works Depot Development Application, Lawson and Treloar, September 2000

The report is an assessment of aspects of water management for the site development by Pittwater Council, except for potable water supply and wastewater disposal. Narrabeen Creek flows through the site.

The report identifies several factors that control the flooding behaviour at the site, namely:

- downstream tailwater from Narrabeen Lagoon;
- the culvert under Boondah Road;
- adjacent soccer fields;
- inflows from upstream; and
- the operation of the informal flood bypass across Boondah Road (between the site and Macpherson Street).

Flood levels, velocities and discharges were reported from a previously established model of Narrabeen Creek. The model was run for a lagoon water level of 0.6m. Results for existing conditions are given below:

AEP	Duration	Peak flood level (mAHD)*	Confidence (m)
20%	2 hours	1.85	± 0.2m
5%	2 hours	2.00	± 0.2m
1%	2 hours	3.00	± 0.2m
PMF	3 hours	4.29	± 0.2m

* Flood levels are mid-site

Apart from the filled area, the entire site is inundated in the 1%AEP flood event. Peak velocities are in the order of 0.60 and 0.75 m/s for the 1% AEP and PMF events respectively.

Minimum floor levels on the site are set at RL 3.5 mAHD (FPL of 1% AEP plus 0.5 m freeboard). The report contains a flood evacuation plan, including flood monitoring and evacuation procedures as well as maps of evacuation routes.

Construction of a proposed wetland on the site would reduce flows entering the creek system, especially after rainfall events. The report states that this could result in some minor alleviation of flooding downstream. However, exact results are not reported.

3.1.24 Management Objectives and Options Discussion Paper, Narrabeen Lagoon Estuary Management Study, Narrabeen Lagoon EMS Committee Workshop, Nov 2000

This paper summarises the key management issues and the key management objectives from various studies and reports that have been done on Narrabeen Lagoon Estuary. There are twenty-eight objectives discussed with suggested management options developed for each objective. The objectives relate to five themes:

- Water quality
- Sediments
- Ecology
- Waterway and foreshore usage
- Bank erosion and foreshore management

Flooding has not been considered within the objectives. The FMP will work in conjunction with management strategies developed for the estuary.

3.2 Management plans

3.2.1 Northern Beaches Stormwater Management Plan, Patterson Britton & Partners Pty Ltd, July 1999

The objective of this plan is to facilitate coordinated management of stormwater within the Northern Beaches to protect and improve riparian vegetation, aquatic habitats and water quality in lagoon catchments.

The issues identified within the Narrabeen catchment included:

- Weed infestation
- Poor water quality
- Pollutant input from septic tanks.

The plan made the following recommendations:

- Maintain existing activities
- Increase resources commitment, particularly with respect to planning issues

- Implement new activities, including raising awareness, industry involvement, construction of infrastructure.

The implementation of the recommendations of the plan should have a positive affect on those issues relevant to the Narrabeen catchment, listed above, but are not expected to impact on the flooding experienced within the Lagoon areas.

This document may be useful as an environmental reference during the preparation of the FMP.

3.2.2 Jamieson Park, Narrabeen – Plan of Management, 2000

This plan was prepared to provide Warringah Council with a framework in managing Jamieson Park. The plan identifies values attached to the community as highlighted in stakeholder consultation meetings, the values as addressed in the plan are:

- Environmental/ biodiversity values;
- Indigenous heritage values;
- European cultural heritage values; and
- Recreational values.

Although the issue of flooding is not one of the main subjects of this plan, there is brief reference to it in the environmental/biodiversity ‘basis for management’ strategies titled *Catchment Management*, where main stormwater lines and excessive number of private residential drains are the main focus. The Catchment Management strategy also deals with issues of ridge line developments, urban run-off, altered hydrology, nutrient loading, localised track flooding, “die back” and weed invasion of Jamieson Park.

As a product of a number of consultation activities undertaken by Warringah Council, a *Community Issues Discussion Paper* was prepared and attached as an appendix with this plan. The impacts of stormwater run-off and nutrient loading from surrounding developments was presented as a main concern, as well as the impacts on the overall water quality of the Narrabeen Lagoon. A concern outlined in the paper which is the direct consequence of flooding is ‘multiple tracking’ in the park, leading to erosion as people attempt to seek alternative tracks to the main bush track during flooding times.

This Plan will be referenced where necessary during the preparation of the FMP.

3.2.3 Berry Reserve & Adjoining Foreshores, Narrabeen – Plan of Management, 2000

This plan outlines a framework for Warringah Council for managing Berry Reserve and adjoining foreshores. The plan is value-driven and addresses the main community concerns of the subject area. The community values identified in the plan are:

- Natural/ cultural setting;
- Heritage; and
- Recreation/ access and circulation

The Narrabeen Lagoon is listed under natural/cultural setting and is referred to as

the largest of the estuarine lagoons along Sydney’s northern beaches ... connected to the open ocean by a narrow entrance channel which is flushed by tidal currents...subject to marine sedimentation.

The plan notes that the lagoon offers a number of recreational activities driven by its proximity to the commercial centre of Narrabeen, attracting both local residents as well as visitors from metropolitan and regional areas.

The issue of flooding is not addressed in the plan, however, management strategies for the maintenance of foreshores and stormwater outlets in the natural/cultural setting are discussed where it is suggested that inflatable booms be installed on stormwater outlets in order to improve controls on litter and pollutant discharge.

A *Community Issues Discussion Paper* is attached as an appendix to the plan. The paper presents a summary of the issues that have been of concern to the local community and key stakeholders throughout the preparation process of the plan. Environmental issues are one of eight issues discussed in the paper, with foreshore management and water quality presented as sub issues. General disagreement was expressed by the community towards any further development in the area which could potentially harm the ecology of the area, and in terms of water quality, harmful recreational activities such as the use of motorised boats was also a main concern.

This Plan will be referenced where necessary during the preparation of the FMP.

3.2.4 Dee Why Valley and South Creek Open Space Corridor – Geographic Plan of Management, 1996

This plan introduces ‘a practical working tool for future planning’ as the product of the general attitudes of the community and the review of the then existing documents. The aim of the plan is to introduce an approach that will reverse or stop the negative pressures of urbanisation, pollution and managerial neglect occurring in and around the study area. Flooding is discussed in the ‘Water Management’ issues chapter where information on the existing status, community perceptions and general discussion are presented. A summary for South Creek is given below as it is within the study area for the Narrabeen Lagoon FMP.

Existing Status, South Creek:

- Plan of Management presented findings from the Narrabeen Lagoon Flood Study including estimated flood levels for the 100 year ARI flood;
- no known private property along South Creek subject to over floor flooding in an 100 year ARI event;
- the construction of a flood retarding basin south of McIntosh Road by Landcom is thought to have resulted in the low incidence of mainstream flooding; and
- the flood mapping program is recommended to be completed prior to finalising reserve boundaries and negotiating ‘land swap’ deals.

Community Perceptions: flooding has not been raised as an issue by the community.

3.2.4.1 General Discussions:

- a separate management plan to be prepared for South Creek;
- thorough removal of weeds to maximise stream flow; and
- the preparation of floodway and channel design for South Creek for 1 in 100 year ARI flood (between Willandra Road and Toronto Avenue)

This Plan will be referenced where necessary during the preparation of the FMP.

3.2.5 Management Policy for Narrabeen Lagoon Entrance, Narrabeen Lagoon Joint Estuary/Floodplain Management Committee, November 1996

This policy was developed to describe the procedures and responsibilities for management of Narrabeen Lagoon Entrance. The management policy has been designed with a number of

objectives, including flood mitigation, improved water quality and biological diversity. The relevant issues were urban development and intermittent but natural closure of the channel.

The study documents the history of works and investigations undertaken, as well as the legislative powers the Councils have under which to exercise the management of the entrance.

The recommended management strategy was structured as follows:

- Monitoring of the lagoon entrance – as well as various water quality monitoring programs in place, there is a computer system which gives real time information on tides, water levels, rainfall and streamflow as well as providing a predictive model for future conditions
- Responsibility for lagoon entrance management – sets out the procedures and responsibilities for lagoon breakouts, entrance clearance operations and entrance closures.
- Lagoon openings/closure conditions and procedures – sets out the essential conditions, desirable conditions and procedures for opening for lagoon breakouts, entrance clearance operations and entrance closures.

Description of lagoon entrance management procedures are defined in the policy as:

- lagoon breakouts – this is the opening of the lagoon entrance using mechanical means to manage flooding in the low lying areas around the Lagoon.
- entrance clearance operations – this serves to promote longevity of lagoon entrance openings and improve hydraulic efficiency of the channel
- entrance closures – used to control the geometry of the entrance plug to make future breakout operations more effective.

As management of the entrance is important for the management of flooding in Narrabeen Lagoon, the document will be an important source of information for the preparation of the Floodplain Management Plan.

3.2.6 *New South Wales State Storm Plan*

This is a general document (effective from August 2000) for use principally by the State Emergency Service and other emergency service agencies. It describes the types of “storms” that may affect NSW, particularly coastal regions, and the measures that SES and other agencies should take before, during and after storms. It specifically states that no local storm plan should be prepared as the principles in the document apply state-wide.

The implications of this document for Narrabeen Lagoon are general only:

- Although there is no strict storm season, there is a marked tendency for major storms to occur in the October to March period;
- There is a need for the community to be aware of measures to take as a storm approaches. This will be addressed through, inter alia:
 - educational campaigns on community preparedness and damage mitigation strategies;
 - tree preservation orders;
 - debris management and removal.
- The local council will participate in these activities under the leadership of the SES; and
- The local council will provide resources to the SES.

It should be noted that warning times for storms are generally short usually a maximum of 6 hours. This places a significant responsibility on the community to be aware of the requirements for mitigating storm damage.

3.2.7 Manly Warringah Pittwater Local Disaster Plan

This Plan (effective from December 1999) is referred to as a DISPLAN and addresses all disasters, natural and man-made that may occur in the Manly, Warringah and Pittwater Council areas. The document covers planning, preparation, response and recovery aspects of dealing with disasters.

It does not have a specific focus on flooding although it does recognise that flooding is a general threat throughout the area. Floods are seen as having a high probability and major consequences.

The SES is nominated as the principal combat and response agency, however the DISPLAN does not contain the necessary storm/flooding Sub-Plan referred to in the document as it is under review.

The DISPLAN clearly states the roles and responsibilities of all the agencies likely to be affected by or involved in the response to a disaster. For “Severe Storm” and “Flooding”, the three Councils are to:

- regulate property development and construction through LEPs and DCPs;
- provide and maintain appropriate drainage infrastructure; and
- implement floodplain management plans.

At the same time, the SES is to prepare storm and tempest sub-plans and develop public education programs. The SES is responsible for the issuing of relevant warnings (in collaboration with the Bureau of Meteorology), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact.

3.2.8 Integrated Water Management Strategy – Warriewood Valley, Lawson and Treloar, November 1997

This strategy aims to address the following objectives:

- Management of the water balance for the development area so that the post-development low flow conditions are as close as possible to the existing conditions;
- Maintain, and where possible, enhance water quality
- Maintain, and where possible, enhance aquatic and riparian ecosystems.

A hydrologic and hydraulic analysis was undertaken as part of the study, flood levels determined and waterway designs developed which aimed to ensure that the existing flooding environment was not worsened. Flood management levels were set and open space drainage corridors defined to contain the 100 year ARI flood.

The study analysed infiltration pits as a means of offsetting the increase in impervious areas due to development and reviewed the detention requirements for development.

It was reported that the peak discharge was for a 2 hour duration event. Peak discharges and water levels are reported for Stage 1 only.

3.2.9 Warriewood Valley Water Management Specification : OSD Specification Review – After Calibration to August 1998 Event, Lawson and Treloar, December 1999

This report updates previous assessment of the OSD requirements for new developments within Warriewood Valley, based on flood data from August 1998. Permissible site discharges were reported for the Warriewood Valley development areas.

This report provides limited information for the floodplain management plan.

3.2.10 Warriewood Valley Urban Land Release Water Management Specification Revised Version, Lawson and Treloar, Draft - August 2000

This specification states the documentation requirements for the application and certification of developments in Warriewood Valley. It gives guidance in relation to water management, including:

- Water cycle management
- Water quality management
- Watercourse and corridor management
- Floodplain management

The requirements are aimed at ensuring water sensitive design is achieved. Water management reports are required to cover the following:

- Water cycle assessment
- Water quality assessment
- Water quality management
- Watercourse and corridor preservation/restoration
- Flood protection
- Stormwater quantity management
- Stormwater drainage concept plan

The discussion on flooding and flood planning levels for the Valley noted that there should be:

- Zero increase in 1% AEP flood levels, achieved through the application of OSD,
- Extent of the PMF and 1% AEP events to be plotted in plan,
- That flood evacuation pathways and upgrades of roads are required, and
- Submissions are to report on design peak flood levels from 100% through to the PMF events.

Recommended flood planning levels for the Valley are given.

3.2.11 Warriewood Square Flood Plan, Lyall and Associates, Sept 2001

This document was prepared following re-development of Warriewood Shopping Centre, located near Mullet and Narrabeen Creeks. The Plan aims to address flooding issues at the site and consists of the following components:

- review of flooding mechanisms at the site and their indicator conditions;
- summary of peak flood levels for various magnitude flood events;
- review of flood proofing measures in place at the shopping centre;
- flood monitoring procedures; and
- procedures to follow in the event of a flood, including evacuation measures.

The peak flood level in the 1% AEP event is reported as 3.0 m AHD. Minimum floor levels in the centre are identified as ranging from 1.75 m AHD in the service lane at the western property boundary to 2.0 m AHD in the eastern carpark. Finished floor levels of the old and new sections

of the centre have been set to 3.0 m AHD. Minimum levels on Jacksons Road are reported as around 2.6 m AHD at the southwest corner of the site and around 2.2 m AHD near the intersection with Garden Street. Evacuation is therefore northwards along Pittwater Road when Jacksons Road is inundated.

Existing flood proofing measures consist of a 600 mm high waterproof membrane, rubber-sealed doorways and sealing of internal connecting walkways. Flood monitoring relies on information from Narrabeen Lagoon Watch, the Bureau of Meteorology and three flood depth gauges located at the rear of the service lane.

3.3 Local Planning Instruments and Policies

Development in flood prone land in Narrabeen Lagoon floodplain is subject to controls from both Pittwater and Warringah Councils. Documents that have been used by Councils to manage development are given below. The current plans and policies are:

- Pittwater Floodplain Management Policy, 2001;
- Pittwater Local Environmental Plan, 1993;
- Warringah Local Environmental Plan, 2000, and
- Warringah Design Guidelines, 2000 – supplements Warringah LEP with more detailed controls

A comparison of these documents and the previous flood policy that was applied to both Pittwater and Warringah LGAs, “Interim Policy and Guidelines, 1990” is given in **Table 3.2**.

3.3.1 Warringah Council Local Environmental Plan 2000

3.3.1.1 Exempt and Complying Development

Amendments to the *Environmental Planning and Assessment Act* in 1998 have resulted in the creation of categories of exempt and complying development within each local government area. Exempt development may be carried out without development consent, whilst complying development is assessed on the basis of its level of compliance with council planning instruments. Development that does not fall into either of these categories is assessed on the basis of its merits and level of compliance with planning instruments. Each council is responsible for allocating types of development to the exempt and complying categories.

Exempt development in Warringah is outlined in Schedule 1 of the LEP. Clause 1(c) of the LEP allows that, regardless of Schedule 1, exempt development does not include development on flood prone land.

Clause 7 of the LEP allows that all development except that which is exempt and that in Schedule 2 require Council consent. Clause 7(b) and Schedule 2 of the LEP allow that flood mitigation works may take place without development consent, where carried out by Council or the Department of Land and Water Conservation. However, this does not allow the erection or installation of buildings, plant or other structures; the reconstruction or alteration of buildings such that change is physically evident; or the formation or alteration of any means of access to a road, without development consent. Also under this clause, maintenance dredging may occur without development consent where carried out by a public authority, provided that certain bodies are consulted.

The LEP also identifies development that is complying, which is assessed on the basis of compliance with the provisions of Council’s LEP and where the merit of the proposed development is not considered. Clause 8(2)(b) of the LEP specifically excludes development on

floodprone land from this category. These clauses ensure that full development assessment is carried out for any development on flood prone land, except for flood mitigation works.

3.3.1.2 Environmental Protection of Waterways

Clause 60 of the LEP requires that development must be ‘sited and designed to maintain and enhance natural watercourses and aquatic habitat’. This clause encourages the continuing preservation of watercourses such as Narrabeen Lagoon, and its natural flow of water. Water quality is also preserved through clause 78, which specifies controls over erosion and sedimentation on a site during development. A soil and water management plan must be prepared to minimise soil erosion and maintain downstream water quality, wherever a degree of soil erosion and sedimentation is likely to occur.

3.3.1.3 On-site Detention of Stormwater

Clause 76 of the LEP relates to stormwater management, and requires that stormwater runoff from a development be discharged to a Council approved drainage system. The clause refers to Council’s *On-site Stormwater Detention Technical Specification*, which presents the standards for incorporating on-site stormwater detention into all development, except where certain conditions can be met. These include that:

- discharge from the development will not pass through any drainage control structure or natural drainage system before reaching receiving waters;
- additional runoff created by the development will not adversely affect any natural or constructed drainage system, upstream or downstream of the development site;
- the total post-development impervious area is equivalent to less than 35% of the total site area;
- the development will not increase the impervious surface of the site by more than 50m²;
- the soil conditions allow on-site retention and disposal of stormwater;
- the site is within an established 100-year ARI floodplain and the local drainage system is not adversely affected by lesser storm events.

The above controls provide that on-site stormwater detention will be used to control stormwater runoff, unless it can be shown that such runoff will not adversely impact any existing natural or constructed drainage system, and that the development does not significantly increase the impervious site area. The final point above allows that if the site is within an area affected by the 100year ARI event, provided that the drainage system has capacity to cope with all events up to the 100year ARI event, an OSD system is not required to be installed on the property.

3.3.1.4 Housing for Older People or People with Disabilities

The LEP takes a permissive approach to housing for older people or people with disabilities, the provision of which is regulated under State Environmental Planning Policy No. 5 (SEPP 5). Clause 40 of the LEP describes the various requirements for such housing developments, including adequate access to various goods and services. Schedule 16, *Principles and standards for housing for older people or people with disabilities*, adds further detail to the standard of such housing. The need for flood free access to and from the development (to the extent of the flood planning level) should be incorporated into both clause 40 and Schedule 16. Housing for older people or people with disabilities should be expressly prohibited on flood prone land.

3.3.1.5 Development on Flood Prone Land

Clause 47 is the main clause relating to flooding in the Warringah LEP. This states:

Development on flood plain land is to be sited and designed to minimise impacts of flooding on property and have regard to the existing flood regime.

In particular:

- *development is not to reduce flood storage area or impact upon the existing flood regime,*
- *habitable floor areas of buildings are to be at a level of at least 500mm above the 1% annual exceedence probability flood level, and*
- *buildings or works affected by flooding are to be constructed of flood compatible building materials.*

A number of flood compatible building components and materials are outlined in the *Interim Warringah Design Guidelines* (2000). It is recommended that more detailed provisions be included in these guidelines to outline how developers may avoid adverse impact on the existing flood regime, that would support and reinforce clause 47 of the LEP. Further points are recommended to be added to this clause, for instance regulating landfill (which is discussed in clause 77 without reference to flooding) in flood prone areas. These matters will arise upon more detailed investigation of the flood regime.

In addition to clause 47, Schedule 7 of the LEP, *Matters for Consideration in a Subdivision of Land*, has some relevance to development on flood prone land. Clause 4 of the Schedule states that ‘subdivision on flood prone land should be avoided’, effectively discouraging the intensification of development on flood prone land. This clause could be strengthened to prohibit any form of subdivision of land within flood prone land.

The Dictionary to the LEP should also incorporate definitions of flood prone land, flood planning levels, and other flood related terms. These should be derived from the NSW *Floodplain Management Manual*.

3.3.2 Representation of the Warringah Local Environmental Plan 2000

This set of maps accompanies the Warringah LEP 2000 and provides the land use zones for areas within the flood plain.

3.3.3 Interim Warringah Design Guidelines

The Interim Warringah Design Guidelines were prepared in December 2000 as an accompaniment to Warringah LEP 2000. The Design Guidelines provide a greater level of detail and explanation of the design standards for development in Warringah than is found in the LEP.

Part D of the Design Guidelines relates specific clauses of the LEP to the appropriate development controls. It expands clause 47 of the LEP, *Flood Affected Land*, to outline the appropriate guidelines for development on flood affected land. The first guideline is:

Do not reduce the flood storage area or impact upon existing flood regime

The three categories of flood liable land are described as being floodways, flood storage areas and flood fringe area. The text explains that if the flood storage area is reduced by landfill or the construction of levees, adjacent flood levels will rise and the peak discharge downstream may increase. It is then stated that plans accompanying development applications should show the 1% AEP flood level.

Other ways in which the flood storage area could be reduced, or the existing flood regime changed by development, have not been considered by the Guidelines. Considerations that could be added to the instructions under this first guideline include the impact of fencing on the flood regime, and the need to prevent further building, filling or construction of fencing in the floodway.

The second guideline states:

Design habitable floor areas at least 500mm above the 1% Annual Exceedence Probability

A brief explanation of the meaning of the term ‘1% Annual Exceedence Probability’ is provided below this guideline, as well as a diagram to demonstrate the habitable floor level, being 500mm above the flood level.

The third guideline states:

Use flood compatible building materials

The text provides a list of the materials and construction methods that are suitable for development on the flood plain. This list expands the statement in the LEP that buildings affected by flooding should be constructed of flood compatible building materials, giving appropriate guidance to developers. The list of materials and construction methods is derived from the NSW Government *Floodplain Development Manual*, and should be updated to refer to the *Floodplain Management Manual*.

We would recommend that this section of the Guidelines refer to:

- electrical and mechanical equipment, heating and air conditioning systems, and services that are appropriate for use in the floodplain.
- potential distinction of floor levels for residential dwellings and commercial premises;
- potential distinction of floor levels and permissible development between the floodway, flood fringe and flood storage areas;
- location of critical utilities and public facilities on the floodplain;
- need for development applications relating to areas of high flood hazard to prove the ability of structures to withstand the force of floodwater, debris and buoyancy;
- need for development applications relating to flood affected land to consider the impact of development on flood levels elsewhere;
- need for adequate evacuation procedures to be in place;
- availability of flood-free access to developments; and
- potential impact of house raising on surrounding development, on residents who may be isolated during flooding, and the impact of a higher than design flood on raised houses.

Other clauses related to flooding in the LEP are also expanded in the Design Guidelines. These provide guidelines for erosion and sedimentation, landfill, stormwater management, and watercourses and aquatic habitat. The flood-related guidelines focus on preventing unnecessary alteration or inhibition to the natural flow path of watercourses. Within the guidelines on stormwater management, the use of on-site stormwater detention is encouraged to reduce the impacts of increased run-off on the existing natural and constructed drainage systems. Within the guidelines on landfill, some reference to discourage filling of flood affected land, particularly in flood storage areas, could be incorporated.

3.3.4 Pittwater Council Local Environmental Plan 1993

Pittwater Local Environmental Plan (LEP) 1993 was gazetted on 4 February 1994. This LEP applies to all land within the Pittwater LGA. The LEP does not make any specific reference to development on flood prone land. There is potential to incorporate a clause to highlight the existing flood hazard in areas of Pittwater, and to refer to maps which may identify the affected areas. Such a clause could also refer to various development control plans to provide further detail. Depending on the future level of detail provided in the LEP, it may be appropriate to incorporate flood-related definitions as adopted from the *Floodplain Management Manual* in Clause 5 (Interpretation) of the LEP.

3.3.5 Interim Policy and Guidelines for Development and Use of Land likely to be affected by the Designated Flood Event, 1990

Both Pittwater and Warringah Council had adopted the Interim Policy and Guidelines. Since this time both Councils have superseded these documents with Warringah Council LEP and Design Guidelines 2000 and the Flood Risk Management Policy for Pittwater (June 2001).

3.3.5.1 Interim Policy for Development and Use of Land Likely to be affected by the Designated Flood Event

The Policy is to be used in conjunction with the Guidelines (see above). The Policy adopts the 1% AEP flood event as the designated flood for planning purposes. Properties affected by flooding are identified in maps held by Council, and on their Section 149 certificates in accordance with Section 149 of the *Environmental Planning and Assessment Act, 1979*.

The Policy outlines general aims and objectives, followed by aims and objectives that are specific to Pittwater Council. The former, general aims and objectives, are to:

- alert the community to the extent of land affected by flooding, and to evacuation and warning procedures
- inform the community of Council's policy in relation to the development and use of land affected by flooding
- reduce the risk and costs of flooding to existing areas
- encourage occupation, development and construction compatible with the flood hazard
- ensure that emergency buildings and services are designed above the probable maximum flood level
- provide direction and policies relating to the development of flood affected land.

Within the latter category, relevant aims and objectives include:

- adopt an Interim Local Flood Policy for development decisions, to apply until a Floodplain Management Plan is implemented
- through effective building and development controls, minimise the potential for flood losses within flood liable land
- notify relevant landowners of the constraints on development of their property
- obtain, where necessary, the height of existing flood levels to Australian Height Datum (AHD), and other survey information by a Registered Surveyor
- create maps that reflect affected properties according to Council's Interim Flood Policy
- include notification on Section 149 Certificates in sections (2) and (5), to advise of Council's Interim Flood Policy, and of development restrictions on the subject land
- clearly mark potential liability of the land to flooding on all consents and permits issued
- relevant subdivision, rezoning, development and building applications be assessed in accordance with the State Governments' Floodplain Development Manual and Council's Interim Floodplain Development Policy
- only allow filling of land with development consent
- make flooding information available upon request.

3.3.5.2 Interim Guidelines For Development and Use of Land Likely to be affected by the Designated Flood Event

The Guidelines define the designated flood event / flood standard as:

the flood which has a 1% AEP or a 1 in 100 chance of occurring in each and every year including an 0.5m freeboard.

Thus the design floor level is the 1% AEP flood level plus 0.5m freeboard.

All development applications must be accompanied by a survey plan showing ground levels and floor levels, certified by a registered surveyor. Survey levels are not required for structures, however it is recommended that they are provided. Structures should be designed to incorporate pier/pile footings instead of enclosed structures or filling, which minimises the loss of flood storage and the impacts of surface water flow. Also, for major development proposals that increase occupation potential in the floodplain, existing floor levels may be required to be raised to the design floor level. It is recommended that garages also be raised to the design floor level, and that valuables be stored at a higher level.

Part B of the Guidelines contains a statement that Council must include with all development approvals issued in the area. It states:

The property is in an area where there is likely to be a risk of flooding from a 1% AEP flood. It should be noted that this is not the maximum predicted flood. Design floor levels have been derived from information on this flood contained in flood studies available for each floodplain.

Council strongly recommends that if not specified in the conditions of approval, effective precautions be taken at least to the design floor level, to reduce any potential risk to personal safety and to minimise any property damage to the structure, its fixtures and contents. These precautions may include: raising of floor levels; provision of levees; barriers or waterproofing of the structure to prevent ingress of flood waters; use of flood compatible building materials; relocation of wiring; fuel supply lines and storage of hazardous materials; plant; water damage; above the specified level. It should be noted that flood waters may rise rapidly with little warning, inhibiting evacuation of and emergency access to the site. (Model Condition 18R).

In general, structures incorporating filling will not be approved, though they will be assessed on their merit. Careful consideration will be made of the footprint of new structures, to ensure that any alteration of flood flow or flood storage characteristics does not have a significant adverse impact.

The Guidelines divide development proposals into categories of major and minor development. Major development includes, *inter alia*:

new dwellings, commercial and industrial development, subdivisions, and where proposed alterations and additions involve habitable rooms (other than where it is a minor development) or any redevelopment which extends the life of the building.

Minor development includes:

ancillary structures such as sheds, swimming pools, garages, carports, fences, pergolas, awnings, verandahs, porches or minor once-off additions/conversions of 30m² or less.

Suggested conditions of consent for both categories are provided, dealing with the following matters:

- minimum floor levels
- certification by a registered surveyor
- construction of the sewerage system to prevent surcharge during flooding
- construction of buildings and services below a minimum height so as to withstand flooding – addressing factors of buoyancy, flowing water with debris, wave action, flood compatible materials, and waterproofing
- electrical equipment, wiring and fuel lines below the design floor level to be watertight
- storage of any hazardous materials or items susceptible to water damage above the design floor level.

For instances where the above requirements are inappropriate, special requirements may be applied under Part F of the Guidelines. These include controls over floor levels, waterproofing, safe access, structural integrity in flood inundation, and the provision of ‘Flood Awareness’ signs.

3.3.6 Flood Risk Management Policy for Pittwater, June 2001

Pittwater Council has adopted a Flood Risk Management Policy for planning purposes on flood prone land within the Pittwater LGA. Generally, the objective is to regulate development in flood liable areas. Other aims include alerting and informing the community of the flood risk and introducing flood warning and evacuation systems. The policy also uses Section 149 Certificates and maps to identify flood prone areas.

3.3.6.1 Flood Planning Levels (FPL)

The default FPL for all flood affected areas is the 1% AEP plus 500mm freeboard.

3.3.6.2 Development Controls

Applicants for development in flood affected areas are required to lodge a survey plan prepared by a registered surveyor that shows existing ground and floor levels, and the location of existing and or proposed buildings. A certificate prepared by a qualified engineer defining the 1% AEP level, the PMF level and any constraints on the proposed development should also be lodged. The certificate should state that the proposed structure will satisfactorily withstand flood effects such as water forces and the impact of debris, and immersion up to the PMF. Construction below the FPL must use flood compatible building materials and waterproofing. All applications are to incorporate effective precautions and accompanied by a flood evacuation strategy.

3.3.6.2.1 *i. Residential*

Multi-unit housing, medium density development and housing for the aged and disabled (SEPP 5) are not permitted in flood prone areas. Subdivision of flood affected land is also not permitted where it will create additional flood prone allotments. Filling is also not permitted, unless there is no net decrease in the floodplain storage capacity. Detached dual occupancies are permitted within the flood plain. All additions to existing structures are to have all floor levels above the FPL, and the floor is to be supported on open piers where possible.

3.3.6.2.2 *ii. Commercial and Industrial*

Floor levels for all new buildings and additions or modifications to existing structures are to be constructed above the FPL, and preferably on open piers. Change of use is allowed for minor works with provisions for flood proofing or locating services above the FPL. Exceptions to the required floor levels may be considered if a site-specific assessment is made of the flood hazard, and a permanent sign to indicate flood proofing and how it was achieved is displayed. Basement

parking is only permitted if the basement is fully flood protected, and the crest level of all access to the basement is fully contained and above the greater of the PMF or FPL. There must also be a flood free evacuation route.

3.3.7 On-Site Stormwater Detention Technical Specifications, Warringah Council, 2000

The objective of Council's OSD specifications is to ensure that the stormwater runoff after any development does not exceed the runoff prior to the development. Implementation of OSD helps to reduce the impacts from urbanisation. Warringah Council's specifications are to be applied as detailed in the *LEP 2000*. It is not applicable to "green fields" developments.

3.3.8 Development Control Plans – Pittwater Council

3.3.8.1 Development Control Plan LP23 - Narrabeen Valley Locality Plan

The Narrabeen Valley Locality Plan applies to the residential areas of Narrabeen Valley, which are dissected by a ridgeline. The Plan identifies and evaluates the existing character of Narrabeen Valley, aiming to maintain and modify environmental characteristics according to their desirability. The low-lying residential areas, to which this Plan applies, are subject to a number of controls to this end.

One of the aims of the Plan, outlined in section 1.5, is

to have regard for... natural hazards likely to affect development.

Section 3.4 of the Plan outlines the requirements for on-site stormwater detention, stormwater drainage, and stormwater flooding. The aim of this section is to ensure that all new developments in Narrabeen Valley do not increase flooding or stormwater flows in downstream areas, for all rainfall events up to and including the 1% AEP. On-site stormwater detention facilities must be designed in accordance with Council's *Policy and Guidelines for On-site Detention of Stormwater*.

Section 3.4.2, *Council's Stormwater Drainage and Natural Watercourses*, aims to protect new developments from flooding up to and including the 1% AEP event. It requires that any application for a development proposed adjacent to a watercourse, open channel, stormwater drainage pipeline or drainage easement, submit details in accordance with Council's *Building / Development Works Adjacent to Easements and Watercourses*.

Section 3.4.3, *Stormwater Flooding*, similarly aims to protect new developments from flooding up to and including the 1% AEP event. It restricts development on certain properties that are subject to stormwater flooding, as identified on Council's *Plan No 97-009*. Development applications pertaining to such properties are required to be accompanied by a survey plan that shows the existing ground and floor levels and is certified by a registered surveyor. This section also notes that the design floor level of development is the level of the 1% AEP flood event plus 500mm freeboard.

3.3.8.2 Residential Development Control Plan No. R1- Residential Flat Buildings and Group Buildings

Residential Development Control Plan (DCP) No. R1 became effective from 3 November 1997. DCP R1 applies to all land within Pittwater LGA that is zoned residential 2(a), 2(b), or 2(e). The DCP does not address any issues of relevance to development on flood-prone land. Land to which this plan applies is located within the study area.

3.3.8.3 Policy and Residential Development Control Plan No. R2- Dual Occupancy

Policy and Residential Development Control Plan (DCP) No. R2 applies to all land where dual occupancy development is permissible under Pittwater Local Environmental Plan (LEP) 1993, comprising non-urban zones 1(a) and 1(b), and residential zones 2(a), 2(b), and 2(f). The DCP has been in force since 20 October 1997. Clause One in Part C of the DCP identifies relevant drainage objectives, which demonstrate the desired outcome of dual occupancy development in relation to drainage. The objectives relevant to flooding are:

- to ensure that new developments provide appropriate disposal of storm water and storm water detention;
- to minimise adverse affects on adjoining properties from drainage and storm water run-off;
- to minimise hard surfaced areas, therefore maximising opportunities for surface infiltration of storm water;
- to ensure that mixed development will not be subject to flooding or tidal inundation.

The drainage objectives are reinforced by design requirements, which are specific standards to ensure that objectives are met. The relevant drainage design requirements include the need for all developments to prepare a Stormwater Drainage Concept Plan to demonstrate that the proposed drainage is feasible. The Concept Plan is to show site constraints, the treatment of surface flow paths, and the location of easements and storage areas for on-site detention. On-site stormwater detention is a central aspect of Council's drainage requirements, and is required for the majority of sites. The design requirements state, however, that on-site detention may not be required in designated flood prone areas.

The Drainage Design Requirements in the DCP also state that development subject to flooding, tidal inundation, and/or adjacent to easements and watercourses will not be approved unless Council's specific requirements are met.

3.3.8.4 Residential Development Control Plan No. R3- Multi Unit Housing

Residential Development Control Plan (DCP) No. R3 has been in force since 9 April 1998. DCP R3 applies to all land within Pittwater LGA that is zoned residential 2(a), 2(b), or 2(e), similar to DCP R1. The DCP identifies drainage objectives under Part C Clause 1. The relevant objectives for development on flood-prone land are:

- to ensure that new developments provide appropriate storm water detention and disposal of stormwater;
- to minimise adverse affects on adjoining properties from drainage and storm water run-off;
- to minimised hard surfaced areas, therefore maximising opportunities for surface infiltration of storm water;
- to ensure that new development will not be subject to flooding or tidal inundation.

The relevant drainage design requirements also under Part C Clause 1 of the DCP include the need for:

- all developments to include a Stormwater Drainage Concept Plan to demonstrate that the proposed drainage system is feasible, subject to the same requirements as in DCP R2 above;

- on-site detention systems are also required in the majority of cases, but may not be required in designated flood prone areas;
- similar to DCP R1, development subject to flooding, tidal inundation, and/or adjacent to easements and watercourses will not be approved unless Council's specific requirements are met.

Multi-unit housing is thus subject to the same drainage requirements as dual occupancy development.

Under Part B Clause 7 the DCP also requires consideration of landscaping. A sufficient area of the development must be devoted to landscaping so that efficient on-site infiltration of stormwater can occur. The DCP states that stormwater, on-site detention and landscaping systems must work in conjunction with each other, such that stormwater and on-site detention systems do not interfere with landscaping requirements.

3.3.8.5 Residential Development Control Plan No. R4- Shop Top Housing

Residential Development Control Plan (DCP) No. R4 came in force on 29 April 1999. The DCP applies to all land within Pittwater LGA, which is zoned General Business 3(a), Service Business 3(b), or Neighbourhood Business 3(c). It aims to improve the quality, choice and overall appearance of housing in commercial areas, with sensitivity to Pittwater's natural and built context. The DCP addresses stormwater drainage under Part B Landscaping, which has as an objective:

to maximise the area devoted to landscaping for the purposes of efficient on-site infiltration of stormwater

There are no further references to flooding in the DCP. The general emphasis of the DCP is on encouraging shop-top housing to add vitality to the streetscape in commercial areas. This emphasis should be questioned, in the light that it encourages residential development in the most flood susceptible area of the catchment.

3.3.8.6 Local Approvals Policy and Development Control Plan No. 2- Carparking

Local Approvals Policy and Development Control Plan (DCP) No. 2 has been in force since 18 December 1997. The DCP applies to all land within Pittwater LGA. The DCP regulates the provision of safe, adequate and appropriate areas for car parking. One aim of the DCP relevant to the consideration of flood prone land is,

any parking area in Pittwater should be designed and located ... to minimise hard surfaces and provide adequate drainage and stormwater control.

3.3.8.7 Development Control Plan No. 8- Height of Buildings

The Local Approvals Policy and Development Control Plan (DCP) No. 8 applies to all land within Pittwater LGA, and has been in force since 3 November 1997. The DCP was later amended to include an interim Council policy that was adopted on 27 September 1999. The Policy makes allowances for maximum building heights to be greater in flood prone areas. It states that:

In designated flood prone areas as indicated on Council's flood constraint maps, where owners choose to or are required to raise the floor level of the building above the 1% flood level, the height of the building is to be:

- i) *a maximum of 8.0 metres above the level dictated by the 1% flood level; excluding freeboard requirements, or:*

- ii) *8.5 metres above existing ground level, whichever is the greater overall height. Where it is proposed to floodproof a building and maintain its floor level below the 1% flood level, the overall height of the building is to be 8.5 metres above ground level as per the existing controls.*

The Policy states that its provisions should be incorporated into Council's relevant DCPs, and a formal review of those DCPs should occur. The Policy is presented as Council's 'current policy for development in those floodprone areas', and is applicable to both residential and commercial development in village centres that are affected by flooding.

Again, the encouragement of increased density in flood prone areas should be questioned, and attention given to the potential impacts of flooding. Potentially, the allowance of increased density could be dependent on the provision of flood evacuation plans and emergency procedures.

3.3.8.8 Development Control Plan No. 10 - Subdivision and Code for Subdivision

Development Control Plan (DCP) No. 10 came into effect on 24 December 1994. The DCP applies to all land in Residential zones, General and Special Industrial zones, Special and Neighbourhood Business zones, and Non-Urban zones within Pittwater LGA, with the exception of land within the Barrenjoey Peninsula and the Pittwater Environmental Study Area.

Clause 3 of the DCP addresses the design criteria for allotments in residential zones. It states:

- 3.1 (b) *In areas subject to constraints such as flooding, tidal inundation, subsidence, slip, bush fire or any other risk, adequate safe area for building, where the risk from hazard is minimal, is to be provided within an allotment.*

Clause 3.1 (d) also addresses the need for special attention to be given to drainage for all allotments. Council's Public Works specifications for drainage are held as a minimum requirement for subdivisions.

Clause 3.3.7 further states that:

The minimum building area being the area available for a dwelling house and car accommodation is to be free from all constraints, including geological, environmental, drainage and easements. It is to be located so as to protect any environmentally significant features. Where a minimum building area cannot be sited so as to comply with these requirements then the minimum site area of the allotment should be increased until these requirements are met. If it can be demonstrated by way of plans that a satisfactory dwelling house can be designed and constructed, Council may consider a reduced minimum building area.

This clause indicates Council's commitment to protection of new housing against environmental constraints. The clause is all-inclusive and thus also applies to development in areas subject to flooding. This type of clause could potentially be expanded to make specific reference to subdivision in flood affected areas, for example, reference could be made to the availability of land situated above flood planning levels in flood affected areas. Clause 7.5, Non Urban Zones, further addresses the need to avoid the creation of additional lots in areas of natural hazard, including flood prone land.

Clause 4 relates to access for residential allotments. Access to and from properties can be restricted during flooding, causing isolation and intensifying flood impacts. This can be avoided through implementation of planning regulations as part of flood management. At present, driveways and access corridors are not permitted to have a gradient exceeding 1:4. This clause

should include reference to the need for access to and from residential properties to be available above the flood planning level.

Clause 6 looks at Special Residential Areas – Natural Hazard Areas, which includes land subject to tidal inundation and flooding. It is stated in Clause 6:

- (c) Subdivision should be avoided in flood prone lands. Some lands within the area of Pittwater may be susceptible to flooding. Council's Works & Services Branch should be consulted for details. Council may require the submission with a proposed subdivision of a report from a Hydraulics Engineering Consultant or other professional person where land is identified by Council as being at risk of flooding.*

Clause 7.1 provides standards for subdivision in areas zoned Light Industrial 4(b). There are two objectives for the subdivision of industrial zoned land that relate directly to flooding. These are:

- (d) to ensure that development is located minimising the risk from floods*
- (e) special attention is to be given to drainage for all allotments notwithstanding that this is a normal requirement under the Environmental Planning and Assessment Act and the Local Government Act. Council's Works and Services specifications are to be considered a minimum requirement for all issues of drainage in relation to subdivision.*

A parcel of land currently zoned for light industrial development is located north of the Lagoon, between Garden Street and Warraba Street.

Clause 8 outlines the need to provide Council with enough information to make accurate assessments of risks associated with Development Applications. Under Clause 8.1, Council must take into account the following factors relevant to flood affected land:

- the nature and topography of the land
- the likely geotechnical, bushfire and flooding risks and any other risk likely to be encountered on the land
- the likely impact of the proposed subdivision on stormwater run-off and drainage.

Clause 8.2 provides means for Council to assess the above factors, by requiring, *inter alia*, the following information:

- (k) any existing dams, watercourses or creeks within or adjoining the site with information on flood levels or extent of flooding affecting the site*
- (l) any existing drains, easements or rights of carriageway affecting/benefiting the site*
- (n) the proposed means of disposal of stormwater from future lots or from a right of carriageway and/or road pavements*
- (o) in some instances it may be necessary to submit preliminary engineering design for road and drainage works to assist in determination of the application.*

This DCP clearly considers the risk of flooding and discourages subdivision in flood affected areas. Further detail may be needed in some areas, including reference to flood prone land where subdivision is not permitted, and the availability of flood free access to properties.

3.3.8.9 Development Control Plan No. 15 - Heritage Conservation

This DCP applies to all land within Pittwater LGA. The DCP does not address any issues of relevance to development on flood-prone land.

3.3.8.10 Local Approvals Policy and Development Control Plan No. E3 – Driveways and Internal Roadways

DCP E3 – Driveways and Internal Roadways accompanies DCP 2 – Carparking. It contains the same aim to minimise hard surfaces and provide adequate drainage and stormwater control, and makes no further reference to flooding. DCP E3 could incorporate more detailed controls, to require applicants to consider the influence of driveways and internal roads on floodwater flow paths and diversion routes. The DCP should also incorporate some consideration of how driveways and internal roadways can be linked to on-site stormwater detention systems.

3.3.9 Section 94 Plans

3.3.9.1 Warringah Section 94 Contributions Plan, 1997

Section 94 of the *Environment Planning and Assessment Act 1979* (as amended) makes provision for a council to require that a developer dedicate land, provide ‘material public benefit’ and/or make a monetary contribution in connection with a development scheme.

The Plan lists various contributions in regards to:

- embellishment of open space in Warringah LGA;
- acquisition of open space in medium density areas
- embellishment of open space in medium density areas;
- open space – specific facilities in new release areas, Frenchs Forest;
- Warringah Mall public library in Warringah LGA;
- child care centres in Warringah LGA;
- community centres in Warringah LGA;
- roads and traffic management in Frenchs Forest;
- roads and traffic in Warringah LGA;
- carparking in Dee Why commercial centre; and
- carparking in Brookvale Commercial Centre.

The Warringah Section 94 Contributions Plan does not require contributions specifically for management of Narrabeen Lagoon floodplain.

3.3.10 Warriewood Valley Section 94 Contributions Plan

The Warriewood Valley Section 94 Contributions Plan aims to enable Pittwater Council to require payment for public amenities and services that are necessary in the course of development of the Warriewood Valley Urban Release Area. Payment may be made by developers in the form of a monetary contribution, dedication of land, or the provision of material public benefits or works in kind.

Development in Warriewood Valley is forecast to result in an increase of over 4,200 additional residents in the Pittwater Local Government Area by 2010. Residential development will be accompanied by industrial and commercial development in various parts of the Valley. The resulting increased demand for public amenities and services will be met by various developer contributions.

The Warriewood Valley Urban Release Area extends from Cabbage Tree Road in the north to Pittwater Road in the east, and Garden Street in the south. Narrabeen Creek and Fern Creek flow directly through the area, and Mullet Creek flows along parts of the southern boundary of the

release area. Among other services, water management facilities will be required to operate at increased capacity in the area. This involves the upgrading of water quality, stormwater and drainage facilities. Council's approach to water management is based on the dedication of land by developers for creekline corridors, as well as monetary contributions towards various drainage and retention works.

Two flood-related environmental objectives of development in the Warriewood Valley Urban Release Area are:

to ensure urban development and associated works are sensitive to the limitations and capabilities of the site in terms of ... flooding... (and)

to ensure that development is as safe as possible from ... flood hazard. (page 15)

Part six of the Plan outlines the way demand for water management facilities will be met through developer contributions. There is a need to manage stormwater run-off, both up and downstream of development, to protect properties from flooding and to protect catchment ecosystems from poor quality urban run-off. In particular, the Warriewood Wetlands and Narrabeen Lagoon are both situated downstream of the Valley, and need to be protected against run-off.

To cater for these needs, land along creeklines will be acquired by Council. These will provide vegetation corridors for local flora and fauna, add to local amenity, and serve as a drainage channel. The corridors will be a total of 100 metres in width, comprising 50 metres either side of the creeks. Of this corridor, 25 metres either side of the creeks will be acquired by Council, intended to serve as a pedestrian and cycle route and a flora and fauna habitat. This is also intended to contain the flow of floodwaters in a 1% Annual Exceedence Probability (AEP) flood event. The remaining 25 metres either side of a creek is a buffer in private ownership, and will contain flora and fauna habitat as well as water quality and quantity treatment measures such as water quality control ponds. With regard to flooding, the intention is to retain floodwaters in public lands.

The corridors will be accessible to pedestrians and cyclists, and a number of access works will be constructed to facilitate access. Both road bridges and pedestrian / cycleway bridges over the creeks will allow flood-free access across the creeks up to the 1% AEP flood event. This is intended to provide adequate emergency and evacuation access to the entire release area during flood events.

Other relevant strategies for water quality and quantity management are:

- The quantity and quality of stormwater run-off from new development will be managed, to protect downstream properties from local flooding.
- Excavation and filling adjacent to the creek is to be balanced to ensure waste minimisation and no net loss of flood storage.
- All development is required to provide stormwater detention, either on site or for each sector of the development area. Contributions will be used to provide a water retention basin as part of a broader strategy for stormwater detention in the Valley.

The Plan provides a sound basis for using developer contributions to mitigate the impacts of flooding in Warriewood Valley. Whilst it is not sufficient as a sole means of mitigating the impacts of flooding on new development, the Plan may be used to formulate future evacuation procedures and manage the risk of flooding from Narrabeen, Fern and Mullet Creeks.

Table 3.2 – Comparison of planning policies – Warringah and Pittwater LGAs

This table does not represent a comprehensive review of each document. It should be read and referred to only in conjunction with the document reviews contained in Volume 2. The words ‘no reference’ in the following table indicate that controls on that particular aspect made no reference to development relating to flood affected land.

<i>Aspect</i>	<i>Interim Policy and Guidelines</i>	<i>Pittwater 2001 Floodplain Management Policy</i>	<i>Warringah Design Guidelines</i>	<i>Pittwater LEP</i>	<i>Warringah LEP</i>
Design Floor Level	1% AEP + 500mm freeboard	1% AEP + 500mm freeboard	Habitable floor levels to be at the 1% AEP + 500mm freeboard	No reference	Habitable floor levels to be at the 1% AEP + 500mm freeboard
Flood Planning Level extent	Land within the 1% AEP extent	All land below the level of the FPL (1% AEP + 500mm)	Land within the 1% AEP extent	No reference	No reference
Existing Floor level	Required to be raised to design floor level where the proposed development will increase occupation potential of the floodplain.	All additions to existing structures (commercial, residential and industrial development) are to have all floor levels above the flood planning level..	No reference	No reference	No reference
Exceptions for floor level	No reference	Alternatives given for additions to residential full brick/brick veneer structures and additions to commercial and industrial development Flood proofing required in such cases. Exceptions to the required floor levels considered for new commercial development and industrial development provided satisfactory flood proofing or a site specific assessment of the flood hazard.	No reference	No reference	No reference
Required to accompany DA	Survey plan showing ground levels, floor levels, levels for structures. Conditions of consent included for all development approvals on flood prone land, advising of flood risk and precautionary measures. Further conditions relating to: <ul style="list-style-type: none"> ▪ minimum floor levels 	<ul style="list-style-type: none"> ▪ survey plan showing existing ground levels, floor levels, location of existing and proposed buildings. ▪ engineer’s certification/report defining 1% AEP, FPL and PMF levels, constraints on proposed development and statement of structural performance of 	plans showing the 1% AEP flood level	No reference	No reference

<i>Aspect</i>	<i>Interim Policy and Guidelines</i>	<i>Pittwater 2001 Floodplain Management Policy</i>	<i>Warringah Design Guidelines</i>	<i>Pittwater LEP</i>	<i>Warringah LEP</i>
	<ul style="list-style-type: none"> ▪ certification by a registered surveyor ▪ construction of the sewerage system to prevent surcharge during flooding ▪ construction of buildings and services to withstand flooding – addressing factors of buoyancy, flowing water with debris, wave action, flood compatible materials, and waterproofing ▪ electrical equipment, wiring and fuel lines ▪ storage of any hazardous materials. 	<ul style="list-style-type: none"> ▪ building due to flooding. ▪ effective precautions ▪ evacuation strategy 			
Flood Proofing	No reference.	Use of flood compatible building materials and waterproofing recommended in various applications. No guidance as to what constitutes flood compatible materials.	All buildings and works affected by flooding are to be constructed of flood compatible building materials. A list of suitable building materials and construction methods for flood prone land is provided that references the Floodplain Development Manual..	No reference	All buildings and works affected by flooding are to be constructed of flood compatible building materials (clause 47). No guidance as to what constitutes flood compatible materials in LEP – see design guidelines.
Filling	Generally, structures involving filling will not be approved. Structures are encouraged to incorporate pier or pile footings in place of filling or enclosed structures.	Filling or perimeter enclosures are not permitted unless there is no net decrease in flood storage capacity. Support of structures on open piers is encouraged.	Development is not to reduce the flood storage area or impact on the existing flood regime – eg. by landfill or the construction of levees.	No reference	Landfill clause (cl.77) makes no reference to flood prone land, however clause 47 states that development on flood prone land is not to reduce flood storage area.
Sensitive Development	No reference.	<ul style="list-style-type: none"> ▪ Multi-unit housing, medium density development and housing for the aged and disabled (SEPP 5) not permitted in flood prone areas. ▪ Detached dual occupancies permitted in Primary Flood Prone Areas. 	In accordance with requirements in LEP	No reference	Housing for aged and disabled (SEPP 5) is not prohibited by the LEP on flood prone land – see clause 40 and schedule 16.

<i>Aspect</i>	<i>Interim Policy and Guidelines</i>	<i>Pittwater 2001 Floodplain Management Policy</i>	<i>Warringah Design Guidelines</i>	<i>Pittwater LEP</i>	<i>Warringah LEP</i>
		<ul style="list-style-type: none"> Basement car parking is permitted in commercial and industrial developments where suitable vehicle and pedestrian access provided and pedestrian flood evacuation route from the basement. 			
Subdivision	No reference.	Not permitted on flood affected land where it will create additional flood prone allotments. Exception provided for commercial and industrial development.	No reference	No reference	Clause 4 states that subdivision on flood prone land should be avoided.
Change of use	No reference.	For changes of use to commercial and industrial premises allowed for minor works with provisions for flood proofing or locating services above FPL.	No reference	No reference	No reference
Major Development	New dwellings, commercial and industrial development, subdivisions, and where proposed alterations and additions involve habitable rooms (other than where it is a minor development) or any redevelopment which extends the life of the building	Implied to be all residential, commercial and industrial development apart from minor works.	No reference	No reference	No reference
Minor Development/ Works	Ancillary structures such as sheds, swimming pools, garages, carports, fences, pergolas, awnings, verandahs, porches or minor once-off additions/conversions of 30m ² or less	Residential - garden shed, swimming pools (in-ground), garages (<40 m ²), carport, fences, pergola, deck, open awnings, verandah, internal fitout. Commercial/Industrial - open carport, signage, paving, internal fitout.	No reference	No reference	No reference
Flood Awareness	Use of Section 149 (2) and Section 149 (5) Certificates and	Use of Section 149(2) Certificates and maps within the	No reference	No reference	No reference

<i>Aspect</i>	<i>Interim Policy and Guidelines</i>	<i>Pittwater 2001 Floodplain Management Policy</i>	<i>Warringah Design Guidelines</i>	<i>Pittwater LEP</i>	<i>Warringah LEP</i>
	Conditions of Consent to raise awareness.	Policy identifying flood prone areas.			
Height of Buildings	No reference.	Maximum 8m above the FPL, or 8.5m above the existing ground level, whichever is the greater.	In accordance with requirements in LEP (Locality Statements)	No reference	No reference
Exempt and complying development	No reference	No reference	No reference	No reference in LEP. Exempt and Complying Development is regulated by DCP 22, which places all land constrained by flooding into Region 1. Exempt development in Region 1 includes: aerials, air conditioning units, barbeques, bird aviaries, clothes lines, cubby houses, fences, flagpoles, garbage storage enclosures, goal posts, letter boxes, hairdressing shops, minor (non-structural) alterations to commercial premises, navigation aids, play equipment, portable building site sheds, public meetings, recladding of roofs and walls, satellite dishes, scaffolding, skylights, tree and bushland removal, water heaters, water tanks, replacement of windows and doors. Complying development in Region 1 includes: bed and breakfast accommodation (in an existing dwelling), demolition, landfill, and strata subdivision.	No development on flood prone land is 'exempt' or 'complying'. All development on flood prone land requires development consent (with the exception of flood mitigation works and maintenance dredging, see Schedule 2).

3.4 State and Regional Planning Instruments and Policies

3.4.1 Sydney Regional Coastal Management Strategy, Sydney Coastal Councils Group and the Regional Steering Committee, 1998

The study applies to the Sydney Local Government Areas (LGAs) that are located on the coast, including Pittwater and Warringah LGAs. The Strategy aims to implement sustainable coastal planning and management practices, which will be achieved through protecting and conserving terrestrial and marine ecosystems. It initiates a strategy framework addressing the goals and objectives for achieving Ecologically Sustainable Development (ESD) as well as a strategy framework for Coastal Management Objectives and Guiding Principles.

The Study contains a Strategic Actions Program, which outlines problems and identifies solutions for several issues affecting the coast. One such issue is water cycle management. Under this heading the strategy promotes sustainable water cycle management by the protection of natural flow regimes and natural processes, and enhancing water quality.

The Strategy highlights the following issues relevant to coastal flooding and stormwater management:

- insufficient use of semi-permeable surfaces to promote infiltration and reduce stormwater runoff;
- lack of implementation and consistent policies for the installation of on-site stormwater retention and detention devices;
- continual loss of natural drainage water courses to pipes and channels.

The Strategy then explores key outcomes that are proposed to address these issues. With regard to flooding, the document proposes that local floodplain management plans be produced

for all identified floodplains that protect aquatic and riparian ecosystems as well as life and property.
(page 25)

A specific action to achieve this is the continuing development of Floodplain Management Plans that are:

consistent with the NSW Government's Floodplain Development Manual and linked to the preparation of catchment based stormwater management plans.
(page 25)

One of the key outcomes which was identified to address issues specific to stormwater management was described as:

A catchment based stormwater management plan that includes strategies to promote increased infiltration under suitable local conditions and reduced stormwater runoff using appropriate landscape and planning mechanisms.
(page 21)

This would be implemented by the identification and assessment of existing stormwater and sewerage infrastructure, and encouraging an innovative approach to stormwater treatment.

A further outcome is to establish on-site stormwater retention and detention strategies, achieved at a local government level by policy implementation.

3.4.2 The Urban Storm Water Initiative

The Urban Storm Water Initiative (USI) provides Federal funding of \$11 million between 1999-2002, under the *Living Cities Program*. The Initiative aims to encourage integrated catchment management approaches to stormwater management works that incorporate source control measures. Such works will serve as best practice demonstration projects. Funding is available under the Initiative to stakeholders who have formed a consortium and can demonstrate a contribution to better stormwater management through on-ground works in major coastal cities.

3.4.3 State Government Flood Prone Land Policy

3.4.3.1 Primary Objective

The State Government Flood Prone Land Policy 1984 has the objective to “*reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding*” (NSW Government 1986:33). There are three main aspects to this objective:

1. The reduction of flooding and flood liability impacts on existing developed areas will generally be attained by flood mitigation works, the removal of unnecessary development controls, property acquisition, flood awareness programs and evacuation strategies where necessary.
2. The application of effective planning and development controls will contain the potential for flood losses in new developed areas.
3. Broad consideration of social, economic, and ecological, as well as flooding matters, will be made for all development decisions, based on a “merit approach”.

3.4.3.2 Implementation

Implementation of the above objectives was planned to occur at Federal, State, and Local government levels.

The Flood Prone Land Policy identified various local government responsibilities for the management of flood prone land. To assist local governments in their role, the State Government developed a program of technical and financial assistance to councils for the undertaking of flood mitigation works and property acquisitions, and for the reinforcement of emergency and relief services.

In addition to this program, the State Government passed legislation providing indemnity to councils for decisions made in relation to flood prone land. This legislation is contained in section 733 of the Local Government Act, 1993.

3.4.4 Floodplain Management Manual, March 2001

The Floodplain Development Manual 1986 has been recently revised and published in March 2001. The FMM reflects changes to policy and practice over the past 15 years. This Floodplain Risk Management Plan is prepared in accordance with the FMM.

3.4.4.1 Flood Planning Levels

Under the Manual, the concept of Flood Planning Levels (FPLs) replaces that of the standard or designated flood. The FPL will be used as a planning tool, to set development controls on flood prone land.

Essentially the FPL is a result of balancing two risk factors:

- the potential damage to property and risk to human life, which may occur as a result of flooding; and
- the value of the use of the floodplain for development and occupation.

FPLs attempt to strike a balance between these two factors, according to land use needs and certain physical factors, which vary across the floodplain. If the FPL is set too low, it will result in excessive damage to property, but if set too high unnecessary restrictions will be placed on land which is capable of development, and uneconomic use of the land will result.

While a FPL will not generally define the full extent of flooding, it will take into account the full range of floods, the likelihood of their occurrence, and the related consequences for development.

3.4.5 Section 117 Direction – No G25

On 1 June 1987 the Minister for Urban Affairs and Planning issued Direction G25 under section 117 of the *Environmental Planning and Assessment Act, 1979*. Direction G25 sets out provisions that regulate Local Environmental Plans (LEPs). It aims to ensure that, where relevant, the objectives of the Flood Policy are reflected by LEPs. The Direction provides a statutory basis for the planning principles in the Floodplain Development Manual.

Draft LEPs generally must not rezone flood liable land for development, and must not permit development in flood liable land, or anything which would cause the need for the Government to increase spending on mitigation, infrastructure, or servicing. Any flood liable land which presents high hazard, or land in a floodway, must be zoned “special uses environment protection” or similar, by a draft LEP.

Development for agricultural purposes, or minor alterations and additions to existing development, may be permitted without development consent in low hazard, flood fringe, and flood storage areas.

The revised Floodplain Management Manual will necessitate amendments to Direction G25, to reflect upgraded policies and practices.

3.4.6 Circular C9 – Floodplain Development Manual

Circular No. C9 – Floodplain Development Manual was issued on 17th March 1989. It works in conjunction with the Floodplain Development Manual, liability legislation made by the *Local Government (Flood Liable Land) Amendment Act, 1985*, and the Section 117(2) Direction, No. G25. Circular C9 aims to assist councils by relating the Floodplain Development Manual to the *Environmental Planning and Assessment Act, 1979*, and also by indicating DUAP’s approach to the implementation of the Flood Policy.

While the Manual establishes that Floodplain Management Plans should be prepared by councils, and that LEPs should be based on the implementation of those Plans; Circular C9 acknowledges that there is some delay in the preparation of the plans. For the interim period, the Circular identifies matters that are to be considered in the preparation of a draft LEP. Among these is the consideration of “any relevant floodplain management plan or interim policy”, and also any further information on the extent or impacts of flooding.

The Circular also emphasises the need to consider the impacts of development and of flooding in adjacent local government areas. There must be consultation between councils to ensure that their floodplain management plans support consistent standards. Cumulative impacts of the various aspects of development and flooding should also be considered. The Circular also highlights the need to consider certain matters of state and regional significance, such as those contained in State Environmental Planning Policies (SEPP), Regional Environmental Plans (REP) and any diversion or retention of floodwaters, or reduction of catchment storage capacity.

It is understood that Circular C9, and related planning documents, are currently being revised by the Department of Urban Affairs and Planning, parallel to the revision of the Floodplain Management Manual.

3.4.7 Circular C31

Following the Section 117 Direction 7(i)(a) from the Minister, Circular No 31 was issued. The aim of this circular was to essentially promote the removal of urban development from flood prone lands. Flood prone land was defined as areas covered by the 1 in 100 year flood.

3.4.8 Rivers and Foreshores Improvement Act, 1948

A permit is required under Part 3A of the Rivers and Foreshores Improvement Act for any actions affecting a river and connected lakes, their associated banks, shores and beds, and any land within 40 metres of the riverbank or lake shore. The consent authority for any works would be the Minister for the Department of Land and Water Conservation.

3.4.9 State Environmental Planning Policy (SEPP) No 5 – Housing for Older People or People with a Disability

This policy, which commenced on 14 February 1998, aims to encourage the provision of housing that will increase the supply and diversity of housing that meets the needs of older people or people with a disability. This land applies to land within NSW but does not apply to environmentally sensitive land which is land that can be identified by any of the following descriptions or by descriptions that incorporate any of the following words or expressions:

- ◆ floodway; or
- ◆ natural hazard.

It is recommended that no SEPP 5 housing be constructed or existing infrastructure and services be used for SEPP 5 housing in the Narrabeen Lagoon catchment, in areas defined as floodways or natural hazards.

3.4.10 State Environmental Planning Policy (SEPP) No 44 – Koala Habitat Protection

This policy, which commenced on 13 February 1995, aims to protect the habitat of koalas. It applies to land with an area of more than one hectare. The Pittwater and Warringah Local Government Areas are covered by this policy.

Before a consent authority may grant development consent on land, it must decide whether or not the land is “potential koala habitat”. The definition of potential koala habitat is “an area of native vegetation where the trees or the types listed in schedule 2 (koala feed trees) constitute at least 15% of the total number of trees in the upper or lower strata of the tree component” (clause 4).

3.4.11 Total Catchment Management (TCM) and Planning

Circular F13 was issued on 21 August 1995 and introduces the Department of Urban Affairs and Planning (DUAP) document entitled *Total Catchment Management and Planning*. This document promotes an understanding of the relationship between TCM and planning legislation, and encourages councils to integrate TCM into their works and practices.

TCM aims to promote the sustainable use of natural resources, through involvement of all levels of government agencies and individuals. It involves the integrated management of environmental components including land, water, vegetation, fauna and other natural resources.

The document highlights specific land use planning issues, which relate to flooding, helping to identify ways in which legislation can accommodate these issues. The issues are:

- risks to human life, property and stock;
- debris, litter, chemicals and fuel entering and polluting rivers during floods; and
- conservation of wetlands, floodplain vegetation and native fauna, which is, threatened when water flows are modified and water quality declines.

Those issues should therefore be considered in a floodplain management plan and the relevant planning documents.

3.4.12 NSW State Rivers and Estuaries Policy

The NSW State Rivers and Estuaries Policy sets out a framework for the consideration of issues affecting rivers, estuaries and their adjacent riverine plains. Factors such as vegetation, water chemistry and geomorphology are to be considered within the overall framework of total catchment management.

The objective of the Policy is:

*“To manage the rivers and estuaries of NSW in ways which
~ slow, halt or reverse the overall rate of degradation in their systems,
~ ensure the long-term sustainability of their essential biophysical functions, and
~ maintain the beneficial use of these resources.”*

Management principles are aimed at encouraging the sustainable and non-degrading use of rivers and estuaries. Where areas of estuaries or rivers are currently degraded, the policy encourages their restoration and rehabilitation. Where there are areas of particular significance, the policy provides for their protection. These management principles are combined under an ethos of sustainability.

The Policy is based on the development and review of strategies for sustainable resource management. Sustainable resource management is defined as:

“that which ensures resource use is consistent with the long term biological and physical function of the natural system.” (NSW Water Resources Council 1993:23)

Regional Estuaries Reports will be produced for each region every two years, to monitor the improvement and/or degradation of resources. Every four years, these regional reports will be compiled into a State of the Rivers and Estuaries Report. The Policy also initiates development of ten component policies by certain nominated agencies. The key components are wetlands, riparian zones, riverine plains, streams and estuaries.

Implementation is now the responsibility of the Department of Land and Water Conservation.

4 ECONOMIC IMPACTS OF FLOODING

4.1 Introduction

A flood has a variety of effects on the lives and livelihoods of people whose possessions and places of residence or employment are inundated. Flood damages are either financial or social in nature. The total potential financial “damage” caused by a flood can be separated into two major components: the cost of the direct damage to inundated property; and the cost of the indirect damage associated with the disruption of social, community and commercial relationships during the post-flood period.

The costs arising from an actual flood are referred to as actual flood damages. Invariably the actual damages differ from potential damages due to actions taken to reduce flooding after flood warnings are issued. The higher the community flood awareness, preparedness and experience, the lower the ratio of potential damages to actual damages will be. Preparedness of a community is a function of both the turnover of the population and the time since the last flood. Estimation of damages has accounted for community “flood awareness” and their experiences in coping with floods. Details are given in the following sections.

The Narrabeen Lagoon FMS (1992) presented flood damages for all uses within the floodplain. Combined they gave Annual Average Damages (AAD) estimates. These figures were derived using the program ANUFLOOD. Limited data from the ANUFLOOD database was available during the preparation of the FRMP; thus economic assessment of mitigation options using this method was not possible. SMEC was commissioned to re-establish flood damage estimates for use in the assessment of mitigation options as part of the FRMP. Damage estimates drew on information from the ANUFLOOD database, recent developments reported in the Appraisal Study (2000) and sample checking of property information.

Potential damages are not based on actual evaluations of possessions within residential properties. They are based on state wide averages, any references to insurances or insurable losses without valuations would be misleading and give rise to greater concern within the community.

4.1.1 Direct Damages

The direct costs of flooding can be subdivided into the cost of damage to the actual structure of an inundated building, the cost of damage to its contents, and the cost of the immediate post flood clean up operations. These costs are referred to as "structural", "contents" and "clean up" costs.

The type of structural damage sustained by a building depends upon both the materials and manner of its construction and the depth of inundation and velocity of the floodwaters. Inundation by deep, fast-flowing floodwaters may actually wash a building away, whereas shallow, slow moving water may cause relatively minor structural damage.

The damage to the contents of residential dwellings and other buildings includes the cost of cleaning, repairing or replacing flood damaged furnishings (carpets, furniture, etc), appliances, services (electricity, telephone, water supply and sewerage) and clothing. Content damage to commercial property includes damage to raw materials, plant and equipment, stock, and "incidentals" (for example office furnishings, employees' possessions, and services).

4.1.2 Indirect Damages

A flood can severely disrupt the commercial and community based activities indirectly by the clean up costs, loss of wage or salary (both during and after a flood), cost of removal and accommodation, loss of trading profit, inconvenience and loss of amenity. It may take many weeks for a community to regain their pre-flood levels of productivity. Indirect damages also arise in a number of other ways. For example, the disruption and diversion of traffic, both during and immediately after a flood. Indirect damages do not apply to infrastructure or the government sector.

4.2 Methodology

A variety of factors affect the flood damage caused to a particular piece of property. In this case the following three factors have been used to predict direct, potential flood damages:

- ◆ land use;
- ◆ the "size" of the buildings and other improvements associated with the land use; and
- ◆ the depth of flooding.

Land in the flood-prone areas of the Narrabeen Lagoon catchment is used for a variety of purposes, including residential, commercial, light industrial, utility services and recreation. Detailed descriptions of damage estimates for these types of land use are given in the following sections.

The amount of damage that occurs on a particular piece of land tends to increase with the "size" or "scale" of the operations undertaken there, other factors remaining constant. Measures of property size can include annual assessed value as the measure of size for residential property and floor area for all other types of property.

The cost of immediate post flood clean-up operations is essentially the value of the time of those engaged in the clean-up process plus the cost of removing and dumping flood damaged materials, together with loss of business for commercial establishments.

4.2.1 Allowance for flood warning and community preparedness

Preparedness of a community is a function of both the turn-over of the population and the time since the last flood. The higher the awareness and experience, the lower the ratio of potential damages to actual damages will be. A reduction factor is applied to reflect community flood awareness and flood warning procedures for residential, commercial and industrial premises.

4.3 Residential Damages

4.3.1 Direct Damages

The list of residential properties supplied by Warringah Council was updated using lists of development applications submitted to each of Warringah and Pittwater Councils. Once updated, the database contained information on 1003 properties (including Nareen Creek catchment). Sample checking of property information was done, this was not an extensive survey of all affected properties and it did not include floor or ground level survey.

The lists of development applications showed details of new houses, dual occupancy conversions and new unit block developments. In updating the database, the following assumptions were made:

- Where construction materials were not specified, new developments were assumed to be constructed of brick;
- Where floor levels were measured on site, readings were taken to the nearest 0.25 metres;

- Ground heights were estimated to the nearest 0.25 metres from topographic contours on digitised cadastral maps;
- Where it was not known how many apartments were on each floor of a building, the total number of units was divided by the number of floors;
- Generally, a height of 2.7 metres per storey was assumed; and
- For dual occupancy dwellings and apartment blocks, structural damages were calculated per building.

Information contained in the database includes:

- type of property (house, unit, etc);
- number of storeys and units (if applicable);
- ground height and height to floor;
- construction material; and
- a value code.

Each residential property was assigned one of four possible value codes, “A” through “D”, where “A” refers to a high value property and “D” a low value property. Value codes were assigned on the basis of field observation and survey data. Factors such as construction material, size, number of storeys, age, condition and location were taken into account. For example, a small run-down single storey fibro home would be generally be assigned a low value code (C or D) whereas a well-maintained, large 2 storey brick house would be give a higher value code (A or B). A property price range was assigned to each value category, based on discussion with local real estate agents and consultation of local real estate advertisements. Separate price ranges were developed for units/townhouses and for detached dwellings.

Damage costs are divided into 3 types: internal, external and structural. Appropriate values for each were obtained by scaling the figures for the Newport Beach Floodplain Management Study (SMEC, 2001) according to a comparison of property prices. Newport figures were in turn based on methods adapted from PPK, 1993 in their Tamworth study, which uses an assessed value of residential property damage at a height of 2 m above floor level. The values adopted for the Narrabeen study are given below in **Table 4.1**

Table 4.1: Residential property value categories

Value Code	Property value (\$1000s)	Internal damages	External damages	Structural damages
For houses:				
A	1500 - 700	\$30,042	\$3,303	\$20,560
B	700 - 550	\$18,443	\$2,019	\$11,568
C	550 - 350	\$17,742	\$1,922	\$10,308
D	350 - 300	\$16,902	\$1,854	\$9,204
For units:				
A	550 - 400	\$65,361	\$7,187	\$44,732
B	400 - 300	\$33,104	\$3,623	\$20,763
C	300 - 250	\$28,402	\$3,077	\$16,501
D	250 - 200	\$24,491	\$2,686	\$13,336

The following equations were used to calculate flood damage estimates.

Depth of over floor flooding (H) < 1 m

$$D = D_2(0.06 + 1.42H - 0.61H^2) (1 + ID) + D_{\text{CLEAN}}$$

Depth of over floor flooding (H) ≥ 1 m

$$D = D_2 (0.75 + 0.12H) R (1 + ID) + D_{\text{CLEAN}}$$

- Where D = Value of damage to property (\$)
D₂ = Assessed value of residential property damage at 2 m depth of flooding (H) or "size" (\$)
H = Depth of over floor flooding (m)
R = Reduction factor to take into account provisions for flood warning
ID = Indirect damage factor.
D_{CLEAN} = Clean-up cost (\$)

D₂ is the summation of the internal, external and structural damage amounts. To account for varying size, type of building the following formulae was used:

$$D_2 = X (\text{Int} + \text{Ext}) + (Y \times \text{Struct})$$

D₂ = Annual assessed value of residential property at 2 m depth of flooding (H) or size (S) (\$)

X = Total number of units/flats located on title block

Y = Total number of buildings which contain X

Int = Internal property value (\$)

Ext = External property value (\$)

Struct = Structural property value (\$)

4.3.1.1 Allowance for flood warning and community preparedness

It is expected that there is generally a low level of flood awareness in the community for several reasons:

1. it has been some time since significant inundation has occurred either as a result of high ocean level (1974) or a general flood (1942),
2. there is a continuing population turnover, and
3. there is no Local Flood Plan for the study area thus there is limited application or knowledge of flood emergency procedures.

The FMS adopted reduction factors of 0.3 and 0.6 for the 5% AEP and 1% AEP events respectively. However, these values appear optimistic considering the points noted above. In light of these factors, a reduction factor of 0.9 has been assumed for both events. No reduction was applied in the FMS for the extreme event; this is considered appropriate.

4.3.2 *Indirect Flood Damages*

Indirect damages were assumed to be 15% of direct damages for residential properties. This is in accordance with the FMS (1992).

4.3.3 *Results*

The number of houses flooded above floor level as well as total damages (including indirect damages and reduction for warning) are presented in **Table 4.2**. Properties in the Nareen Creek catchment were removed from the database as they are being covered in a separate study.

Table 4.2: Residential damage estimates

Flood event (AEP)	Total damages (\$ million)	Number of houses affected
5%	7.5	162
1%	11.3	208
Extreme	28.4	434

Note: Nareen Creek not included

4.4 Commercial/Industrial Damages

4.4.1 *Direct Damages*

For this study, damages for commercial and industrial properties were based on a database of local businesses, obtained from Council, and potential damages derived in the Newport Floodplain Management Study (SMEC, 2001).

The database from Council contained 249 commercial/industrial properties. This was updated to consider the most current (2002) occupancy in Warriewood Shopping Centre (WSC). This information was obtained from WSC centre management and floor levels from the emergency flood plan for the centre. As for the residential sector, properties in the Nareen Creek catchment were removed from the database.

Each business was placed into one of the following categories, according to the type of damages that would be sustained during a flood:

- light industrial;
- hair/beauty;

- office;
- restaurant/café;
- retail; and
- medical/dental services.

As part of the Newport FMS a comprehensive survey of the business entities was undertaken which considered damage to various components of enterprises, such as stock, fittings, fixed or moveable machinery. It was assumed that there would be no significant difference in damages between businesses in the two catchments. **Table 4.3** shows the average damage values that were adopted for each business category, for various flood heights. Damages are cumulative with flood level.

Table 4.3: Average damages for commercial/industrial businesses for Newport Beach

Business category	Flood depth (m)		
	0.5	1	1.5
light industrial	\$114,900	\$181,200	\$281,200
hair/beauty	\$15,742	\$26,792	\$130,792
Office	\$109,289	\$178,020	\$376,620
restaurant/cafe	\$117,436	\$168,652	\$268,652
Retail	\$323,232	\$425,351	\$911,351
medical/dental services	\$219,433	\$250,258	\$355,258

Information for each property (floor levels and ground levels) and flood levels were used to calculate the depth of flooding above floor level for each business in Narrabeen. This was then used to estimate damages.

A reduction factor of 0.9 was applied to commercial damages to account for flood warning and preparedness, as per the residential sector.

4.4.2 Indirect Damages

The indirect damages were assumed to be 33% of direct damages for commercial and industrial properties, in accordance with the Narrabeen Lagoon FMS (1992).

4.4.3 Results

The number of businesses flooded above floor level as well as total damages (including indirect damages and reduction for warning) are presented in **Table 4.4**.

Table 4.4: Commercial damage estimates

Flood event (AEP)	Total damages (\$ million)	Number of businesses affected
5%	14.3	87
1%	24.9	113
Extreme	68.1	241

Note: Nareen Creek not included

4.5 Government Infrastructure and Recreational Facilities

Potential damages to recreational facilities and government infrastructure were taken from the FMS (1992) and increased to reflect inflation. Costs were increased comparing building indices for June 1992 and June 2000, taken from Rawlinsons (2001); a factor of 45% was applied.

Damage estimates in current prices are presented in **Table 4.5**.

Table 4.5: Damage estimates for recreational facilities and government infrastructure

Facility / Infrastructure	Items	Damages per flood event (\$000's)		
		5% AEP	1% AEP	Extreme
RECREATIONAL FACILITIES				
Narrabeen Academy of Sport	clean up and damage	36	51	499
Cromer golf course	clean up	36	43	72
Council parks and reserves	clean up and damage	109	217	588
Lakeside Caravan Park	clean up and damage	-	-	1,303
Subtotal		181	311	2,462
PUBLIC UTILITIES				
Gas	damage	29	116	217
Water and sewage	Pittwater Rd main	-	-	7
	pumping stations	-	760	3,619
Telecommunications	exchange	-	-	369
Electricity	substations	72	290	579
RTA Roads	road repairs	58	347	1,609
	traffic lights	-	-	145
	bridges	-	22	290
Council Roads	road repairs	1312	1427	1933
Dept of Education	Narrabeen High School	-	7	14
Subtotal		1471	2969	8782
Total		1652	3280	11244

4.6 Traffic Disruption

The costs associated with disruption to traffic due to road closures were taken from the FMS (1992) and updated by obtaining current Average Annual Daily Traffic (AADT) counts from the RTA.

The most current Average Annual Daily Traffic (AADT) counts were obtained from the RTA for various locations, as shown in **Table 4.6**. It was assumed that 50% of traffic must divert and the average additional distance travelled is 10 km for Wakehurst Parkway (9500 vehicles) and 15 km for Pittwater Road (24,000 vehicles). A travel cost of \$0.60 per km was assumed and a flood duration of one day. This brings travel costs to \$57,000 for Wakehurst Parkway and \$216,000 for Pittwater Road. Assuming a cost of time of \$17 per hour and an average speed of 60 km/h, travel time costs are approximately \$27,000 for Wakehurst Parkway and \$102,000 for Pittwater Road. This brings the total cost associated to traffic disruption to approximately \$402,000.

Table 4.6: Average Annual Daily Traffic (AADT) Counts

Location	AADT	Year recorded
Wakehurst Parkway, west of Pittwater Road	19073	1991
Pittwater Road bridge	48011	1999
Pittwater Road, north of Nareen Parade	57973	1999
Garden Street, west of Pittwater Road	10791	1991
Ocean Street, north of Malcolm Street	6514	1987

4.7 Average Annual Potential Damages

Average annual potential damages (AAD), for existing conditions, were calculated assuming an ARI of 100,000 years for the extreme event. A summary of potential damages and AADs for each sector is presented in **Table 4.7**.

Table 4.7: Summary of damages for existing conditions, Narrabeen Lagoon floodplain

Damage Type	Potential Damages (\$ million) per flood event			Average Annual Potential Damages (\$ million)
	5% AEP	1% AEP	Extreme	
Residential	7.4	11.1	28.0	0.75
Commercial	14.3	24.9	68.1	1.6
Government Infrastructure	1.5	3.0	8.8	0.22
Recreational Facilities	0.2	0.3	2.5	
Traffic Disruption	-	-	0.40	0.002
Total	23.4	39.3	107.8	2.57

Nareen Creek catchment not included

These damage estimates, for the residential and commercial sectors, are higher than those estimated in the FMS (1992). This is due to three main reasons:

- Inflation since the FMS was completed
- ANUFLOOD was used in the FMS and this is recognised to give lower damage estimates than other methods currently used. This was affirmed by representatives from the Natural Hazards Research Centre at Macquarie University (personal communication 2001). A similar difference had been noted for comparative studies. It is expected that this contributed to many mitigation options considered in the FMS not being economic as the AAD were low.
- The FMS adopted high reduction factors to account for flood warning and community preparedness.

Accordingly, it is considered that the damage figures published here more accurately reflect the potential flood damages in the catchment.

5 FLOOD MANAGEMENT MEASURES REVIEW

5.1 Summary of Options

A review of floodplain management options proposed for Narrabeen Lagoon FRMP is presented in this section. All of the options that have been presented for their inclusion within the FRMP have been assessed and reviewed. **Table 5.1** shows all of the management options considered, indicating those options for inclusion in the FRMP. The assessment of each management option considered is provided in the following Sections.

Table 5.1 Summaries Management Options Considered for Implementation

Floodplain Management Measures Considered	Implement
GENERAL MODIFICATIONS	
<i>Flood Risk Management Plan Review</i>	YES
FLOOD MODIFICATIONS	
<i>Maintain Current Entrance Management Policy Procedure</i>	YES
<i>Revise the Entrance Management Policy 1996 to update necessary approvals and responsibilities to undertake management operations</i>	YES
<i>Investigate alternate entrance dredging methodology and regularity of clearance operations</i>	YES
<i>The Construction of Wetlands on Middle Creek</i>	YES
<i>Raise Wakehurst Parkway at Middle Creek</i>	YES
<i>Investigate floodway diversion at the Mullet Creek Bridge on Pittwater Road</i>	YES
<i>A levee in Progress Park</i>	NO
<i>Flood Gates at Mullet Creek and Narrabeen Lagoon</i>	NO
<i>Additional Openings under Pittwater Road and/or Ocean Street</i>	NO
<i>Levee between Pittwater Road and Ocean Street</i>	NO
<i>Levee around Warriewood Shopping Centre</i>	NO
<i>Retarding Basin in Narrabeen Creek Catchment</i>	NO
<i>Improvements to Warriewood Square Culvert Entrance</i>	NO
PROPERTY MODIFICATION	
<i>That Pittwater Council's flood prone land development control be included in the revised Local Environment Plan – Pittwater 21</i>	YES
<i>That Pittwater Council's Locality Plans refer to flood risk development controls for new development within the Narrabeen Lagoon floodplain.</i>	YES
<i>That the Pittwater Council Flood Planning Level for Narrabeen Lagoon be set at the 1% AEP flood event plus 500mmm freeboard.</i>	YES
<i>That Pittwater Council revises the Flood Risk Management Policy for Pittwater for inclusion as a Development Control Plan</i>	YES
<i>That Pittwater Council provides a mechanism for all flood affected property owners to obtain the flood levels that affect their property and to obtain certification as to the flood affects on their property</i>	YES
<i>That Pittwater Council revises the wording on Section 149 Certificates</i>	YES
<i>That Pittwater Council continue to review and update its Flood Affected Property Map for the Narrabeen Lagoon floodplain as new information becomes available</i>	YES
<i>That Warringah Council review SEPP5 provisions relating flood free access for developments within Narrabeen Lagoon floodplain.</i>	YES
<i>That Warringah Council modify requirements for subdivision of land to prohibit subdivision within flood prone land within WLEP 2000.</i>	YES
<i>That Warringah Council to incorporate definitions of floodplain management within WLEP 2000.</i>	YES
<i>That Warringah Council address issues of flood impacts by property development within the Warringah Design Guidelines</i>	YES
<i>Implementation of a Voluntary House Raising Program</i>	YES
<i>Voluntary purchase of flood affected properties</i>	NO
RESPONSE MODIFICATIONS	
<i>Upgrading of the current Lagoonwatch Monitoring System</i>	YES
<i>Development of a Local Flood Plan</i>	YES
<i>Development of a Community Awareness Program</i>	YES

5.2 General Management Measures

5.2.1 Flood Risk Management Plan Review

Management Option 1: - Flood Risk Management Plan Review

To maintain the relevance of the FRMP, it needs to be reviewed and updated, if required, at regular intervals. This will ensure that the document continues to meet the aims of a FRMP and remains relevant to the needs of the community. It is recommended that this be undertaken every five years or after a major flood event, under the direction of the Narrabeen Lagoon Joint Estuary Floodplain Management Committee (NLJE/FMC) if Council's funding resources allow. This review would include a review of the modelling techniques from the Flood Study to ensure results are valid during all stages of implementation of the FRMP.

5.3 Flood Modification Measures

5.3.1 Entrance Management

Management Option 2a: - Maintain Current Entrance Management Policy Procedure

Management Option 2b: - Revise the Entrance Management Policy 1996 to update necessary approvals and responsibilities to undertake management operations

Management Option 2c: - Investigate alternate entrance dredging methodology and regularity of clearance operations

In November 1996, the NLJE/FMC adopted a Management Policy for Narrabeen Lagoon Entrance. The procedures outlined in the policy are in accordance with the recommendations made in the FMS (1992), that in turn was based on the studies by PWD (1989).

The main objectives of entrance management are to mitigate the flood effects in Narrabeen Lagoon, conserve biological diversity and to maintain or enhance the water quality. The Policy documents the management of the lagoon entrance by defining the requirements for:

- monitoring of the lagoon entrance;
- responsibility for lagoon entrance management; and
- lagoon openings/closure conditions and procedures.

Monitoring of the lagoon water levels and ocean levels is part of the Lagoonwatch system, which is discussed as a response modification measure.

The Lagoon Opening/Closure procedures include the following components:

- ◆ lagoon breakouts – the opening of the lagoon entrance using mechanical means to manage flooding in the low lying areas around the Lagoon.
- ◆ entrance clearance operations – this serves to promote longevity of lagoon entrance openings and improve hydraulic efficiency of the channel
- ◆ entrance closures – used to control the geometry of the entrance plug to make future breakout operations more effective.

The procedures outlined in the Policy are considered well documented and appropriate for flood control. The Policy is to have an ongoing review, some comments to be considered during future reviews are given below. It is noted that since formal implementation of the Policy, there has not been a large flood event to test all the procedures.

Breakouts

It was noted in “Review of tailwater conditions” (Lawson and Treloar, 1999) that “*it is understood that Council is restricted in the opening of the entrance and requires the approval of the DLWC before the entrance can be opened in flood conditions. The consequence of this control may be that Council is unable to maintain an open Lagoon and hence tailwater conditions may be higher than otherwise might be the case.*” There are a range of approvals that need to be in place before entrance breakout can take place. To expedite the breakout under emergency conditions, it is recommended that all relevant approvals are arranged and in place, ready for such conditions.

Clearance operations

The policy sets out the preferred areas and dimensions for the channel clearance, however, to date this template has not been applied. At the time of production of this report Warringah Council was in the process of completing the latest clearance operation after an assessment of options to determine the most beneficial areas clearance for flood mitigation was determined. This clearance operation involved initial detailed modelling of the entrance conditions to identify the most salient points for sediment removal in order to achieve maximum flood mitigation. Recommendations from the modelling were included in the detailed tender documents for the project.

The entrance clearance works involved the excavation of up to 36,000 cubic metres of sand over an approximate twelve-week period. Excavators removed the sand before being stockpiled prior to transportation via trucks for beach nourishment along Collaroy and Narrabeen Beaches.

The previous operations, undertaken by Warringah Council in 1998/99, endeavoured to take the elevation to –1.0 m AHD, which involved the removal of 70,000 tonnes of material upstream and downstream of Ocean Street Bridge at cost of \$330,000 (DLWC, 2000). To comply with the policy specifications, there would have been significant additional material dredged from upstream of the Ocean Street Bridge.

It is recommended that a more economic method of dredging be used in the future. As part of the Entrance Study (1989), PWD investigated methods for undertaking clearance operations and it is recommended that this study be used as a guide for the selection of a method for future works.

It is recommended that the regularity of clearance operations be reviewed, to determine if it could be more cost effective to carry out operations more frequently. The feasibility of undertaking clearance operations if there are not the sufficient funds available to carry out the works in accordance with the specifications of the Policy should also be closely considered for future operations. The concurrence of DLWC’s Flood Group is required for future clearance campaigns if future funding is provided under the NSW Government’s Floodplain Management Plan.

5.3.2 Middle Creek

Management Option 3:- The Construction of Wetlands on Middle Creek

Management Option 4: - Raise Wakehurst Parkway at Middle Creek

As described in the SEE (Patterson Britton, 1993), construction of wetlands on Middle Creek was primarily considered in order to improve water quality. Reduction in flood levels along Wakehurst Parkway is a secondary benefit, caused by increasing the channel cross section and creating wetlands that act as a retarding basin. The proposed site for this option is on Middle

Creek, approximately 2km upstream of Narrabeen Lagoon. Works would consist of a sediment basin and wetland with provisions for casual recreation, including walking tracks, boardwalk, regenerated bushland and a viewing platform.

Modelling in HEC2 was used to determine the reduction in flood levels due to construction of the wetlands. These results are presented in **Table 5.2**. As indicated, the road will still be inundated at places in both the 5% and 1% flood events.

Table 5.2: Reduction in flood levels on Wakehurst Parkway

Chainage (m)	Cross Section	Flood levels above road, per flood event (m)								
		Existing conditions			With wetlands			Reduction		
		50% AEP	5% AEP	1% AEP	50% AEP	5% AEP	1% AEP	50% AEP	5% AEP	1% AEP
1624	CS 35	-0.79	-0.22	0.14	-0.79	-0.22	0.14	0	0	0
2037	CS 30	-0.57	-0.01	0.35	-0.59	-0.03	0.33	0.02	0.02	0.02
2714	CS 18	0.27	0.71	1	-0.47	-0.01	0.37	0.74	0.72	0.63
2889	CS 17	0.20	0.62	0.87	0.18	0.56	0.78	0.02	0.06	0.09

Source: SEE (Patterson Britton, 1993)

It should be noted that although this option would reduce flood levels near CS 18 by around 700 mm and keep the downstream reaches (to CS 35) dry, the road would still be subject to flooding in the vicinity of CS 17. Continuous access would not be maintained during flood events.

A layout of the proposed wetland development, Middle Creek flood levels, flood profiles and cross section locations can be found in **Appendix B**. Further information also can be found in the SEE document. An economic assessment of this proposal was not given in the SEE document, and Council has advised that to date this has not been undertaken; therefore costs have not been included here.

Raise Wakehurst Parkway at Middle Creek

Flooding of Wakehurst Parkway can be reduced by raising a section of the road at a location around 1.6 to 2.9 km upstream of the lagoon. Several options were considered, namely:

- constructing 4 lanes raised above the 1% flood level;
- providing 3 raised lanes to protect against a 1% AEP flood; and
- keeping 2 lanes at the existing level and adding two lanes adjacent to the creek raised above the 1% AEP flood level. The two raised lanes would provide protection for the 2 lanes that remain at the existing level. Works would be included to avoid backwater effects in the vicinity of the culvert between CS 18 and CS 19.

The 1% AEP flood level was considered in keeping with RTA upgrade requirements of designing to at least the 1% AEP level. A freeboard of 0.5 metres was included in each case.

Assuming an embankment slope of 1:2, a lane width of 3.5 metres, and road shoulders of 2 metres on both sides, there is sufficient space available to raise 3 lanes above the 1% AEP flood level without significantly encroaching onto the Middle Creek channel. Cross sections made available by Council indicate that the escarpment on the right hand side (looking downstream) of the Parkway is at least 10 metres from the edge of the road shoulder in the region from CS17 to CS19 (where the road must be raised the most). Council drawings show no trees adjacent to the road that could be a constraint.

At CS 18, the Middle Creek channel is approximately 5 metres from the road shoulder. If four lanes were to be provided, re-alignment of the channel between CS17a and CS19 would be required to provide additional width for construction and avoid encroaching on the cross section of the channel. Reducing the channel section would reduce its flow capacity and alter flood behaviour. Channel re-alignment would involve excavation of a new channel and the clearing of

some vegetation. However, flora in this area consists primarily of exotic species and revegetation after construction would allow for planting of native species.

Table 5.3 shows the lengths of road to be raised to achieve immunity from the 1% AEP flood.

Table 5.3: Proposed levels for Wakehurst Parkway

Creek Chainage (m)	HEC-2 Cross Section	Existing Road level	1% AEP		
			Flood Level	Proposed Road Level	Road Raised (m)
1624	CS 35	3.45	3.59	4.09	0.64
2037	CS 30	3.65	4.00	4.50	0.85
2139	CS 29	4.00	4.14	4.64	0.64
2213	CS 28	4.08	4.21	4.71	0.63
2245	CS 27b	4.10	4.22	4.72	0.62
2280	CS26c	4.64	4.24	4.74	0.46
2341	CS24	4.75	4.29	4.79	0.44
2391	CS23	4.75	4.34	4.84	0.46
2419	CS22	4.73	4.36	4.86	0.47
2493	CS 21	4.30	4.52	5.02	0.72
2567	CS 20	4.08	4.66	5.16	1.08
2628	CS 19	3.97	4.75	5.25	1.28
2714	CS 18	3.86	4.86	5.36	1.50
2802	CS 17a	4.25	5.05	5.55	1.30
2889	CS 17	4.36	5.23	5.73	1.37

Source: Patterson Britton (1993)

Note: - All levels are in m AHD

- Road levels in italics refer to the left hand road edge (all other levels are for right hand edge)

Raising Wakehurst Parkway would cause significant traffic disruption, as the road is a major thoroughfare. To minimise disruption, works would have to be undertaken out of peak hour and an extensive traffic management program would be necessary. Costs for the construction works are in the order of:

- \$4.20 million for the raising of 4 lanes;
- \$3.25 million to raise 3 lanes; and
- \$2.38 million to provide an additional 2 raised lanes (whilst keeping the existing 2 lanes).

In addition to basic construction costs, these prices include preparation and implementation of a traffic management plan; extension of culverts; compilation of an Environmental Impact Statement; and preparation and on-site implementation of an Environmental Management Plan. As part of the proposed road raising, the capacity of the existing culverts in this vicinity would need to be checked as they may require enlargement.

The benefits of raising Wakehurst Parkway are both direct and indirect. The direct benefits of raising Wakehurst Parkway are in the form of a reduction in road repair costs, which represents savings in Average Annual Damages of around \$7,500. The indirect benefits result from the better access achieved by improved flood immunity of this major roadway. This benefit has not been quantified in this study.

5.3.3 Mullet Creek

Management Option 5: - Investigate floodway diversion at the Mullet Creek Bridge on Pittwater Road

Not Recommended – A levee in Progress Park

Not Recommended - Flood Gates at Mullet Creek and Narrabeen Lagoon

Floodway Diversion

Properties at the confluence of Mullet Creek and Pittwater Road are recommended to be investigated for floodway diversion. At the 1% AEP flood, these premises are potentially subject to high velocity floodwaters from short duration (2 hour) storms in the Mullet Creek catchment. Appropriate protection to floodway flows for the properties in the immediate area should be investigated. This will require consultation with the residents and property owners affected and possible owner contributions to any capital works necessary.

Progress Park Levee

This option is for a levee between Garden Street and Mullet Creek to be located in Progress Park. It would provide protection to the residential/commercial/light industrial area adjacent to Garden Street.

The FMS did not formally recommend this option as the proposal required survey and analysis. A levee in Progress Park would isolate properties from elevated lagoon levels but due to site constraints its height would be restricted to 2.7m AHD. Additionally, if a levee were constructed in this area flood impacts on surrounding properties would occur due to catchment runoff building up behind the levee and surcharge from the stormwater system.

To counter catchment flooding behind the levee a system of pumps would need to be installed to remove ponded floodwater, otherwise there would be an equalisation of flood levels on each side of the levee and the flood protection would be lost. This then places reliance on a mechanical pump system to provide flood protection that would be expensive to implement and maintain, with probability of breakdown during a flood event a real consideration. Therefore this option is not considered for implementation.

Flood Gates at Mullet Creek and Narrabeen Lagoon

Flood gates at Pittwater Road bridge would isolate high water levels in Narrabeen Lagoon from inundating Mullet Creek floodplain. Detailed design of this option would need to include discharge of water from Mullet Creek into the lagoon. Two options are suggested, both would require a pump system that enables the local catchment to be discharged to the lagoon. The two options are:

- install flood gates without raising Pittwater Road or providing a levee. Mullet Creek would be isolated for events up to the 5% AEP.
- install flood gates and provide a bund for the 1% AEP flood by raising Pittwater Road or providing a levee on the eastern side of the road.

Both options have environmental implications in that the Mullet Creek floodplain may experience considerably less inundation, which could impact the ecologic environment.

A similar scheme was proposed for Nareen Creek (draft FMS, 2000). It was found that this measure was uneconomic and would be technically difficult to build. A similar result is expected for Mullet Creek. This option would also have significant environmental concerns. Therefore, this option will not be recommended.

5.3.4 Additional Openings under Pittwater Road and/or Ocean Street

Not Recommended – Additional Openings under Pittwater Road and/or Ocean Street The Anglers Action Group proposed a structural option consisting of constructing one or two large diameter pipes or culverts on the northern sides of the Pittwater Road and/or Ocean Street bridges. Their submission to the NLJE/FMC is attached in **Appendix C**. Additional drainage

structures would aim to increase the rate of discharge of floodwaters and assist in the flushing of sand from the entrance.

The following features for the pipes/culverts were proposed:

- should be large enough to provide an easy flow of water and to ensure that any person, sucked in during a flood event would not be trapped.
- should be set above normal water level of the lagoon so that at normal times no water would be in them. This would eliminate any likelihood of the growth of oysters or marine invertebrates.
- constructed in the direction of flow down the Lagoon.

Preliminary sizing of drainage structures was determined considering the physical constraints at the existing road bridges. At both bridge sites an additional three 3.0m x 1.5m box culverts were tested for 3 cases using the CELLS model developed in the Narrabeen Lagoon Flood Study (1990):

- Culverts into the northern abutment at Pittwater Road bridge,
- Culverts into the northern abutment at Ocean Street bridge, and
- Culverts into the northern abutments at Ocean Street and Pittwater Road bridges.

Results are given in **Table 5.4** and indicate that:

- additional culverts at Ocean Street has no affect on water levels in the lagoon, and
- additional culverts at Pittwater Road bridge (with or without additional culverts at Ocean Street Bridge) results in minimal reduction in flood levels upstream of Pittwater Road and a slight increase in flood levels downstream of Pittwater Road.

The cost of using three 3.0 m x 1.5 m box culverts for both the Ocean Street and Pittwater Road bridge sites was estimated to be in the order of \$396,000.

This option is not considered for implementation.

Table 5.4: Results for Anglers Option

	Change in flood levels per flood event (m)		
	1% AEP	5% AEP	20% AEP
Pittwater Road Option			
Upstream of Pittwater Rd	-0.02	-0.01	-
Between Pittwater Rd & Ocean St	0.01	0.01	-
Downstream of Ocean St	0.01	0.01	-
Ocean Street Option			
Upstream of Pittwater Rd	-	-	-
Between Pittwater Rd & Ocean St	-	-	-
Downstream of Ocean St	-	-	-
Both Options			
Upstream of Pittwater Rd	-0.02	-0.01	-
Between Pittwater Rd & Ocean St	0.01	0.01	-
Downstream of Ocean St	0.01	0.01	-

5.3.5 *Levee between Pittwater Road and Ocean Street*

Not Recommended - Levee between Pittwater Road and Ocean Street

The Flood Management Study recommended a levee to run between Pittwater Road and Ocean Street to protect the Lake Park Road residential area and the Lakeside Caravan Park. It is understood from Pittwater Council and responses from the community that this option was investigated following the Flood Management Study. It did not have community support and was abandoned. Thus it is not considered for inclusion within the Flood Risk Management Plan.

5.3.6 *Narrabeen Creek and Warriewood Shopping Centre*

Not Recommended - Levee around Warriewood Shopping Centre

Not Recommended - Retarding Basin in Narrabeen Creek Catchment

Not Recommended - Improvements to Warriewood Square Culvert Entrance

Levee around Warriewood Shopping Centre

This option is for a levee around the Warriewood Shopping Centre (WSC) to isolate the centre and car park from high water levels. The top of the levee would be at 3.5m AHD, i.e. the 1% AEP flood level plus 0.5m freeboard. This would require road works to Jacksons Road as the road varies from 3m AHD to 2.6m AHD across the east west boundary of the WSC. The height of the levee would be in the order of 1.5m to 2m.

Implications for floods larger than the design event for the levee would mean significant emergency problems and potential damages. A levee would require extensive earthworks to join it to higher ground. Economic benefits are mainly to commercial properties and as such the centre would be required to fund this option. Due to the low economic benefits, potential construction issues and emergency services requirements for large flood events this measure will not be recommended.

Retarding Basin in Narrabeen Creek Catchment

Construction of a retarding basin on Narrabeen Creek was proposed as a measure for managing increased runoff caused by development in Release Area Sector 1 of the Warriewood Valley development. A basin located between McPherson Street and Ponderosa Avenue is nominated in “Integrated Water Management Strategy – Warriewood Valley” (Lawson and Treloar, 1997) report. A basin with 16,700m³ capacity would return discharges to pre-development flows. It is noted that for other sectors either on-site detention or shared detention basins are incorporated.

Previous investigations indicate basins can have a significant impact to flood levels from storms over the local catchment (2 hour duration). However up to Boondah Road Narrabeen Creek peak flood levels are generated from elevated lagoon levels. As such, basins are not recommended to mitigate the impacts of flooding to WSC. It will be a recommendation of the plan that retarding Basins not be recommended.

Improvements to Warriewood Square Culvert Entrance

The “Hydraulic Review of Warriewood Square Culvert” (1996) recommended that:

- Modifications be undertaken to the culvert inlet;
- Culvert headwall downstream be maintained;
- Sediment and other debris be removed; and
- Aquatic weeds at inlet are removed/controlled.

These works, which do not significantly change the 1% AEP flood level upstream of the culvert, result in around a 5% increase in culvert flow. There is no change in flood levels at Jacksons Road (near the wetlands) which is where inundation of commercial properties occurs. This option is not recommended for implementation by the NLJE/FMC as it is expected to have minor economic benefits.

5.4 Property Modification Measures

PITTWATER COUNCIL

Management Option 6a: - That Pittwater Council’s flood prone land development control be included in the revised Local Environment Plan – Pittwater 21

Management Option 6b: - That Pittwater Council’s Locality Plans refer to flood risk development controls for new development within the Narrabeen Lagoon floodplain.

Management Option 6c: - That the Pittwater Council Flood Planning Level for Narrabeen Lagoon be set at the extent derived from the 1% AEP flood event plus 500mm freeboard

Management Option 6d: That Pittwater Council revises the Flood Risk Management Policy for Pittwater for inclusion as a Development Control Plan

Management Option 6e: - That Pittwater Council provides a mechanism for all flood affected property owners to obtain the flood levels that affect their property and to obtain certification as to the flood affects on their property

Management Option 6f: - That Pittwater Council revises the wording on Section 149 Certificates

Management Option 6g: - That Pittwater Council continue to review and update its Flood Affected Property Map for the Narrabeen Lagoon floodplain as new information becomes available.

WARRINGAH COUNCIL

Management Option 6h: - That Warringah Council review SEPP5 provisions relating flood free access for developments within Narrabeen Lagoon floodplain.

Management Option 6i: - That Warringah Council modify requirements for subdivision of land to prohibit subdivision within flood prone land within WLEP 2000.

Management Option 6j: - That Warringah Council Flood Planning Level for Narrabeen Lagoon be set at the 1% AEP flood extent plus 500mm freeboard applied to those properties affected

Management Option 6k: - That Warringah Council to incorporate definitions of floodplain management within WLEP 2000.

Management Option 6l: - That Warringah Council address issues of flood impacts by property development within the Warringah Design Guidelines

5.4.1 Zoning and Local Environment Plan

The division of flood prone land into appropriate land-use zones is an effective and long-term means of limiting the damage floods will have on future developments. Moreover, any flood-related zoning should be incorporated in a local environmental plan or development control plan in conjunction with the Floodplain Risk Management Plan.

Zones over flood prone land are based on an objective assessment of hazard, environmental and other factors, for example:

- whether the land is in the high hazard or floodway category;
- potential for future development to have an adverse impact on flood behaviour at existing developments, particularly the cumulative effects of on-going development;
- whether or not adequate access is available during floods;
- whether certain activities should be excluded because of additional or special risk to their users, e.g. accommodation for aged people, hospitals and the like;
- existing planning controls; and
- the requirement under Sections 26 and 27 of the *Environmental Planning and Assessment Act, 1979*, for a public authority to own land which is reserved for a public purpose.

The current land use zoning applied to the study area is discussed below. No changes to the zoning are considered necessary assuming building and development controls are applied to developments in flood liable lands. No further intensification of development in flood liable areas, or areas that could experience emergency access difficulties, should be allowed as this increases the flood risk to the community and potential flood damages. Areas are indicated on **Figure 3**.

It is recommended that zoning be revised to exclude SEPP5 developments within flood prone land. Further, zoning should restrict intensification of development (subdivision, dual occupancy or units) within the floodplain.

No changes to the current land use zoning are considered necessary assuming building and development controls are applied to developments in flood liable lands. No further intensification of development in flood liable areas, or areas that could experience emergency access difficulties, should be allowed as this increases the flood risk to the community and potential flood damages.

Pittwater Council - LEP

Pittwater Local Environmental Plan (LEP) 1993 was gazetted on 4 February 1994. This LEP applies to all land within the Pittwater LGA. The LEP does not make any specific reference to development on flood prone land. Pittwater Council is currently undertaking Pittwater 21, which is a review of the Local Environment Plan 1993. The Pittwater 21 is to include specific development controls for flood prone land.

Changes to Pittwater's LEP are not to permit development that will place at risk elderly or disabled people, i.e. SEPP 5, or development that intensifies the number of residents within the floodplain, such as dual occupancies, multi-unit development and subdivisions.

Warringah Council - LEP

Ranges of localities in Warringah are affected by flooding. The zoning provisions in these areas are discussed below:

Locality B10: Narrabeen Lake

Uses that may occur within Narrabeen Lake and its immediate foreshores include maintenance dredging, and the construction of minor low intensity structures such as viewing platforms. No development may occur except that which is consistent with an adopted plan of management. Some recreational and public open space areas exist within this locality, which are not inundated in the 1% AEP flood event, however are classified as high hazard due to their inaccessibility during flooding, creating risks of isolation and making evacuation difficult.

Locality B5: Narrabeen Lakeside

The Narrabeen Lakeside Locality extends along the south eastern boundary of the Lake. The locality is characterised by detached housing and a number of blocks of medium density residential development. SEPP 5 housing (housing for older people or people with disabilities) is generally considered to be Category 2 development in this locality, meaning that it would be permitted if deemed to be within the desired character of the locality.

Residential developments in the locality including units, townhouses, dual occupancies and detached houses are affected by flooding up to the 1% AEP event. These residential areas along the foreshore of the Lake serve as high hazard and low hazard flood storage areas.

Locality B4: Narrabeen Village

Narrabeen Village is predominantly characterised by retail and business development, with some shop-top housing. A three storey height limit applies to this locality. Properties whose boundaries adjoin the Lake have a minimum building setback of 15 metres from that boundary, which does not apply to exempt (minor) development. A small number of properties in this locality, adjoining the Lake, are affected by the 1% AEP event on their rear property boundary. SEPP 5 housing is permitted where it is consistent with the desired future character of the locality.

Locality D1: Collaroy / Narrabeen

The Collaroy / Narrabeen Locality is characterised by detached housing and medium density residential development. While there are a number of medium density areas in the locality, none of these are affected by the 1% AEP flood event. However, a number of residential properties with detached housing are situated in areas of high and low hazard flood storage.

Exempt and Complying Development

Exempt development in Warringah is outlined in Schedule 1 of the LEP. Clause 1(c) of the LEP allows that, regardless of Schedule 1, exempt development does not include development on flood prone land.

Clause 7 of the LEP allows that all development except that which is exempt and that in Schedule 2 require Council consent. Clause 7(b) and Schedule 2 of the LEP allow that flood mitigation works may take place without development consent, where carried out by Council or the Department of Land and Water Conservation. However, this does not allow the erection or installation of buildings, plant or other structures; the reconstruction or alteration of buildings such that change is physically evident; or the formation or alteration of any means of access to a

road, without development consent. Also under this clause, maintenance dredging may occur without development consent where carried out by a public authority, provided that certain bodies are consulted.

The LEP also identifies development that is complying, which is assessed on the basis of compliance with the provisions of Council's LEP and where the merit of the proposed development is not considered. Clause 8(2)(b) of the LEP specifically excludes development on flood prone land from this category. These clauses ensure that full development assessment is carried out for any development on flood prone land, except for flood mitigation works.

Environmental Protection of Waterways

Clause 60 of the LEP requires that development must be 'sited and designed to maintain and enhance natural watercourses and aquatic habitat'. This clause encourages the continuing preservation of watercourses such as Narrabeen Lagoon, and its natural flow of water. Water quality is also preserved through clause 78, which specifies controls over erosion and sedimentation on a site during development. A soil and water management plan must be prepared to minimise soil erosion and maintain downstream water quality, wherever a degree of soil erosion and sedimentation is likely to occur.

Development on Flood Prone Land

Clause 47 is the main clause relating to flooding in the Warringah LEP. It states:

Development on flood plain land is to be sited and designed to minimise impacts of flooding on property and have regard to the existing flood regime.

In particular:

- *development is not to reduce flood storage area or impact upon the existing flood regime,*
- *habitable floor areas of buildings are to be at a level of at least 500mm above the 1% annual exceedance probability flood level, and*
- *buildings or works affected by flooding are to be constructed of flood compatible building materials.*

A number of flood compatible building components and materials are outlined in the *Interim Warringah Design Guidelines* (2000). It is recommended that more detailed provisions be included in these guidelines to outline how developers may avoid adverse impact on the existing flood regime, which would support and reinforce clause 47 of the LEP. Further points are recommended to be added to this clause, for instance regulating landfill (which is discussed in clause 77 without reference to flooding) in flood prone areas. These matters will arise upon more detailed investigation of the flood regime.

In addition to clause 47, Schedule 7 of the LEP, *Matters for Consideration in a Subdivision of Land*, has some relevance to development on flood prone land. Clause 4 of the Schedule states that 'subdivision on flood prone land should be avoided', effectively discouraging the intensification of development on flood prone land. This clause could be strengthened to prohibit any form of subdivision of land within flood prone land.

The Dictionary to the LEP should also incorporate definitions of flood prone land, flood planning levels, and other flood related terms. These should be derived from the NSW *Floodplain Management Manual*.

5.4.2 Flood planning level

Within the Floodplain Management Manual (2001) the definition of a flood planning level is detailed below.

“The flood planning level (FPL) used for planning control purposes is derived from a combination of the adopted flood level plus freeboard. It is determined as part of the flood risk management study and is based on a detailed understanding of the flood behaviour across the full range of flood events, their risk of occurrence and the social, economic and ecological consequences associated with those floods.”

The concept of a “Flood Planning Levels” (FPLs) supersedes the “standard flood” of the 1986 Manual. It should be noted that a FPL could be number of FPLs for a range of land uses.

The concept of the FPL is based on a trade off between risk to the community and community amenity and expectations. The selection of a planning level worked from the top (PMF) down, establishing and accepting the risks involved for certain developments until the risks are no longer acceptable is a selection made by Council. The selected flood level thus becomes the FPL.

The 1% AEP flood has become the most common basis for FPLs used in Australia, particularly for residential development in urban areas. From this level the freeboard or 0.5m is applied. The Australian Water Research Council (AWRC) proposed the adoption of the 1% AEP event as the standard for Australia. This was based on the widespread used of this event in America. Also, a series of major floods with 1% and 2% AEPs occurred in Australia during the early and mid-1970s. These floods caused considerable devastation and therefore the 1% AEP was seen as being indicative of a big flood with potentially adverse consequences. Also this flood was likely to be experienced at least once in a lifetime.

It should also be noted that the FPL is not tied to **any** AEP, it is a flood level. This is an attempt to overcome the problems that may arise when re-calculation of frequency means that the 1% AEP flood has a new level, be it an increase (the usual scenario) or a decrease.

As part of the Flood Management Study for Narrabeen Lagoon Floodplain the adopted design floor level for developments was the 1% AEP flood level plus 0.5m freeboard. It is recommended that this level be maintained for the Flood Planning Level, in line with Warringah and Pittwater Council’s recent planning instruments. No amendments to the FPL are recommended assuming building and development controls are applied consistently to developments in flood prone land.

Councils apply the FPL in different ways. Differences include:

- Pittwater Council applies development controls to all properties within an area defined by land below the FPL (1% AEP flood level plus 0.5m), whereas Warringah generally considers properties within the 1% AEP flood extent;
- Pittwater Council applies the FPL to existing structures (commercial, residential and industrial development) when additions are constructed; Warringah assesses development application on merit basis.

5.4.3 Development Controls

The following recommendations are provided for the Narrabeen Lagoon floodplain. The review of current planning instruments for the study area highlighted strengths and weaknesses of existing controls. Recommendations to supplement these controls are based on the *Floodplain Management Manual* (2001). Current planning policies for Pittwater and Warringah LGAs are scheduled for ongoing revision, during such processes these recommendations should be considered and incorporated, as appropriate.

The aim for development controls is to implement measures that, over time raise the floor levels of all affected development on flood affected properties to the Flood Planning Level (FPL) as a minimum floor height requirement.

All Development (General Controls for Residential and Commercial/Industrial)

To reduce the risk to personal safety and of flood damage to property, the following development controls are recommended:

- All structures below the Flood Planning Level shall be constructed from flood compatible materials.
- All development must be designed and constructed so that it will have a low risk of instability due to flood hazard.
- All development must be design and constructed so that it will not impact on surrounding properties.
- All foundation structures, where the floor level is greater than 500mm above the existing ground level, are to incorporate a suspended floor on open pier/pile footings to allow for the flow of surface water and flood storage.
- All electrical equipment, wiring, fuel lines or any other service pipes and connections shall be waterproofed to the Probable Maximum Flood (PMF) level or Flood Planning Level (FPL), whichever is the higher level.
- For existing structures, tolerance of up to minus 100mm may be applied to the Flood Planning Level in respect of the determination of the criteria for compliance with these controls. The floor level of all new structures must be to the Flood Planning Level or Probable Maximum Flood Level as set out in the controls.

Filling of Land or Enclosure of Structures

The filling of land or enclosure of structures will only be permitted where there is no net decrease in floodplain storage capacity for the property and there is no increase in flood impacts to surrounding properties.

Carparking Facilities

The floor level of new enclosed garages shall be at or above the Flood Planning Level.

Basement (ie below natural ground level) carparking must have all access and potential water entry points above the Probable Maximum Flood level or Flood Planning Level whichever is the higher).

Open car park areas and carports are permissible at the existing ground level.

Development on Land with a High Hazard Classification

For development on land that has a High Hazard Classification, there is to be no net loss in flood storage and floodway area, as a result of the development, for the Probable Maximum Flood event, i.e. the development is not to increase its impact on the floodway. All structures are to be designed to withstand the High Hazard condition.

Open carpark areas and carports on land that has a High Hazard Classification are not permissible in a floodway area.

Additions to Existing Residential Dwellings (Single Residential Dwelling / Dual Occupancy)

- The floor levels of the entire dwelling including that of the existing structure must be at or above the Flood Planning Level (i.e. the existing floor levels shall be raised if they are below the FPL).

The Following Exceptions may Apply for Additions to Existing Dwellings (Single Residential Dwelling/Dual Occupancy)

An addition to residential dwellings, may be permissible where existing levels remain below the Flood Planning Level provided that the following controls are complied with;

- The addition is less than 30m².
- The floor levels of the addition must be at or above the Flood Planning Level.
- The existing dwelling remaining at the existing level must be satisfactorily flood proofed to protect the dwelling from the ingress of water to the Flood Planning Level.
- If the 30m² restriction is exceeded, at any point in time, the whole of the dwelling must be raised such that the whole floor level of the dwelling is above the Flood Planning Level.
- This provision does not apply to a property identified within a high hazard classification.

Medium Density / Multi Unit Housing

- All floor levels are to be at or above the Probable Maximum Flood Level or Flood Planning Level (which ever is the higher level).

Subdivision

- Subdivision within the Flood Planning Level extent will not be permitted where additional flood affected allotments will be created

Shop-Top Housing

- The floor levels of the residential component of Shop-Top Housing shall be at or above the Probable Maximum Flood Level or Flood Planning Level (which ever is the higher level).

Change of Use to Existing Premises

- All floor levels of the development, including any existing components to be retained, are to be at or above the Flood Planning Level or raised to the Flood Planning Level.

Special Flood Protection Purpose Development

This type of development includes schools, child care centres, hospitals, tourist accommodation and housing for the elderly of people with disabilities.

- All floor levels are to be at or above the Probable Maximum Flood Level or Flood Planning Level, which ever is the higher level.

Information To Be Submitted With Development Application

A statement of the Flood Planning Level and Hazard Classification details that apply to the subject property are to be submitted with the application.

Survey details that address the following:

- The location of existing building or structures;
- The floor levels and ceiling heights of all existing buildings or structures to be retained;
- Existing and/or proposed drainage easements and watercourses, or other means of conveying stormwater that are relevant to the flood characteristics of the site;
- Flood Planning Level, Probable Maximum Flood Level and flood extents;
- 0.2 metre contour intervals across the entire property; and
- All levels must be relative to Australian Height Datum (AHD).

An integrated Flood Risk Report is to be submitted for all development on flood prone land, where the development is subject to a High Hazard Classification or has floor levels retained below the Flood Planning Level.

Professional Requirements – Floodplain Management and Structural Consultants

Floodplain Management and Structural Consultants engaged to undertake Flood Risk Reports must satisfy the following requirements, in order for the assessment of the Development Application to proceed:

- a) Registration on the National Professional Engineers Register (NPER) as administered by Institution of Engineers Australia.
- b) Floodplain Management Consultant:
 - Have a minimum 10 years practice as a Floodplain Management Engineer during the past 15 years, and;
 - At least 5 years specific practical experience relevant to flooding and floodplain management in small urban coastal catchments in New South Wales.
- c) Structural Consultant:
 - Have a minimum 10 years practice as a Structural Engineer during the past 15 years.
 - Experience in design of structures and foundations that could be subjected to water inundation and velocity flow (in particular impact loading, flood compatible materials, buoyancy and flood proofing).

5.4.4 Advice to Applicants - Section 149 Certificates

The primary function of S149 Certificates is as a planning tool for notification that the land is affected by a policy that restricts development due to the likelihood of a risk, in this instance, flooding. The S149 Certificates can play a role in community awareness but should not be relied on to provide detailed flood information.

Part of Council's statutory responsibility is to update S149 Certificates as new information, that poses a risk to the community, becomes available. Section 149 (2) and Section 149 (5) certificates are used to inform property owners, prospective property buyers and property developers of the flood risk associated with any particular property and that development may be restricted. Properties highlighted on Council's Flood Affected Properties Maps carry S149 Notations.

Clause 279 and Schedule 4 (7) of the Regulations to the Environmental Planning and Assessment Act 1979 states that a Section 149(2) certificate must contain information relating to:

Whether or not the land is affected by a policy... that restricts the development of the land because of the likelihood of land slip, bushfire, flooding, tidal inundation, subsidence, acid sulphate soils or any other risk.

The following are points for consideration for Section 149 Certificates under the Environmental Planning and Assessment Act (1979).

Warringah Council

"The property is in a flood prone area and is subject to flood related development controls. Restrictions on development are available from Council."

"Council strongly recommends that effective precautions should be taken at least to the specified design floor level, to reduce any potential risk to personal safety and to minimise any property damage to the structure, its fixtures and contents. These precautions may include: raising of floor levels; provision of levees; barriers or waterproofing of the structure to prevent ingress of flood waters; use of flood compatible materials; relocation of wiring, fuel supply lines and storage of hazardous materials, plant, water damage, above the specified level.

Pittwater Council

The following are points for consideration for Section 149(2) and Section 149(5) Notations for the Pittwater area:

Section 149(2) Notation

- The Flood Category and flood event that applies to the land subject to the notation;
- The Flood Hazard that applies to the land subject to the notation;
- A statement as to the flood risk associated with the land, i.e. that it may need to be evacuated during a flood event;
- The development control that regulates development on the this land in relation to flood risk;
- That further advice should be sought from Council in regard to the flood levels and hazard; and
- That all flood level should be compared to ground survey detail to assess the flood risk.

Section 149(5) Notation

- A general statement that the land is in the vicinity of a watercourse, drainage system, drainage easement, low point in the road or associated floodways and floodplains;
- The development control that regulates development on the this land in relation to flood risk; and
- That further advise should be sought from Council in regard to the flood levels and hazard;

5.4.5 Interim Warringah Design Guidelines

The Interim Warringah Design Guidelines were prepared in December 2000 as an accompaniment to Warringah LEP 2000. The Design Guidelines provide a greater level of detail and explanation of the design standards for development in Warringah than is found in the LEP.

Part D of the Design Guidelines relates specific clauses of the LEP to the appropriate development controls. It expands clause 47 of the LEP, *Flood Affected Land*, to outline the appropriate guidelines for development on flood affected land. The first guideline is:

Do not reduce the flood storage area or impact upon existing flood regime

The three categories of flood prone land are explained as being floodways, flood storage areas and flood fringe area. The text explains that if the flood storage area is reduced by landfill or the construction of levees, adjacent flood levels will rise and the peak discharge downstream may increase. It is then stated that plans accompanying development applications should show the 1% AEP flood level.

Other ways in which the flood storage area could be reduced, or the existing flood regime changed by development, have not been considered by the Guidelines. Considerations that could be added to the instructions under this first guideline include the impact of fencing on the flood regime, and the need to prevent further building, filling or construction of fencing in the floodway.

The second guideline states:

Design habitable floor areas at least 500mm above the 1% Annual Exceedance Probability

A brief explanation of the meaning of the term ‘1% Annual Exceedance Probability’ is provided below this guideline, as well as a diagram to demonstrate the habitable floor level, being 500mm above the flood level.

The third guideline states:

Use flood compatible building materials

The text provides a list of the materials and construction methods that are suitable for development on the flood plain. This list expands the statement in the LEP that buildings affected by flooding should be constructed of flood compatible building materials, giving appropriate guidance to developers.

Other clauses related to flooding in the WLEP are also expanded in the Design Guidelines. These provide guidelines for erosion and sedimentation, landfill, stormwater management, and

watercourses and aquatic habitat. The flood-related guidelines focus on preventing unnecessary alteration or inhibition to the natural flow path of watercourses. Within the guidelines on stormwater management, the use of on-site stormwater detention is encouraged to reduce the impacts of increased run-off on the existing natural and constructed drainage systems. Within the guidelines on landfill, some reference to discourage filling of flood affected land, particularly in flood storage areas, could be incorporated.

The list of materials and construction methods in Warringah's Interim Design guidelines is derived from the NSW Government *Floodplain Development Manual*, and should be updated to refer to the *Floodplain Management Manual*. It is recommended that this section refer to:

- electrical and mechanical equipment, heating and air conditioning systems, and services that are appropriate for use in the floodplain.
- potential distinction of floor levels for residential dwellings and commercial premises;
- potential distinction of floor levels and permissible development between the floodway, flood fringe and flood storage areas;
- location of critical utilities and public facilities on the floodplain;
- need for development applications relating to areas of high flood hazard to prove the ability of structures to withstand the force of floodwater, debris and buoyancy;
- need for development applications relating to flood affected land to consider the impact of development on flood levels elsewhere;
- need for adequate evacuation procedures to be in place;
- availability of flood-free access to developments; and
- potential impact of house raising on surrounding development, on residents who may be isolated during flooding, and the impact of a higher than design flood on raised houses.

SCHEDULE 1 - FLOOD COMPATIBLE MATERIALS

Building Component	Flood Compatible Material	Building Component	Flood Compatible Material
Flooring and Sub-Floor Structure	<ul style="list-style-type: none"> • pier and beam construction, or • suspended reinforced concrete slab 	Doors	<ul style="list-style-type: none"> • solid panel with water proof adhesives • flush door with marine ply filled with closed cell foam • painted material construction • aluminium or galvanised steel frame
Floor Covering	<ul style="list-style-type: none"> • clay tiles • concrete, precast or in situ • concrete tiles • epoxy, formed-in-place • mastic flooring, formed-in-place • rubber sheets or tiles with chemical set adhesives • silicone floors formed-in-place • vinyl sheets or tiles with chemical-set adhesive • ceramic tiles, fixed with mortar or chemical set adhesive • asphalt tiles, fixed with water resistant adhesive • removable rubber-backed carpet 	Wall and Ceiling Linings	<ul style="list-style-type: none"> • brick, face or glazed • clay tile glazed in waterproof mortar • concrete • concrete block • steel with waterproof applications • stone, natural solid or veneer, waterproof grout • glass blocks • glass • plastic sheeting or wall with waterproof adhesive
Wall Structure	<ul style="list-style-type: none"> • solid brickwork, blockwork, reinforced, concrete or mass concrete 	Insulation	<ul style="list-style-type: none"> • foam or closed cell types
Windows	aluminium frame with stainless steel or brass rollers	Nails, Bolts, Hinges And Fittings	<ul style="list-style-type: none"> • galvanised • removable pin hinges

Electrical and Mechanical Equipment	Heating and Air Conditioning Systems
For dwellings constructed on flood prone land, the electrical and mechanical materials, equipment and installation should conform to the following requirements.	Heating and air conditioning systems should, to the maximum extent possible, be installed in areas and spaces above the flood planning level. When this is not feasible every precaution should be taken to minimise the damage caused by submersion according to the following guidelines.
Main power supply - Subject to the approval of the relevant power authority, incoming electricity mains, service equipment and meters shall be located at the probable maximum flood level or flood planning level (which ever is the higher). Means shall be available to easily disconnect the building from the main power supply.	Fuel - Heating systems using gas or oil, as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.
Wiring - All wiring, power outlets, switches, etc, should, to the maximum extent possible, be located at the probable maximum flood level or flood planning level (which ever is the higher). All electrical wiring installed below the flood planning level should be suitable for continuous submergence in water and should contain no fibrous components. Only submersible-type splices should be used below the flood planning level. All conduits located below the relevant flood level should be so installed that they will be self-draining if subjected to flooding.	Installation - The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to an elevation of 600 millimetres above the flood planning level.
Equipment - All equipment installed below or partially below the flood planning level should be capable of disconnection by a single plug and socket assembly.	Ducting - All ducting located below the flood planning level should be provided with openings for drainage and cleaning. Self-draining may be achieved by constructing the ducting on a suitable grade. Where ducting must pass through a watertight wall or floor below the relevant flood level, the ducting should be protected by a closure assembly operated from above the flood planning level.
Reconnection - Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.	Services All sewer connections to buildings on flood prone land are to be fitted with reflux valves to prevent backflow of sewage in a flood event.

5.4.6 Voluntary House Raising

Management Option 7: - Implementation of a Voluntary House Raising Program

House raising has long been a traditional response to managing flood risk in New South Wales, as demonstrated by the number of raised houses in flooded urban areas such as Lismore and Fairfield.

Avoidance of flood damage by house raising achieves the following three important objectives:

- a reduction in personal loss;
- a reduction in risk to life and limb and in the costs of servicing isolated people who remain in their homes to protect possessions; and
- a reduction in stress and post-flood trauma.

While raising a house may achieve the objectives described, care must be exercised in implementing this measure by considering the implications of a flood that is higher than designed. The new construction may be isolated during floods, necessitating an increased load on emergency services should it be required. Thus it is essential that both the benefits and disbenefits of house raising be considered in the floodplain management planning process and any subsequent community education campaign.

Not all houses are suitable for raising. Houses of double brick construction or slab-on-ground construction are generally either impossible or too expensive to raise, however the decision on this latter issue is very site specific. Houses best suited to raising are timber framed and timber / fibro clad with non-masonry materials.

House raising does require special treatment from an emergency management viewpoint. If adopted, special measures will need to be put in place within the Local Flood Plan to address the possible evacuation needs of the residents of the raised properties.

There were 150 properties identified as potentially benefiting from a House Raising Program. These properties are those considered to be raiseable with the floor level below the flood planning level. Properties not deemed suitable for raising are two-storey or blocks of units. Potential flood damages were calculated by raising the floor level of the 150 properties to a level equal to the flood planning level, being the 1% AEP flood level plus 0.5 m freeboard.

Using the available property information for the study area, **Table 5.5** summarises the number of properties for raising in each LGA.

Table 5.5 - Properties suitable for house raising - Narrabeen Lagoon floodplain

House Raising	Warringah LGA	Pittwater LGA
Weatherboard/wood/fibro houses	21	60
brick houses	9	60
<i>Total house raising</i>	<i>30</i>	<i>120</i>

Note: Nareen Creek catchment is not included

It should be noted that properties identified for house raising is based on property information collected for the FMS supplemented by property information for developments that have occurred from 1992 to 2000. This information will require further detailed survey and investigation as part of a voluntary house raising program.

While every care has been taken to ensure accuracy when making the recommendations, information will need to be verified during the detailed assessment of each case. In all cases, the decision on whether house raising or flood proofing will be implemented must be assessed on the merits of each case. Such an assessment will include detailed internal and external examination, a structural examination and a check of whether any lower storey rooms are habitable. Any illegal development, such as habitable lower storey rooms contrary to development approval, will need to be addressed before implementation of the scheme. Flood levels used to assess this measure were taken from the Flood Study.

The implementation of a voluntary house raising program would accord an application by each Council which is forwarded to the Floodplain Management Authorities of NSW and the Department of Land and Water Conservation for prioritisation with other state wide capital flood projects. Upon notification of funding success from the State Government, an expression of interest would be let to the community, to determine those who maybe interested in participating in the program. Consideration maybe given to staging a voluntary house raising program, depending on funding availability and community response.

If funding of a program were successful a 2:1 subsidy would be offered by the State Government, with the onus on the property owners to provide funding for the 1/3 portion of the cost of raising the dwelling. There is no certainty that this funding will be available. Council would act as an intermediary to ensure the subsidy provided by the State Government is expended correctly.

As part of any potential voluntary house raising program, all affected residents should be educated on what actions to take in case of a flood and preparations that can be taken to minimise flood impact.

5.4.7 Voluntary Purchase

Not Recommended – Voluntary purchase of flood affected properties

The Floodplain Management Manual considers purchase of properties in high hazard flood areas. There are no properties in the study area that are in this category for flooding from the Narrabeen Lagoon Catchment as flooding in the Lagoon does not necessarily result in fast flowing waters near properties and/or excessive water depth in events up to the 1% AEP. It is noted that fast flowing water may occur from the local catchment flows in the tributary creeks, yet these would be the subjects of the Flood Management Study for individual tributary creeks.

5.5 Response Modification Measures

5.5.1 Lagoonwatch

Management Option 8: - Upgrading of the current Lagoonwatch Monitoring System

Lagoonwatch has been reviewed during the preparation of the FRMP. Recommendations on where improvements can be made are given below:

- ◆ The various coefficients that are used in the hydrological model were based on data to hand at the time the system was developed. This included continuous hydrodynamic data since 1986 and data since 1980 from five automatic rainfall recorders around the catchment. However, the rainfall data was considered to be unreliable up until 1994 when the management of the recorders was taken over by Manly Hydraulics Laboratory as part of the Narrabeen Lagoonwatch System (Couriel et al, 1995). It is considered that the accuracy of the model could be improved by using data that has been collected since the development of this model to review and refine the model, updating coefficients and factors used in the prediction of outputs as appropriate.

- ◆ Since Lagoonwatch was installed, there has been an additional gauge installed on Middle Creek that records rainfall and streamflow. To date, this has not been incorporated into the system. This option should be considered, as linking it into the model is likely to give more accurate results.
- ◆ The Lagoonwatch hydrological model bases its predictions on temporal patterns with a 30 minute interval, using a 30 minute timestep. Under normal conditions, it does not continually update. There is only a daily calculation, giving sample output to ensure it is functioning normally. Once an alarm has been triggered when environmental conditions are exceeded, a prediction is initiated using real-time data scanned from all gauges at that time. The system then remains on alert, and during this time it undertakes hourly predictions, unless it is overridden by the operator asking for an immediate prediction. The various time intervals in this process should be reviewed to determine if there are improvements to accuracy or effectiveness that can be made. At the same time, the environmental conditions that trigger an alarm should be reviewed to ensure that they are still appropriate.
- ◆ At present, there have been no flood emergency procedures formalised in a Flood Plan for Narrabeen Lagoon. While this is discussed in the following sections in more detail, an issue that relates specifically to the Lagoonwatch System is the allocation of responsibility for receiving the alarms from Lagoonwatch, running the model and issuing warnings based on this system.

At present, Warringah Council has the responsibility for monitoring Lagoonwatch and issuing warnings. There is a need to have a wider allocation of responsibility for this task to include SES personnel. The relevant SES personnel should also have access to, and derive flood information from, this system and use it to make predictions for the purposes of flood warnings and evacuations. The allocation of these responsibilities and procedures would be incorporated in a Local Flood Plan.

- ◆ The Narrabeen Lagoon is a small geographic area, and therefore while there is a medium response time for the Lagoon flooding, the tributaries have a very short response time and therefore limited prediction and warning time. To improve the short duration response time, and as an additional predictive tool, Bureau of Meteorology (BoM) information on storm systems occurring in and around Sydney could be incorporated into the system. A storm system could be tracked, its trajectory computed and extrapolated to determine if and when it is likely to move across the Narrabeen catchment. This information would give emergency response personnel better standby capability.
- ◆ The output from Lagoonwatch is in the form of a plot of water level against time. This then needs to be interpreted by the operator as to what this means for the catchment conditions. Linking the output to a GIS system that gives flood inundation maps for the catchment based on the predicted levels would enhance this interpretation. These maps could also indicate the location of significant areas, for example those areas where access may be restricted or properties require evacuation.

5.5.2 Emergency Response and Community Awareness

Management Option 9: - Development of a Local Flood Plan

Management Option 10: - Development of a Community Awareness Program

Local Flood Plan

From a floodplain management viewpoint, it is essential that a specific Flood Plan be developed for the area. It is recommended that consideration be given to the development of a combined Flood Plan for the Northern Beaches area, covering the Local Government Areas of Manly, Warringah and Pittwater. Such a combined plan would have Annexures detailing each catchment's specific requirements such as vulnerable properties, roads that are cut by floodwaters, etc. This concept for a Flood Plan for the Northern Beaches is agreeable with SES.

A Flood Plan would include community awareness and preparedness, evacuation procedure, flood intelligence, warning systems, emergency response procedures, evacuation centres and recovery procedures.

Specific aspects that would be included in a Local Flood Plan for Narrabeen Lagoon floodplain are:

1. The SES "Flood Intelligence" for Narrabeen Lagoon be reviewed and updated based on the flood information published in this and earlier studies. In particular attention needs to be given to those areas with emergency access and isolation problems, indicated by either high hazard ratings or with special notes on the flood inundation map prepared for this Plan. It is noted that local drainage problems are present along Mactier Street, which should be included in emergency procedures until such time as this is rectified.
2. The Flood Plan, when written, include defined "flood warden" arrangements, with suitable delegation rules and to require that Warden Sector data folders are reviewed and updated regularly, with a concentration on those residents who may have special needs.
3. An automated telephone system is developed to allow the targeted population to be notified of the warning in the shortest time. However, telephone systems may fail in a major flood. The Flood Plan should include an alternative message dissemination process to cover the failure of telephones
4. The Lagoonwatch system needs to be incorporated into the SES flood prediction and warning process. Thus, in addition to Warringah Council personnel, SES personnel need to take on responsibility for receiving alarms from Lagoonwatch. The LEOCON should also be able to monitor Lagoonwatch output for the purposes of flood prediction. The Flood Plan, when written, needs to define the administrative arrangements and responsibility for accessing and monitoring the Lagoonwatch system.
5. A systematic flood awareness strategy be implemented, having regard to the following potential initiatives:
 - development of a local schools campaign, run at both primary and high school levels
 - occasional major events, possibly based around the anniversary of a major flood. Such events have been very successful elsewhere and provide an opportunity for a multi-faceted approach, which could include an 'awareness day/week', parade or festival. competitions and general information distribution
 - information desks in public locations, such as supermarkets and Narrabeen Markets

- some focus on property management initiatives, for both commercial and residential properties, including the development of flood plans for individual properties, flood proofing initiatives for commercial properties and review of property safety (eg under-house wiring problems).
6. That a major part of the Community Awareness Program be devoted to information dissemination and that both Council and SES provide a budget to promote this process.
 7. An SES sub-office be located in the Narrabeen Lagoon area and that it be fitted out to allow plug-in communications so that local action can be coordinated locally.
 8. Evacuation centres be clearly identified as part of the Flood Plan, and sited above extreme flood levels, until such time as the PMF is determined for the study area the extreme event reported in the Flood Study could be taken as it approaches a PMF event in impact.
 9. The SES and Council, acting through either the Local Government Association or Department, seek specific undertakings from the broadcast media that in the event of a flood situation, quick and effective action can be taken to organise the broadcast of warnings into the local area.

The Local Flood Plan should incorporate the following:

Introductory information

The Introduction to the document should cover:

- ◆ the **purpose** of the document;
- ◆ the **authority** under which the plan is issued, either legislation or decree;
- ◆ a short description of the **area covered** by the plan, including any **specific risk locations**;
- ◆ the **responsibilities** of the emergency service organisations and supporting services; and
- ◆ procedures for the **review** of the document.

Preparedness

This section to the document should cover:

- ◆ **public education programs**, including information on the flood threat that is faced, the steps residents should take to prepare themselves, evacuation routes, the location of evacuation centres and the general contents of the plan;
- ◆ **activation procedures**, including:
 - under what circumstances will the plan be activated, such as warning received, a specific flood level or climatic conditions;
 - which organisations are to be advised of activation; and
 - which organisations are to be contacted to commence co-ordination.
- ◆ **flood intelligence** gathering, including:
 - the warning agency; and
 - gauge monitoring;
- ◆ issuing of **flood warnings**, including details of message content, audience, and, most importantly, the value adding information of what the warning means to the recipient; and
- ◆ issuing of **evacuation warnings**, including who is covered by the warning and the information to be provided in the warning message.

Response activities

This section to the document should cover:

- ◆ who is to **control** the situation, what powers that position holds and under what circumstances control will devolve to a higher level of authority;

- ◆ where principal **operations centres** will be located, and the location of alternative operations centres;
- ◆ the provision of **liaison officers** from other agencies and how these are to be contacted;
- ◆ the **communications** requirements and procedures;
- ◆ the **provision of information** to the community;
- ◆ **requirements specific** to the affected area such as road/railway closures, infrastructure requirements and medical facilities;
- ◆ detailed **evacuation procedures**, including:
 - recording procedures, especially who was evacuated and where they were taken;
 - which sectors of an area are affected by what level of flooding and details of specific requirements for each sector;
- ◆ **logistics and supply** information including locations of equipment, stores, foodstuffs and aerial activities.

Recovery

While this activity is more closely related to the welfare agencies, the flood emergency plan must include some necessary activities that assist in the recovery phase. These activities would include:

- ◆ provision of **welfare assistance** by the emergency service until the welfare agency can take control of those affected;
- ◆ **registration** of all evacuees;
- ◆ the passing of “**all clear**” messages;
- ◆ **coordinating** the recovery activities; and
- ◆ **debriefing** of all agencies involved in the emergency. This is a commonly overlooked aspect of emergency planning and activity and it is essential if lessons are to be learned from the emergency just passed.

Appendices

The Plan would benefit by including technical information, such as details of the tributary and lagoon system, intelligence on past floods and especially descriptions of what happens at specific levels of flooding.

Community awareness program

There are a number of methods of raising flood awareness in the community. Recommendations in this Plan are not considered complete and the FMC or community input at all stages of the implementation of Plan should be sought to enable an ongoing and increasing community awareness.

Community flood awareness prepares potential flood affected communities for appropriate action before, during and after a flood. Improving flood awareness can be both undertaken by Council or through the implementation of a Local Flood Plan. There are a number of methods of raising flood awareness in the community. An important measure is through policy changes that ensure the use of Section 149 (2) and Section 149 (5) certificates to inform prospective property buyers and property developers of the flood risk associated with any particular property.

It is noted that Clause 279 and Schedule 4 (7) of the Regulations to the *Environmental Planning and Assessment Act 1979* state that a Section 149(2) certificate must contain information relating to:

Whether or not the land is affected by a policy... that restricts the development of the land because of the likelihood of land slip, bushfire, flooding, tidal inundation, subsidence, acid sulphate soils or any other risk.

Councils, in their recent planning instruments, require notification of flood risk on Section 149(2) and 149(5) certificates that make reference, in its title, to flooding when the allotment is affected by a flood event up to the PMF, and the specific development controls apply up to the 1% AEP.

Councils have undertaken to improve community flood awareness by circulation of information - "Be Prepared for your next flood". A systematic flood awareness strategy should be implemented. Potential initiatives that could be undertaken within the study area are outlined below.

Flood awareness strategy

A systematic flood awareness strategy should be implemented, having regard to the following potential initiatives:

- ◆ development of a local schools campaign, run at both primary and high school levels
- ◆ occasional major events, possibly based around the anniversary of a major flood. Such events have been very successful elsewhere and provide an opportunity for a multi-faceted approach, which could include an 'awareness day/week'.
- ◆ Competitions and general information distribution
- ◆ information desks in public locations, such as supermarkets and Narrabeen Markets
- ◆ some focus on property management initiatives, for both commercial and residential properties, including the development of flood plans for individual properties, flood proofing initiatives for commercial properties and review of property safety (eg under-house wiring problems).

That a major part of the Community Awareness Program be devoted to information dissemination and that both Council and SES provide a budget to promote this process.

6 ASSESSMENT OF MANAGEMENT MEASURES

The assessment of flood mitigation options for Narrabeen Lagoon considered the impacts to flooding, social, environmental and economic aspects of options. The assessment is used as a guide to rank the floodplain risk management options in order of importance to the community.

The assessment was done using a multi-criteria procedure that considers relevant issues for the Study Area. The issues are listed in **Table 6.1**. They are selected to meet the expectations of the NLJE/FMC while considering outcomes from other studies done in the study area and findings from similar studies.

Table 6.1: Assessment issues for management measures

Category	Issues
Social	Does the measure reduce trauma to individuals during floods
	Does the measure increase or decrease the disruption to transport either during construction of works or during a flood
	Does the measure have an impact on essential services during and after floods
	Does the measure affect the access to or availability of recreational amenities during construction or during flooding
	Does the measure have a visual impact
Economic	Cost of mitigation measures
	Savings in potential flood damages
	Financial feasibility
Environmental	Will the measure result in increased erosion of lagoon banks?
	Does the measure require the removal of native fauna or flora?
	Does the measure maintain a good estuarine habitat that encourages diversity of species?
	Does measure enhance or degrade water quality
	Is the measure compatible with management measures being developed in the Estuary Management Plan
Flooding behaviour	Does the measure increase or reduce the hazard to the community
	Does the measure improve or worsen the impacts of a flood event larger than the design flood.
	Does the measure change velocities or water levels downstream
	Does the measure change water levels and extent of inundation upstream

Each measure was assessed against these issues using a five point system:

- 1 – major negative impact
- 2 – minor negative impact
- 3 – no impact / negligible
- 4 – minor positive impact
- 5 – major positive impact

The social and environmental assessment is qualitative only, while the flood behaviour and economic assessments are arrived at based on hydraulic model results where applicable and benefit and cost estimates where available.

All members of the NLJE/FMC were invited to assess the options. Responses received are presented at the end of this Section. Scores were compiled and the average shown in Table 6.6.

6.1 Economic impacts

Benefits

Economic benefits have been assessed, where possible, using savings of potential flood damages. Average annual potential damages (AAD) were derived by SMEC during the preparation of the Plan and are used for comparison of mitigation measures against existing AAD. A detailed discussion of the methodology is given in Section 4.

For some measures savings in AAD are not possible to determine and a quantitative approach has been applied that ranks an expected minor reduction in flood damages (4) for potential savings in AAD less than \$0.8 million and an expected major reduction (5) greater than \$0.8 million.

Apart from the values for Progress Park Levee, the reductions in AAD figures are calculated for residential properties only.

Costs

Preliminary costs for options were based primarily on previous studies. To provide an assessment that was quantitative, the following criteria was applied:

Capital cost:

- 1 capital cost \geq \$1 million dollars
- 2 capital cost $<$ \$1 million dollars

6.2 Discussion of assessment for options

6.2.1 Entrance management

Impact to flooding

Adopting the reported entrance management procedures aims to reduce the water levels in the lagoon during a flood.

Economic Assessment

The FMS evaluated this option to have a benefit/cost ration in the order of 0.65. As this was based on damages estimated using ANUFLOOD, it is expected that using current damage estimates this ratio would be in the order of 1 or more.

The capital cost from the FMS was \$0.3 million and an annual operating cost of \$0.09 million for improved controlled opening. Converting this to current prices, using an index of 1.45, gives a capital cost of \$0.45 million and an annual operating cost of \$0.13 million.

Environmental Assessment

Objectives of the formalised entrance management strategy include conservation of biological diversity and maintaining or enhancing water quality. The FMS noted that the formalised

strategy has a minimal impact on the then existing lagoon ecology in comparison to the excavated channel and training wall option. The recent Estuary Processes Study (2001) has not identified specific ecologic issues as a result of the entrance management strategy currently in place.

Social benefits

There are positive social benefits in that inundation of properties is reduced and the recreational features associated with the lagoon are enhanced.

6.2.2 Levee in Progress Park

This option is for a levee between Garden Street and Mullet Creek to be located in Progress Park. It would provide protection to the residential/commercial/light industrial area adjacent to Garden Street.

Economic Assessment

Assuming an embankment height of one metre and a length of 850 metres, the total capital cost was estimated to be in the order of \$0.2million.

The estimated savings in potential flood damages are given in **Table 6.2**. These figures include damages to all sectors. Damages to the commercial sector represent 63% of the total annual average damages. The savings in total AAD are in the order of \$0.67 million for a levee to the 5% flood level, with a net present worth of savings over a thirty year period is \$20 million. There are not savings for a level to the 1% AEP.

A levee in Progress Park would isolate properties from elevated lagoon levels but due to site constraints its height would be restricted to 2.7m AHD. Additionally, if a levee were constructed in this area flood impacts on surrounding properties would occur due to catchment runoff building up behind the levee and surcharge from the stormwater system.

To counter catchment flooding behind the levee a system of pumps would need to be installed to remove ponded floodwater, otherwise there will be an equalisation of flood levels on each side of the levee and the flood protection would be lost. This then places reliance on a mechanical pump system to provide flood protection that would be expensive to implement and maintain, with the probability of breakdown during a flood event a real consideration.

Table 9.2 – Estimated Potential Flood Damages – Progress Park Levee

Damage Type	Potential Damages (\$ million)			Average Annual Potential Damages (\$ million)
	5% AEP	1% AEP	Extreme	
Existing	21.8	36.2	96.5	2.36
With levee	7.0	36.2	96.5	1.69
Savings	14.8	0	0	0.67

Note: Nareen Creek not included

Environmental Impacts

The FMS noted that the construction of levee would have minor adverse environmental impacts as

1. there is scope to align the levee so that existing trees are maintained, and
2. environmental controls would limit water quality issues during construction.

Social Impacts

There are social benefits in that potential inundation and flood hazard in developed areas west of Garden Street is controlled for flood events up to a 5% AEP.

Contrary to the benefit gained by a levee to the 5% AEP level there are also disbenefits.

A levee to this level contradicts Pittwater Council's flood risk management levels that are set to the FPL. This may give the residents in this area a false sense of security as to the flood mitigation they will receive and their requirements in relation to redevelopment and emergency evacuation.

6.2.3 Zoning Local Environment Plan

It is recommended that zoning be revised to exclude SEPP5 developments within flood prone land. Further, zoning should restrict intensification of development (subdivision, dual occupancy or units) within the floodplain.

No changes to the current land use zoning are considered necessary assuming building and development controls are applied to developments in flood liable lands. No further intensification of development in flood liable areas, or areas that could experience emergency access difficulties, should be allowed as this increases the flood risk to the community and potential flood damages. Intensification would include dual occupancy, units and town house developments.

Economic Assessment

Savings of potential flood damages can not be directly evaluated, however this measure would reduce the ongoing potential flood damages by restricting development in flood liable land and the costs associated with emergency management during floods.

Social benefits

Social benefits are significant as appropriate zoning restricts the occupancy of flood liable land thus reducing the community trauma during floods.

Impact to flooding

There would be minimum impacts to the flooding behaviour as the current development of the catchment is maintained.

Environmental Impact

There are no long term adverse impacts to the environment.

6.2.4 Development Control

It is recommended that as part of the ongoing review of planning policy guidelines and recommendations given in Section 5.2 of Volume 2 are included. These relate to the protection and regulation of development and redevelopment in flood prone areas.

Economic Assessment

Savings of potential flood damages can not be directly evaluated for adopting building and development controls. Although this measure would reduce the ongoing potential flood damages

by restricting development in flood liable land and the costs associated with emergency management during floods.

Adopting these appropriate planning policies and guidelines do not have a direct capital cost, however it is recognised that there would be indirect costs to developers.

Social benefits

Social benefits are significant as appropriate development addresses the potential losses in new developments and the trauma associated with the loss and/or damage of properties and personal items.

Impact to flooding

There would be minimum impacts to the flooding behaviour. Adopting the building and development recommendations aim to control ongoing development in the floodplain thus maintaining the current level of infill in flood storage areas. In this way this option has minimal impact in increasing water levels. Any intensification of development allowed in the floodplain may increase flood water levels by decreasing flood storage or increasing velocities locally by redistributing flood waters. Preliminary analysis suggests this effect would be minor for Narrabeen Lagoon. Any potential impact can be minimised by adopting and enforcing pier construction without brick work between floor level and ground level.

Environmental Impact

There are no long term adverse impacts to the environment from adopting building and development controls.

6.2.5 Flood Planning Level

As part of the FMS the adopted design floor level for developments was the 1% AEP flood level plus 0.5m freeboard. It is recommended that this level is maintained for the Flood Planning Level, in line with Warringah and Pittwater Council's recent planning instruments. No amendments to the FPL are recommended assuming building and development controls are applied consistently to developments in flood prone land.

Councils apply the FPL in different ways as follows:

- Pittwater Council applies development controls to all properties within an area defined by land below the FPL (1% AEP flood level plus 0.5m), whereas Warringah generally considers properties within the 1% AEP flood extent;
- Pittwater Council applies the FPL to existing structures (commercial, residential and industrial development) when additions are constructed; Warringah assesses development application on merit basis.

The FPL (s) currently used for Narrabeen Lagoon is the 1%AEP flood level plus 500mm freeboard. This is line with current planning policies for both Pittwater and Warringah LGAs. The FPL is applied to new development and redevelopment.

Economic Assessment

Savings of potential flood damages can not be directly evaluated for adopting a FPL. However, this measure would reduce the ongoing potential flood damages by controlling development in flood liable land.

Adopting a FPL does not have a direct capital cost, however it is recognised that there would be indirect costs to developers.

Social benefits

Social benefits are significant as it addresses the potential losses for developments and the trauma associated with the loss and/or damage of properties including personal items.

Impact to flooding

The impact to flood levels is similar to that assessed for house raising as the result of applying FPL to redevelopments and new developments is potential loss of floodplain storage. Thus it has been assumed there would be minimum impacts to the flooding behaviour.

Environmental Impact

There are no long term adverse impacts to the environment.

6.2.6 Voluntary House Raising

There are 150 properties nominated for voluntary house raising in the study area, 81 are weatherboard/wood/fibro and 69 brick or stone construction. It is recommended that houses be raised to at least the FPL (1% AEP plus 0.5m freeboard), in accordance with the planning policies.

Economic Assessment

The properties for house raising are those considered to be raiseable with floor levels below the Flood Planning Level. Properties not deemed suitable for raising are two-storey or blocks of units. Potential flood damages were calculated by raising the floor level of the 150 properties to a level equal to the flood planning level, being the 1% AEP flood level plus 0.5 m freeboard.

As shown in **Table 6.3** below, the implementation of a House Raising Program would result in a significant reduction in the Average Annual Damage for residential properties in the Narrabeen Lagoon floodplain, with residential damages reducing by an estimated 28% on current estimates.

If the whole recommended program is implemented, residential damages will reduce by an estimated 28% on current estimates. Not all damages will be saved; there will always remain external damage to properties where house raising has taken place and garden sheds and garages may always be damaged, clean up costs and an indirect damage component. In addition, a component of the AAD will remain which represents the continuing flood problem due to floods greater than the 1% AEP event. This is managed through the response modification measures.

Table 6.3 Potential Residential Flood Damages with House Raising

Event (ARI)	Existing Residential Damages	Residential Damages with House Raising
20	\$7,544,790	\$2,992,010
100	\$11,289,310	\$4,426,975
Extreme	\$28,375,575	\$26,643,990
Total	\$47,209,675	\$34,062,975
AAD	\$761,643	\$376,981

As evident from **Table 6.3**, the benefit of implementing a house raising program would be approximately \$385,000 annually. These benefits would be increased by the reduction in damages that arise from flood compatible redevelopment and, most importantly, a significant reduction in the social impacts on the community. While it is difficult to place an exact monetary value on these benefits, it could be expected that it would amount to approximately \$50,000 annually. Thus, the benefit of the recommended floodplain management measures is \$435,000.

The cost of raising fibro/weatherboard/wood houses was taken to be \$30,000 and that of raising a brick house to be \$45,000. There are 69 stone or brick house and 80 fibro or weatherboard houses. Material type was not available for one property, and this is assumed to be weatherboard. Thus, the costs of implementing the house raising program is \$5,535,000.

Assuming that both annual benefits and costs increase over time at equivalent rates, and the economic “life” of the project is 30 years, the Benefit/Cost Ratio can be calculated as 2.4:

Social benefits

Social benefits are significant as voluntary housing raising reduces the trauma associated with the loss and/or damage of properties including personal items.

Potentially, house raising may cause visual disbenefits with a change in streetscape. However design of house raising can reduce these impacts.

Impact to flooding

The impact of past infilling in the floodplain is presented above. It was found that there is a minimal impact in flood impacts.

Environmental Impact

There are no long term adverse impacts to the environment from house raising. Appropriate construction techniques would offset potential adverse impacts of sedimentation or pollution in the creeks.

6.2.7 Flood warning and community preparedness

It is recommended to develop a Local Flood Plan for Narrabeen Lagoon and a community flood awareness program.

Economic Assessment

A preliminary estimate for potential savings has been determined by adjusting the factor used for flood warning when calculating potential flood damages. Savings in AAD are in the order of 15% for the residential sector. The capital and ongoing costs for implementing a Local Flood Plan is expected to be minor, less than \$500,000.

Impact to flooding

Implementation of a community awareness program and development of a Local Flood Plan would have no impact to the flood behaviour.

Environmental Impact

There are no environmental impacts from these measures.

Social benefits

Social benefits are significant as improved community preparedness decreases the trauma associated with floods and helps the community manage likely disruption during floods. Adoption of flood emergency procedures, such as dissemination of warnings, evacuation and recovery, help the community manage during floods and reduce the risk of loss of personal items.

6.2.8 Wakehurst Parkway - Channel enlargement by construction of wetlands.

An option considered to mitigate the flooding of Wakehurst Parkway by Middle Creek is increasing the hydraulic capacity of Middle Creek channel associated with the wetlands proposed in the SEE (Patterson Britton, 1993). This was used as the wetland was considered for environmental improvements in the lagoon. The proposed works in the SEE main objective was to improve water quality with a secondary benefit in reducing flood levels along Wakehurst Parkway.

Works proposed are shown in Appendix B and consist of a sediment basin, wetland and provisions for casual recreation.

Impact to flooding

As part of the SEE, an hydraulic model, based on HEC2 software, was used to assess the change in flood behaviour for construction of the wetlands. A summary of results is given in **Table 5.2** and modelled cross sections (CS) are shown at the end of this Section.

Results indicate that there would be a reduction in flood levels near CS18, however Wakehurst Parkway would have only a minor reduction in flood levels in the vicinity of CS17. As there is a significant reduction in flood levels at CS18 (up to 0.7m in a 50% AEP event), there is expected to be a reduction in frequency of inundation at this location. This is a local affect as in the vicinity of CS17 there is only minor changes in flood levels and the road is still expected to be inundated in a 50% AEP event.

Increasing the channel capacity has local impacts as velocities are increased just upstream of the works. Suitable erosion protection works would need to be incorporated to treat this increase.

Economic Assessment

The capital and ongoing costs associated with the proposed wetlands along Middle Creek was not given in the SEE (1993) report. Without detailed design, an accurate estimate of cost can not be provided. Experience with similar works indicates a likely cost of \$500 000.

The benefits of reducing the frequency of flooding of Wakehurst Parkway are both direct and indirect. The direct benefits are in the form of a reduction in road repair costs, which represents a saving in Average Annual Damages of around \$7,500. The indirect benefits result from the better access achieved by improved flood immunity of this major roadway, however this has not been estimated in this study. Over 30 years the direct savings would in the order of \$0.23 million.

The cost of works far outweighs the benefits. Should this option be considered in detail by Council, the indirect benefits should be estimated.

Environmental Impacts

A purpose of the wetlands is to improve the water quality in Narrabeen Lagoon. There would be sediment transport and water quality issues to manage during construction but the long-term impact to the lagoon would be positive.

Social Impacts

Construction of works along Wakehurst Parkway may cause some traffic disruption, which could be minimised by traffic management program. The long term benefits of reducing the frequency of the road closure outweigh the short term impacts during construction.

6.2.9 Raising Wakehurst Parkway

Flooding of Wakehurst Parkway can be reduced by raising the road where flooding occurs, between 1.6 to 2.9 km upstream of the lagoon. This option adopted a design of the 1% AEP flood, which is consistent with design standards used by RTA. A freeboard of 0.5 metres was included in each case.

Several options for raising the road were considered, namely:

1. constructing dual carriageway (4 lanes) at or above the 1% AEP flood level;
2. constructing single carriageway and overtaking lane (3 lanes) at or above the 1% AEP flood level; and
3. maintaining the existing road and providing flood mitigation for the 1% AEP flood by adjoining additional lanes, either one or two. Detailed design would include upgrading the culvert located between CS 18 and CS 19.

A survey, done as part of the SEE, indicated that the escarpment on the southern side of the road is generally at least 10m from the edge of the road shoulder between CS17 to CS19 and is a minimum of 5m at CS18. Assuming an embankment slope of 1:2, a lane width of 3.5 metres, and road shoulders of 2 metres, the first option (4 lanes) would require re-alignment of the channel between CS17a and CS19 that would involve excavation of a new channel and the clearing of some vegetation. Similarly the third option may encroach into Middle Creek. The second option is recommended as there is sufficient space to raise 3 lanes above the 1% AEP flood level without significantly encroaching onto Middle Creek channel.

Information provided at the end of this Section tabulates the lengths and height of road to be raised to achieve immunity for a 1% AEP flood event. The maximum height being 1.5m which includes 0.5m freeboard.

As part of the proposed road raising, the capacity of the existing culverts in this vicinity would need to be checked as they may require enlargement.

Impact to flooding

There is expected to be local increase in flood levels and velocities associated with raising the road and the encroachment into Middle Creek floodplain. It is not expected that increases in flood levels would impact existing development, as the adjacent areas are undeveloped. Suitable erosion protection works would need to be incorporated to treat this increase.

Economic Assessment

The benefits of raising Wakehurst Parkway are both direct and indirect. The direct benefits are in the form of a reduction in road repair costs, which represents a saving in Average Annual Damages of around \$7,500. The indirect benefits result from the better access achieved by improved flood immunity of this major roadway, however this has not been estimated in this study. Over 30 years the direct savings would in the order of \$0.23 million.

Costs for the construction works are in the order of:

- \$4.20 million for the raising of 4 lanes;
- \$3.25 million to raise 3 lanes; and
- \$2.38 million to provide an additional 2 raised lanes (whilst keeping the existing 2 lanes).

In addition to the basic construction costs, these prices include preparation and implementation of a traffic management plan; extension of culverts; compilation of an Environmental Impact Statement; and preparation and on-site implementation of an Environmental Management Plan.

The cost of works far outweighs the benefits. Should this option be considered in detail by either Council or the RTA, the indirect benefits should be estimated. Upgrading the road has a secondary benefit of augmenting a major arterial road, the cost and benefits of which may justify the works to provide flood immunity.

Environmental Impacts

Construction of works may have local impacts from increased sediment loads, but the long term impacts are expected to be minimal.

Social Impacts

Raising Wakehurst Parkway would cause significant traffic disruption, as the road is a major thoroughfare. To minimise disruption, works would have to be undertaken out of peak hour and an extensive traffic management program would be necessary. However, it is expected that the long-term benefits of having reducing the frequency of the road closure outweigh the short term impacts during construction.

6.3 Outcomes of Assessment

The assessment is a guide to rank options based on their effectiveness and significance to the community. Options with a total value greater than “do nothing” (40) would be beneficial to the community.

Table 6.4 is the average of responses received from the NLJE/FMC. Results indicate that options can be grouped in two ranges high - total of 55 or greater, and medium – total between 40 and 54.

High Scores (55 or greater):

- ◆ Controls for Intensification of Development on floodprone land
- ◆ Local Flood Plan - flood emergency procedures
- ◆ Lagoon Entrance Management Strategy
- ◆ Public Awareness and Preparedness
- ◆ Building and Development Controls
- ◆ Raising Wakehurst Parkway

Medium Score (between 40 and 54):

- ◆ House raising and flood proofing
- ◆ Progress Park levee
- ◆ Increase channel capacity for Middle Creek - wetlands.

Of the two options evaluated for Wakehurst Parkway, the raising of the roadway ranked above the wetlands along Middle Creek.

Table 9.6: Assessment of management Options

Issues	A - Do nothing	B - Development Controls	C - Zoning Local Environment Plan	D - Local Flood Plan	E - Community awareness and preparedness	F - Lagoon Entrance Management	G – Voluntary House raising	I - Progress Park levee	J - Raise Wakehurst Parkway	K - Channel enlargement for Middle Creek - wetlands
Social										
Social trauma during floods	2	4	3	5	4	4	4	4	4	4
Disruption to transport	2	4	3	4	4	3	3	3	5	4
Social disruption / Essential services	2	4	4	3	3	3	3	3	4	4
Recreational amenities	3	4	4	3	3	3	3	2	4	4
Visual	3	2	3	3	3	3	2	2	4	3
Economic										
cost of mitigation measure	3	2	3	2	2	2	1	2	1	2
Reduction in flood damages	2	4	4	4	4	4	5	4	3	4
Financial feasibility	3	4	4	4	4	4	3	4	2	3
Environmental										
Erosion of lagoon banks	3	3	3	3	3	3	3	3	3	3
Floodplain environs/habitat	3	3	3	3	3	3	3	2	3	3
Estuarine habitat	2	3	3	3	3	3	3	2	4	3
Water quality	2	3	3	3	3	4	3	3	4	2
Estuary Management Plan (EMP)	2	4	4	4	4	4	3	3	4	3
Flood Behaviour										
Hazards	2	4	4	4	4	4	4	4	4	4
Consequences of larger floods	1	4	4	4	4	4	4	2	3	3
Downstream impacts	3	3	3	3	3	3	3	3	3	3
Upstream impacts	3	3	3	3	3	4	3	3	2	3
Total	40	57	59	59	58	59	53	46	55	52

- 1 major negative impact
- 2 minor negative impact
- 3 no impact
- 4 minor positive impact
- 5 Major positive impact

APPENDIX A

APPENDIX B

APPENDIX C
