GOSFORD CITY COUNCIL

ERINA CREEK FLOODPLAIN RISK MANAGEMENT STUDY and PLAN



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December 2015

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ERINA CREEK FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

DECEMBER 2015

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Minutes of the Ordinary Meeting of Gosford City Council held in the Council Chamber, 49 Mann Street, Gosford on Tuesday, 8 December 2015.

GOV.186 ERINA CREEK FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN (IR 21288424)

Department: Governance and Planning
Service Unit: Sustainable Corporate and City Planning

2015/593 RESOLVED (Ward/Bowles) that:

A Council adopt the Erina Creek Floodplain Risk Management Study and Plan.

B Council proceed to review and prioritise the management actions for implementation through Council's Integrated Planning framework.

In accordance with Clause 6.1 Consultancy Services Agreement 29 July 2009, WMA Water grants to Gosford City Council a royalty-free non-exclusive irrevocable licence to use such Intellectual Property Rights for any purpose for which the Services are provided.

ERINA CREEK FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

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LIST OF ACRONYMS

AAD	Average Annual Damages
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ALS	Airborne Laser Scanning
BOM	Bureau of Meteorology
CCAP	Climate Change Adaption Plan
CFERP	Community Flood Emergency Response Plan
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECCW	Department of Environment, Climate Change and Water (now OEH)
DRM	Direct Rainfall Method
EMPLAN	Emergency Management Plan
FPL	Flood Planning Level
GIS	Geographic Information System
IFD	Intensity, Frequency and Duration of Rainfall
IPCC	Intergovernmental Panel on Climate Change
LGA	Local Government Area
LiDAR	Light Detecting and Ranging (ALS and LiDAR refer to the same process of obtaining survey)
m	metre
m^3/s	cubic metres per second
OEH	Office of Environment and Heritage
OSD	On-Site Detention
PMF	Probable Maximum Flood
RMS	Roads and Maritime Services (formerly the RTA)
RTA	Roads and Traffic Authority (now the RMS)
SES	State Emergency Service
SWW	Severe Weather Warning
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software program (hydraulic computer model)
WBNM	Watershed Bounded Network Model (hydrologic computer model)
WSUD	Water Sensitive Urban Design
1D	One dimensional hydraulic computer model
2D	Two dimensional hydraulic computer model

FOREWORD

The State Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The flood management process in NSW has recently been up-dated to incorporate consideration of the effects of climate change, and particularly the effects of sea level rise, on mean water levels and on flood levels.

The Policy provides for technical and financial support by the Government through the following four sequential stages:

1. *Flood Study*
   - determines the nature and extent of the flood problem.

2. *Floodplain Risk Management Study*
   - evaluates management options for the floodplain in respect of both existing and proposed development.

3. *Floodplain Risk Management Plan*
   - involves formal adoption by Council of a plan of management for the floodplain/foreshore.

4. *Implementation of the Plan*
   - construction of flood mitigation works to protect existing development,
   - use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

This Erina Creek Floodplain Risk Management Study and Plan constitutes a review of the second and third stage of the management process, namely the June 1991 Erina Creek Floodplain Management Study and Plan.

The results of this Floodplain Risk Management Study and Plan prepared by WMAwater for Gosford City Council and supported by the NSW Government's Floodplain Management Program will provide the basis for the future management of flood liable areas along Erina Creek.

PART A Floodplain Risk Management Study

1. SUMMARY - ERINA CREEK FLOODPLAIN RISK MANAGEMENT STUDY

1.1. Introduction

The Erina Creek Floodplain Risk Management Study has been prepared following completion of the 2012 Erina Creek Flood Study Review (Ref 1) which updated the Erina Creek Flood Study Review 1990 (Ref 2) and is an update to the 1991 Erina Creek Floodplain Management Study and Plan (Refs 3 and 4). The work has been undertaken in accordance with the NSW Floodplain Development Manual (Ref 5) and the August 2010 Flood Risk Management Guide – Incorporating sea level rise benchmarks in flood risk assessment (Ref 6) and:

- is based on a comprehensive and detailed evaluation of factors that affect and are affected by the use of flood prone land;
- represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land; and
- provides a long-term path for the future development of the community.

Erina Creek has a catchment area (Figure 1 and Figure 2) of approximately 32 square kilometres to its confluence with Brisbane Water which exits into Broken Bay. Flood levels in the lower reaches of Erina Creek are influenced by flood levels in Brisbane Water. Therefore it was necessary to consider the interaction of flooding from Brisbane Water with the local Erina Creek catchment flows.

Since the 1970's significant flooding of Erina Creek is known to have occurred on several occasions with events in 1977 and 1978, five events in the 1980's, two in the 1990's and the most recent event occurring in June 2007.

Flooding causes significant hardship (tangible and intangible damages) to the community and the impacts will increase if sea levels rise and/or rainfall increases occur due to climate change. For this reason Gosford City Council has undertaken a program of studies to address the management of flood risks.

The present review has been undertaken by Gosford City Council to reassess flood risk management options utilising data from the 2013 Erina Creek Flood Study. The Flood Study contains information on sensitivity analysis for potential sea level rise and increased rainfall intensities due to climate change. The analysis was based on projections from the Intergovernmental Panel on Climate Change (IPCC) and the CSIRO technical review for Australia. Gosford City Council at its meeting of 10th March 2015 resolved to adopt a sea level rise planning benchmark based on projections for the Representation Concentration Pathway Scenario RCP8.5 utilising the medium sea level rise projection.

This review does not cover adaptation measures due to potential climate change; adaptation measures will be covered in a future adaptation plan.

1.2. Management Measures Considered

Eleven Floodplain Management Areas were identified in the previous 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) as summarised in Table 1 and on Photo 1.

Table 1: Floodplain Management Areas from previous 1991 Erina Creek Floodplain Management Plan (Ref **4** - Appendix C)

Area	Name	Description
EC0	Floodways	They are areas critical to the conveyance of floodwaters. The 1% AEP event was used for floodway identification.
EC1	Council Depot	The Council Depot was relocated to Erina in 1973 and comprised the SES, Fire Control Centre, Council's mechanical workshop, stores and Works Supervision Section.
EC2	Erina Industrial Area	This area comprised the northern parts of lots adjoining The Entrance Road (Central Coast Highway) which back on to the floodway.
EC3	Barralong Road Levee Industrial Protection Area	This area comprised the west end of Barralong Road, as well as industrial properties on Bonnal Road and Aston Road which are now protected by the Barralong Road levee which was constructed following the recommendations of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C). The area is fully developed, largely as a light industrial / commercial area.
EC4	Worthing Road Creek Area	This area comprised land around the confluence of Erina Valley Road Creek with Worthing Road Creek.
EC5	Carlton and Milina Roads Area	This area covered the area upstream of the confluence of Worthing Road Creek and Erina Creek.
EC6	Old Erina Estate Acquisition Area	The area is within the main floodway of Erina Creek and Council has a policy of considering purchasing vacant blocks when offered for sale.
EC7	Barralong Road Levee Residential Protection Area	This area comprised those properties on Winani Road, Lingi Street and Barralong Road which are now afforded protection by the Barralong Road levee. This area is largely residential. In the 1991 Plan, area EC7, also included those properties north of the levee which were purchased by Council as part of the levee construction scheme.
EC8	Clarence Road Area	This area is largely vacant land along the northern fringe of the Erina Creek floodplain.
EC9	Springfield Wetland Area	This area comprises a wetland area with no development, the majority of which is designated as a SEPP14 wetlands area.
EC10	The Upstream Catchment	This area comprised the upstream Erina Creek catchment with a similar area to that covered by the Erina Creek hydraulic model from the 2012 Erina Creek Flood Study Review (Ref 1) and is largely scattered rural holdings.

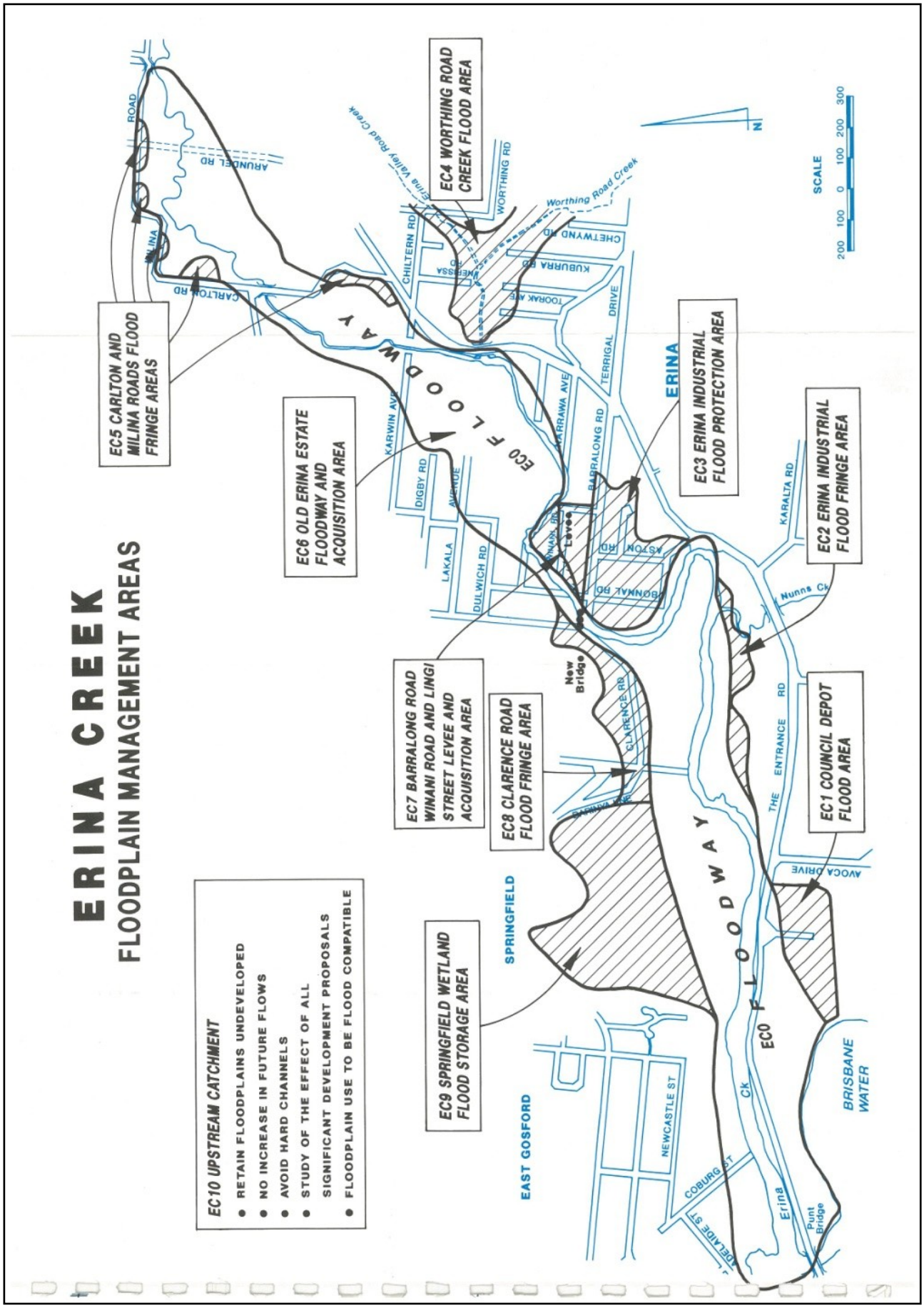


Photo 1: Floodplain Management Areas from the 1991 Erina Creek Floodplain Management Plan (Ref **4** - Appendix C) (new areas referred to in the present study are shown in Figure 3)

As part of the present study and plan the management areas were re-derived based on a catchment basis as indicated on Figure 3 and listed in Table 2.

Table 2: Floodplain Management Areas based on Catchment Areas

Name of Catchment	Number	Previous Management Areas
Upper Erina Creek	C2/A	Not included previously except EC10
Oak Road	C2/B	Not included previously except EC10
Fires Road	C2/C	Not included previously except EC10
Milina Road	C2/D	Part EC0, mainly EC5
Erina Valley Road Creek	C2/E	Part EC4
Worthing Road Creek	C2/F	Part EC4
Barralong Road	C2/G	Part EC0 mainly EC3, EC6, EC7 and some EC8
Nunns Creek	C2/H	Part EC0 and EC2
Springfield	C2/I	Part EC0 mainly EC9 and EC1, some EC8
East Gosford	C2/J	Mainly not included, part EC0

A matrix of possible management measures was prepared and evaluated in this Floodplain Risk Management Study taking into account a range of parameters. This process eliminated a number of floodplain risk management measures for inclusion in the Management Plan including:

- Flood mitigation dams on the basis of high cost, large footprint, and environmental impact;
- Modifying the existing entrance channel of Erina Creek to Brisbane Water or constructing a new entrance at another location on the basis of high cost, may exacerbate flooding, and environmental impact. However this option was investigated as it may be considered if upgrading of The Entrance Road (Central Coast Highway) is undertaken in the future; and
- Voluntary purchase of all flood affected buildings (selected voluntary purchase has been considered) on the basis of being uneconomic and having a high social impact.

The full range of measures was evaluated in Section 6 and the outcomes are summarised in Table 3. Community opinion on the full range of options will be sought during the public exhibition period as detailed in Section 1.3. However it should be noted that these outcomes may change in time if community expectations change and/or as an outcome of future studies. The final options documented in the Erina Creek Floodplain Risk Management Plan will reflect the current community input.

Table 3: Summary of Management Measures Investigated in Study

MEASURE	PURPOSE	COMMENT
FLOOD MODIFICATION MEASURES		
Levee banks (either earth, concrete, small brick wall) and associated flood gates, pumps	Prevent or reduce the frequency of flooding of protected areas.	Relatively expensive for larger structures but may be feasible for smaller structures. May cause local drainage problems and social problems. Possible measure to mitigate sea level rise. Structural integrity and review of Barralong Road levee required.
Local drainage issues – works to minimise local drainage problems	To reduce the incidence of local runoff ponding in yards and streets.	Flooding of this type occurs frequently and causes significant inconvenience. An overland flow flood study is recommended to fully assess this issue and to link in with this study. New or additional pipes required to drain areas upstream of Hylton Moore Park.
Channel modification and clearing	Can increase the capacity of the channel and convey more flow and reduce risk of damage or blockage to structures.	The main channel is a natural system and no significant works are supported. Removal of non natural debris and sediment build up can be justified.
Retarding basins	Small scale flood mitigation dams.	Retarding basins will not significantly reduce flood levels, however they will provide some water quality and quantity benefits if a suitable site is available.
Catchment treatment, water cycle management	To reduce localised runoff by increased attenuation and on site storage of flood waters.	Most beneficial for overland flow flooding after heavy rainfall. Will have some benefit to the catchment but considering the scale of development this will be on a local basis. Should be encouraged through Council's planning controls.
Blockage prevention devices	Reduces the incidence of blockage and thus peak flood levels.	On-going inspection and maintenance will reduce, but not eliminate, the potential for blockage. The impact of blockage at all structures should be investigated immediately following all future flood events.
PROPERTY MODIFICATION MEASURES		
House raising	Raises floor above flood level.	Widely used in the past along Erina Creek. House raising is supported for applicable buildings.
Flood proofing	Prevent flooding of existing buildings by sealing all possible water entry points. Can also be applied to new construction. Also includes suitable installation of electronics and plumbing. Temporary flood proofing can include flood gates fitted across doorways.	Retrofitting generally only suitable for brick, slab on ground buildings. Less viable for residential buildings but should be considered for non-residential buildings such as those in the Barralong Road or The Entrance Road (Central Coast Highway) industrial estates. Grant funding is not available. Flood proofing buildings also can include designing electrical circuits above flood levels to reduce the risk of electrocution. Temporary options such as flood gates could be useful for commercial properties and even some residential dwellings. Council should provide advice to occupants on the frequency and depth of flooding and flood proofing measures. Available for residents to pursue privately.
Voluntary purchase	Purchase of houses using Council and State government funding if acceptable to the owner.	Voluntary purchase of all flood prone properties is not feasible, however, the property owners at 92, 96, 98 and 100 Chetwynd Road (in the Erina Valley Road Floodplain Management Area) should be asked, prior to applying for funding assistance, if they wish to be placed in a voluntary purchase scheme.

MEASURE	PURPOSE	COMMENT
Strategic planning issues	Can prevent or minimise damages to new developments.	A number of strategic planning issues relating to the following issues have been investigated and guidelines provided: 1. filling in the floodplain; 2. filling on the north side of The Entrance Road(Central Coast Highway); 3. sea level rise; 4. ensuring adequate evacuation; 5. development within the Old Erina Estate; 6. discontinuities with the identification of floodways; 7. consideration of impacts in events greater than the 1% AEP for development control; 8. construction on or near levees; 9. Barinya Lane area; 10. filling for parking for the Woodport Inn off Bonnal Road; 11. intensification of development in the 1% AEP floodplain; 12. further development and local drainage within the Barralong Road levee area.
Rezoning of land	Limits extent of future development within the floodplain and reduces risk to life and damage to property.	The wholesale rezoning of flood liable land is not appropriate. However consideration should be given to limiting development on flood islands (i.e areas which become surrounded by flood waters and where residents may attempt access through floodwaters, thus risking their lives and possibly those of any rescuer).
Modification to the s149 Certificates	s149 certificates clearly inform property owners and purchasers of the flood risk.	Council has reviewed flood related information on the s149 (2) certificate to bring it into line with the findings of this study. Property information on flooding should be made available on the web site with additional details provided on application to Council by the property owner.
Provision of public services	To ensure continued supply of public services.	Council and supply authorities need to undertake reviews of the impact of sea level rise on the maintenance of the services provided.
Minimise the risk of electrocution	To reduce the risk to life.	Introduce measures to reduce the risk. Can be incorporated with flood proofing in properties.
Flood planning levels (FPLs)	To ensure floor levels are above flood levels to provide an acceptable level of flood risk (or for less vulnerable properties such as commercial properties flood proofing to this level).	Usually set as the 1% AEP flood level plus 0.5m freeboard for residential. Ensures that new development is built at an appropriate level. Greater restrictions can be placed on buildings more vulnerable to flooding such as hospitals, electricity sub-station, seniors housing and lower restrictions on less vulnerable uses such as commercial activities or industrial activities providing flood proofing to the FPL is undertaken. Council should develop a FPL policy that can be applied throughout the LGA taking into consideration mainstream, overland and estuary/lagoon flooding as well as incorporating any climate change considerations.
Review and update LEP and DCP	To be kept up-to-date with current flood mapping to reduce flood risk through planning controls.	LEPs and DCPs should be up-to-date to effectively manage flood risks for new development. These controls are used to stipulate FPLs, land use zones, flood proofing and floor level requirements.
RESPONSE MODIFICATION MEASURES		
Flood warning	Enable people to prepare and evacuate, to reduce damages to property and injury to persons.	No flood warning system currently in place. Made difficult by the quick response time of the catchment.
Flood emergency management	To ensure evacuation can be undertaken in a safe and efficient manner.	A Local Flood Plan, part of the Local Disaster Plan, should be updated with the latest flood information from the Flood Study and this Plan. Need to include which properties affected and how (ERP classifications), when and where roads and access cut, and other facilities that would be affected. Two key issues to address are access to the Council, SES and Rural Fire Services depot from Avoca Drive and access from upstream rural areas when Carlton Road is inundated.

MEASURE	PURPOSE	COMMENT
Public information and raising flood awareness	Educate people to prepare themselves and their properties for floods to minimise flood damages and reduce risk to life.	An inexpensive and effective method but requires continued effort. Can be linked with updating s149 certificates, Council rate notices, local community events, school education. Recommended also to advise both residential and commercial/industrial residents of possible flood proofing measures, hazard at their properties and suitable evacuation routes.

1.3. Community Consultation

Community consultation has been undertaken as part of preparation of the Flood Study, this Floodplain Risk Management Study and in the Floodplain Risk Management Plan. A summary of the consultation measures are provided below:

- meetings with the technical sub-committee (OEH and Council Officers) who provide direction on the technical aspects of the project. This includes which management measures should be assessed and the approaches to be undertaken;
- meetings with members of Council's Floodplain Management Committee which includes the technical sub-committee members as well as other Council Officers (planners), Councillors and community representatives;
- the general public were informed of the project as part of preparation of the Flood Study which included questionnaires were sent out to approximately 770 property owners in the catchment. The objective of the questionnaire was to advise residents of the study and if possible obtain additional flood level data. 136 responses were obtained, the majority of which were from residential property owners;
- The Draft Floodplain Risk Management Study and Plan was placed on public exhibition in October 2015 and included workshops to explain the outcomes;
- Various tables, text and figures were corrected or adjusted to reflect minor errors and comments received following public exhibition.

2. BACKGROUND

2.1. Introduction

The 32 km^2 Erina Creek catchment is one of the major tributaries entering Brisbane Water at East Gosford (Figure 1). Figure 2 indicates the pre LEP 2014 land use zones while Figure 3 identifies the Floodplain Management Areas referred to in this Study and Plan.

The Erina Creek Flood Study Review was completed in July 2012 (Ref 1), which updated the previous Erina Creek Flood Study Review 1990 (Ref 2) with currently available data, notably the use of airborne laser scanning (ALS) data and more sophisticated hydraulic modelling techniques.

The catchment land use is a mixture of rural and residential with significant light industrial and commercial areas in the lower reaches. The catchment has been extensively urbanised over the last 20 or so years with the development of large residential areas and Erina Fair commercial area in the east.

Erina Creek rises in the hills of the Ridgeway District, approximately 5 km inland from the coast. The creek flows in a south-westerly direction discharging into Brisbane Water at the Punt Bridge. The catchment includes the suburbs (part or all) of Matcham, Erina Heights, Holgate, Mount Elliot, Erina, Springfield, Green Point and East Gosford.

The upper portion of the Erina Creek catchment is fairly steep and the slopes are largely vegetated. Most rural properties are located near to the creek. The lower portion of the catchment is an area of general low relief, particularly surrounding the tidal extent downstream of the Central Coast Highway crossing of the Worthing Road Creek catchment.

There are two major tributaries to Erina Creek, Worthing Road Creek catchment which enters downstream of Carlton Road and Nunns Creek which enters downstream of Karalta Road under the Central Coast Highway. There are also a number of smaller unnamed creeks. Flooding is a known concern in the floodplain areas and significant hardship and damage were experienced in past floods. Since 1992 the only flood of any significance was on 8th June 2007 which is known in the Newcastle area as the Pasha Bulker storm due to the beaching of this bulk tanker.

An extensive floodplain develops downstream of Milina Road as the topography flattens out. Erina Creek is tidal to nearly the confluence with the Worthing Road Creek catchment at the Central Coast Highway; with the reach downstream of Barralong Road lined by mangroves and approximately 10 to 20m wide. The northern bank in this lower reach is heavily vegetated in a semi natural state.

2.2. Objectives

Gosford City Council engaged WMAwater (formerly Webb, McKeown & Associates) to review the 1991 Erina Creek Floodplain Risk Management Study and Plan (Refs 3 and 4) in accordance with the:

- NSW Government's Floodplain Development Manual (Ref 5);

- NSW Government's guidelines for sea level rise (Flood Risk Management Guide - Ref 6);
- NSW Government's guidelines for rainfall intensity increases (Floodplain Risk Management Guideline – Practical Consideration of Climate Change – Ref 7).

The objectives of the present Study are to identify and compare various management options, including an assessment of their social, economic and environmental impacts, together with opportunities to enhance the floodplain environments. The primary aim of the Plan is to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk at this time and as a result of climate change. This review combines and updates the previous 1991 Erina Creek Floodplain Risk Management Study and Plan (Refs 3 and 4) into one document.

A glossary of flood related terminology is provided in Appendix A.

2.3. Floodplain Management Policy

2.3.1. NSW Flood Prone Land Policy

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property and reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual (Ref 5) relates to the development of flood liable land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy.

The Manual outlines a merits based approach to floodplain management. At the strategic level this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk. The Manual recognises differences between urban and rural floodplain issues. Although it maintains that the same overall floodplain management approach should apply to both, it recognises that a different emphasis is required for each type of floodplain.

2.3.2. Gosford City Council's Flood Policy Objectives

The primary objective of the policy is to reduce the impact of flooding liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible. That is:

- a merit approach shall be adopted for all development decisions, which takes into account social, economic and ecological factors, as well as flooding considerations;
- both mainstream and overland flooding shall be addressed, using the merit approach, in preparation and implementation by Council of floodplain risk management plans;
- the impact of flooding and flood liability on existing developed areas identified in floodplain risk management plans shall be reduced by flood mitigation works and measures, including ongoing emergency management measures, the raising of houses where appropriate and by development controls; and

- the potential for flood losses in all areas proposed for development or redevelopment shall be contained by the application of ecologically sensitive planning and development controls.

2.3.3. Related Issues

The objectives of the relevant Section 117 Directions under the 1979 Environmental Planning and Assessment Act are to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the 2005 NSW Government's Floodplain Development Manual (Ref 5), and to ensure that the provisions of an LEP on flood prone land is commensurate with the flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

Council is thus able to manage flooding through the adoption of strategic plans outlining the actions to be undertaken to manage existing and future flood problems.

2.4. Regional Development Strategy

The key document outlining the future development of the region is the Department of Planning and Environment's Central Coast Regional Strategy 2006-2031. The document anticipates further employment and housing growth in the area and acknowledges the restrictions due to flooding. Despite this statement, the pressure to accommodate any additional new houses and commercial buildings by the year 2031 may mean that areas at future risk of flooding are considered for continued development. Any proposals in these areas must therefore carefully consider the impacts of future flooding and climate change.

2.5. Study Area Description

2.5.1. Land Uses

Pre LEP 2014 land use zones are included as Figure 2. The catchment is mixed use with areas of low density residential, industrial, business development, recreation, national park reserves and other non-developed used in flood affected areas. Most land uses in the flood affected areas of the north bank of the lower Erina Creek are designated as National Parks, nature reserves, public conservation and environmental conservation and management or recreation although some residential area border the flood extent. These uses are generally flood compatible with little development and much of this land is owned by Council. Land use along the southern bank of lower Erina Creek comprises more developed uses including industrial, business development and residential.

There is a large amount of available land in the LGA outside the PMF envelope, though in many parts other issues may inhibit development. Higher density development within the PMF area has the potential to increase flood damages and risk to life unless the flood problem is adequately identified and addressed.

The number of cadastral lots within the flood extents is shown in Table 4. This is a simple count of the number of lots which are flood affected, either partially or in their entirety, and not necessarily the actual number of buildings inundated.

Table 4: Lots Affected in Various pre LEP 2014 Land Use Zones

Zoning	PMF	1% AEP	1% AEP High Hazard
Zone 1 - Environmental Management	5	3	3
Zone 2 - General Residential	410	218	110
Zone 3 - Business	69	41	24
Zone 4 - Industrial	36	33	11
Zone 5 - Infrastructure	16	7	6
Zone 6 - Environmental Conservation	149	144	140
Zone 7 - Public Recreation	361	342	328
No Zoning - Deferred Matter	470	416	386
Total	**1516**	**1204**	**1008**
COUNCIL OWNED	**179 (12%)**	**166 (14%)**	**152 (15%)**

Note: 1. For details on the high hazard classification refer Section 4.3
2. No Zoning - Deferred Matter refers to lands deferred from Gosford LEP 2014 which remain under Interim Development Order No. 122 Zones.

The majority of land use, based on the number of properties affected, is Low Density Residential and Public Recreation. It is noted that a relatively high percentage of the flood liable land is owned by Council (33% in the 1% AEP high hazard areas). The *No Zoning* listed at the end of Table 4 refers to parcels where zonings have not yet been resolved between Council and the NSW Government. The properties involved are mostly E2 Environmental Conservation or RE1 Public Recreation.

2.5.2. Environmental Summary

No detailed comprehensive environmental study has been undertaken specifically for the Erina Creek catchment however Gosford City Council prepared the document in Photo 2 (taken from Council's web site). This document provides a broad outline of the ecology of the area and suggestions to reduce any environmental degradation. There are also several other local studies prepared by Council and others but these have not been reviewed as part of this study.

The main environmental studies of relevance to Brisbane Water are the 2009 Brisbane Water Estuary Processes Study (Ref 8) and the 2012 Brisbane Water Coastal Zone Management Plan (Ref 9). These reports cover in detail the issues relating to Brisbane Water and identify the key inputs of which Erina Creek is one of the main systems. However the guidelines and issues raised are only of relevance to this Erina Creek floodplain management study and plan if any of the proposed measures for Erina Creek are likely to affect Brisbane Water. Thus in the evaluation of floodplain management measures a key consideration is the impacts on downstream floodplains and water bodies and ensuring adverse impacts do not occur.

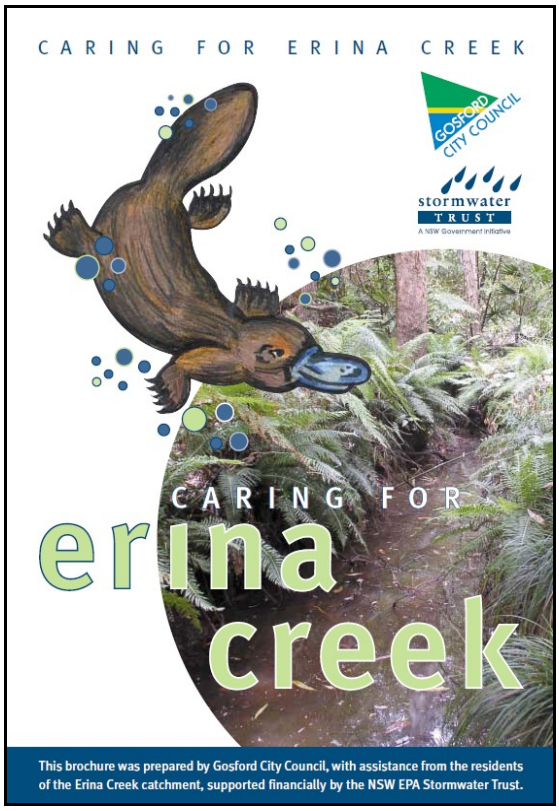


Photo 2: Environmental Study of Erina Creek

2.5.3. Social Characteristics

Understanding the social characteristics of the area can help in ensuring that the right risk management practices are adopted. The census data can provide useful information on categories including dwelling and tenure type, languages spoken, age of population, movement of people into and from the area all of which can be useful to understand and have implications for flood risk management. Information has been extracted for the 2011 census. The suburb of Erina (Green Point) covers much of the study area and has a population of approximately 13,600 living in approximately 5500 private dwellings. Some of these dwellings will be flood prone from Erina Creek and its tributaries.

Of interest is the data on population movement in recent years. Generally residents who have lived in an area for a longer time will have a better understanding of flooding issues in their area than those who have recently moved in to the area. Within the last five years 27% of the population has moved in to the area with 87% of those residents coming from NSW and 7% coming from overseas.

It is useful to consider the tenure of housing. Those living in properties which they own are more likely to be aware of the flood risks and have measures in place to reduce them. Rental properties are likely to have a higher turnover of people living in them compared to privately owned properties. It is expected that those people in rental properties may be less aware of the flood risks unless they have been there for enough time to have experienced flooding or have been sufficiently informed by their landlords. In the Erina suburb area 17% of houses are rented with 77% of dwellings being privately owned. The remaining 6% was not stated or noted as other.

The languages spoken by the population is also useful to consider as it can have implications for the provision of flood information to the public. In the Erina area 90% of the population speak English at home.

2.6. Previous Studies

2.6.1. 2012 Erina Creek Flood Study Review

The 2012 Erina Creek Flood Study Review (Ref 1) provides the most up to date information on design flood behaviour. This report was undertaken to update the previous Erina Creek Flood Study Review 1990 (Ref 2).

The main reasons for updating the hydraulic modelling approach are as follows:

- use of a two dimensional (2D) hydraulic model;
- availability of detailed additional cross section data to better describe the bed of the creek (bathymetric data);
- availability of Airborne Laser Scanning (ALS) survey that provides a more accurate definition of the foreshore topography;
- a more detailed appraisal of Brisbane Water conditions;
- to incorporate projected climate changes and sea level rises; and
- to incorporate an “envelope” approach based on the maximum flood levels of a Brisbane Water event and a catchment rainfall event.

The adopted approach was to establish a TUFLOW 2D hydraulic model based on the available bathymetric and ALS survey with inflows from a WBNM hydrologic model. A calibration / verification was undertaken to the February 1990 and the June 2007 long weekend storm/flood events. The model was then used for design flood estimation with sensitivity analysis undertaken to determine the impacts of various model parameters.

This approach for determining design flood levels used two TUFLOW models; one for the Upper and one for the Lower Erina Creek catchment. Further detail on establishing the design flood levels is given in the 2012 Erina Creek Flood Study Review (Ref 1) but also summarised in this Study in Section 3.1.

Climate Change

Global climate change is projected to raise sea levels and possibly change local rainfall intensities. The NSW Government introduced a set of benchmarks in 2010 for the assessment of raised sea levels and guidelines for increases in design rainfall intensities (Flood Risk Management Guide - Ref 6 and Floodplain Risk Management Guideline – Practical Consideration of Climate Change – Ref 7). In October 2012 the NSW Government withdrew the requirement for Councils to adopt the above sea level rise benchmarks and placed the onus on Council to adopt an appropriate benchmark. The majority of councils have chosen to continue to use the State Government 2010 sea level rise benchmarks.

At the commencement of this study Gosford City Council had adopted the 2010 sea level rise benchmarks. As such these were used when commencing the study. However during the

preparation of the study and plan Gosford City Council at the meeting of 10 March 2015 adopted an alternate SLR planning benchmark based on projections for the Representative Concentration Pathway Scenario RCP8.5 utilising the medium SLR projection. The ratios adopted were:

Year	SLR Increase (m)
2015	0.00
2030	0.07
2050	0.20
2070	0.39
2100	0.74

As a result additional SLR scenarios were analysed under this study.

The following climate change scenarios were analysed as part of this study:

- **Rainfall induced flooding**: increase in design rainfall of 10%, 20% and 30%,
- **Increase in Brisbane Water levels**: increase in sea level 0.2m, 0.4m, 0.74m, and 0.9m.

Section 1.1 details the adopted climate change policy of Gosford City Council.

The study does not consider the effects of flooding due to a tsunami.

2.6.2. 1991 Erina Creek Floodplain Risk Management Study and Plan

The 1991 Erina Creek Floodplain Risk Management Study and Plan (Refs 3 and 4) provided an assessment of management measures to mitigate risk associated with the flood levels provided in the Erina Creek Flood Study Review 1990 (Ref 2). The Plan concluded that the recommended approach for the future development of the Erina Creek catchment should be a combination of controls on future development, protection to existing properties at risk and limited filling on the floodplain. In summary the outcomes were:

- flood mitigation dams, retarding basins, river improvement works and floodways were considered not viable (largely on environmental, economic and practical grounds);
- a levee at Barralong Road was proposed and subsequently constructed which also included purchase and demolition of some existing properties to allow for construction of and mitigate impacts of the scheme;
- local flooding causes inconvenience but does not reach floor levels. There are no viable economic solutions to this problem but it should be monitored. Ultimately redevelopment of properties will result in floor levels being raised to the appropriate level;
- catchment treatment (such as minimising impervious areas in new developments or not forming concrete lined channels) should be encouraged but would not reduce flood levels;

- house raising is only suitable for a small number of buildings but should be implemented where appropriate;
- flood proofing is not viable for residential buildings but is appropriate for commercial buildings;
- improvements to flood related development controls were suggested;
- some buildings upstream of The Entrance Road (Central Coast Highway) in the Worthing Road Creek catchment were considered for voluntary purchase;
- rezoning should be considered as the primary measure to minimise future flood damages;
- improvements to the flood warning, evacuation planning and flood awareness procedures were supported;
- development measures (climate change, further development and filling of the floodplain) were addressed; and importantly
- lands within the floodway are to be maintained for the passage of floodwaters and acquired by Council where appropriate.

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) identified a number of Floodplain Management Areas (see Photo 1). However for this study management areas are based on catchments and are shown in Figure 3. Further information on each of the areas as used in this study is given in Section 3.5.

2.6.3. 1990 Nunns Creek Trunk Drainage Strategy Study

The Nunns Creek Trunk Drainage Strategy Study (Ref 10) established design flood levels and investigated possible floodplain management measures for Nunns Creek, upstream of the Central Coast Highway. The modelling indicated that the only major problems were at the Highway. However since 1991 there have been significant developments upstream which are partly on flood liable lands and may introduce additional problems. The key conclusions from the study were:

- enlarging the culverts under the Central Coast Highway would have a low benefit/cost ratio but should be considered when the Highway is upgraded;
- local flood proofing and a flood awareness program should be implemented in the interim;
- Council should prevent further intrusion into the floodplain;
- the practicality of widening the creek downstream of the Highway should be investigated;
- possible failure of the causeway at the Pine Needles Caravan Park should be examined in greater detail;
- retarding basins were not considered viable;
- limited stream clearing warranted further consideration;
- future development should minimise the adverse effects of urbanisation.

2.6.4. East Gosford Catchment Study

The purpose of this study (Ref 11) was to evaluate the existing stormwater drainage system at East Gosford and to recommend improvement works. Twenty nine major trunk drainage systems were analysed and inspections, dimensions, condition and other criteria evaluated. Questionnaires were also distributed. ILSAX hydrologic/hydraulic modelling was undertaken and the capacity of systems determined. Eight above floor inundated buildings were discovered.

The recommended drainage strategies are sumarised below.

LINE	ITEM	IMPROVEMENT OPTIONS	CAPITAL COSTS
2	(b)	Rebuild Pit No 2.6(c) and bolt down lid	$3,000*
2	(g)	Formalise overland flowpath downstream of John Whiteway Drive (Refer Section 4, Item(b) for further details)	n.a.*
3	(a)	Clean out debris from box culvert under Henry Parry Drive	n.a.*
3	(b)	Coarse trash rack (Type D) and coarse sediment collection pond in creek upstream of Henry Parry Drive	$10,000*
3	(c)	Additional inlet capacity upstream of Albany Street	$20,000
3	(e)	Special development controls for 164 Albany Street	n.a.*
3	(g)	Plan Of Management upstream of Masons Parade including for house raising and controlled filling	n.a.*
3	(k)	Formalise overland flowpath downstream of Henry Parry Drive. Refer Section 4, Item(b) for further details.	n.a.*
5	(b)	Floodwall at rear of 1 Duke Street	$5,000*
5	(d)	Formalise overland flowpath downstream of Florence Street.	n.a.*
6	(a)	Provide additional inlet capacity upstream of 37 York Street	$2,000*
6	(b)	Construct floodwall and associated works at rear of Unit 8, 37 York Street	$4,000*
6	(c)	Construct small GPT (Type A) at outlet in Caroline Bay	$15,000
6	(d)	Formalise overland flowpath downstream of Frederick Street	n.a.*
7	(c)	Small GPT (Type A)at outlet in Caroline Bay	$15,000
7	(d)	Formalise overland flowpath downstream of Lushington Street to Webb Street. (Note that overland flows do not follow the pipe route below Webb Street).	n.a.*
9	(a)	Additional inlet capacity in Melbourne Street and regrade footpath	$20,000
9	(b)	Kerb and gutter and additional inlet pits in Webb Street	$20,000
9	(c)	Small GPT (Type A) at outlet to Caroline Bay	$10,000*
9	(d)	Formalise overland flowpath downstream of Melbourne Street	n.a.*
10	(a)	Construct overland flowpath from Pit No 10.2 to Erina Creek via Pit No 11.1	$70,000
10	(c)	Reconstruct Pit No 10.2 to minimise headlosses	$15,000
10	(d)	Small GPT (Type A) at outlet to Erina Creek	$20,000
11	(a)	Formalise overland flowpath downstream of Brougham Street	n.a.*
12	(c)	Formalise overland flowpath downstream of Brougham Street	n.a.*

LINE	ITEM	IMPROVEMENT OPTIONS	CAPITAL COSTS
13	(a)	Reconstruct Pit No 13.12 to minimise pit losses	$3,000*
13	(c)	Coarse trash rack (Type D) upstream of Pit No 13.6	$2,000*
13	(f)	Provide flood wall along northern boundary of No 25 Waratah Street	$30,000
13	(g)	Construct overland flowpath from Pit 13.2 to Erina Creek	$200,000
13	(h)	Additional inlet capacity adjacent to Pit No 13.2	$5,000*
13	(i)	Small GPT (Type A) at outlet into Erina Creek	$20,000
13	(j)	Coarse trash rack (Type D) upstream of Pit No 13.18	$2,000*
13	(k)	Formalise overland flowpath downstream of Finley Ave	n.a.*
18	(a)	Formalise overland flowpath downstream of Lock Avenue	n.a.*
18	(c)	Provide coarse trash rack (Type D) at headwall No 18.2	$2,000*
18	(d)	Provide additional inlet capacity at Pit 18.1	$8,000*
18	(e)	Provide additional inlet capacity in Tangerine Street	$2,000*
20	(a)	Pipe open channel downstream of Pit 20.2 with 1050mm diameter pipe.	$280,000
22	(a)	Formalise overland flowpath downstream of Green Plateau Road	n.a.*
23	(e)	Create overland flowpath from Pit no 23.1a through to Erina Creek	$90,000
23	(f)	Small GPT (Type A) at pipe outlet to Erina Creek.	$15,000
23	(g)	Formalise overland flowpath downstream of Wells Street	n.a.*
26	(b)	Formalise overland flowpath downstream of Morella Close	n.a.*
27	(a)	Small GPT (Type C) adjacent to Pit No 27.2	$5,000*
27	(b)	Formalise overland flowpath downstream of Minton Street	n.a.*
28	(a)	Construct detention basin in the open space area adjacent to the Council depot off Emma James Drive.	$120,000
28	(c)	Formalise overland flowpath downstream of Emma James Drive	n.a.*
29	(a)	Maintenance of blocked drainage system	n.a.*
29	(b)	Lower eastern berm of Wells Street at low points	$10,000*
		Cost Of Minor Drainage Improvement Works*	$73,000
		Cost Of Major Drainage Improvement Works	$950,000
		TOTAL COST	$1,023,000

NOTE:
1. Further details of the items listed above are given in Section 5 of the report. The items shown above are those with a "high" priority in Section 5.
2. Items marked with an asterisk have capital costs of $10000 or less, and are referred to as "Minor Drainage Improvement Works".
3. Many of the items marked "n.a." or "not applicable", have no capital cost. However items may involve significant on-going costs for Council (eg. additional staff).

2.6.5. Worthing Road Creek, Updating of February 1991 Trunk Drainage Strategy

This report (Ref 12) completed in 1993 updated a prior 1991 study and included a re-survey of cross sections and derivation of updated design flood levels. A review of management measures was undertaken and the following key recommendations determined:

- undertake creek improvement works, including excavation of the creek channel and overbank area in the vicinity of 17 Flakeler Crescent in order to reduce inundation of this property in the 1% AEP event. A design for these works was prepared in 2001 and the 1% AEP design flood extents for pre and post works are shown on Figure 2, **of Ref 12**
- increase the height of the eastern side of the embankment of the Worthing Road retarding basin by 0.5 m. This will ensure an adequate freeboard in the 1% AEP flood event to account for wind and wave action,
- address possible safety concerns with the small dam located near the upstream end of the Department of Housing land,
- prepare a Creek Maintenance Plan and undertake periodic inspections of the creek, hydraulic structures and the immediate surrounds as part of an on-going maintenance program,
- following each future major flood undertake a data collection exercise and review of design flood levels.

2.6.6. Plan of Management, Emma James Detention Basin, East Gosford

This study (Ref 13) was completed in 2011 and set out the design and operational parameters for the detention facilities. The basin was intended to minimise downstream flooding and provide some water quality benefit. However no detailed analysis of the benefit in terms of reducing flood levels on downstream properties was undertaken.

3. STUDY AREA

3.1. History of Flooding

Historical records dating back to the 1970's show that water levels in Erina Creek have periodically risen in response to heavy rainfall over the catchment as well as elevated water levels in Brisbane Water. This has often resulted in the flooding of land and occasionally of building floors. All known significant floods since the 1970's are:

- March 1977;
- January 1978;
- February 1981;
- November 1984;
- October 1985;
- April 1988;
- January 1989;
- 4th and 7th February 1990;
- February 1992; and
- 8th June 2007.

The records show that the highest flood levels probably occurred in the January 1978 event. The event of 7th February 1990 is thought to be the second highest. Accurate recording of peak flood levels is only possible with records from an automatic water level recorder. Prior to the 1970's flooding will have occurred in Erina Creek but the lack of records means that the magnitude of these floods cannot be determined. It is only with continued urban growth and encroachments onto the floodplain since the 1970's that flooding has become a significant issue in the catchment.

Most mainstream flooding problems in the catchment have been caused by inappropriate development in areas of the floodplain which should have been set aside and recognised as floodways. However at the time of approval of the development the impacts of flooding were not recognised and the technology was not available to determine design flood levels or assess the consequences of development on the floodplain. This issue can be found in every town and city in NSW and is the reason that NSW has undertaken floodplain management as described in the Floodplain Development Manual (Ref 5).

3.2. Flood Modelling Approach

3.2.1. Approach for Determining Design Flood Levels

The 2012 Erina Creek Flood Study Review (Ref 1) determined flood levels for the creeks shown on Figure 1 for a range of design flood events. The approach and level of accuracy has varied across the catchment and a brief summary of this is as follows.

Two TUFLOW models; Upper Erina Creek and Lower Erina Creek, were established. In the Lower Erina Creek model, the downstream end is located at the confluence of Erina Creek with Brisbane Water, while the upstream boundary is located mid way through the catchment corresponding to approximately the model extent used in the Erina Creek Flood Study Review 1990 (Ref 2). In the

Upper Erina Creek model, the model extends from the upstream boundary of the Lower Erina Creek model and covers the remaining extent of the "defined" floodplain (i.e the major creeks as shown on Figure 1).

For the Upper Erina Creek model a 2D domain was used throughout to represent the topography of the catchment, whereas the Lower Erina Creek model included both 1D and 2D domains. The small and undefined tributaries in the Upper Erina Creek model were not represented hydraulically due to limitations with the ALS data over highly vegetated areas. These tributaries were represented in the Direct Rainfall Method (DRM) TUFLOW hydraulic model. DRM is a hydraulic modelling approach that divides the catchment into a grid (3 m by 3 m was used in this instance) and assumes the rain falls directly on the grid. Runoff then occurs from one grid cell to the next lower cell. This approach is relatively fast to setup but on the upper catchment is not considered reliable enough for providing design flood levels or extents but used only as a guide to whether part of the property was flood liable or not.

Within the Lower Erina Creek 2D model domain the topography was defined using a regular grid of 3 m x 3 m cells. This resolution was needed to properly define significant localised ground details and other features expected to function as hydraulic controls. Culverts and pipes with a diameter of 600 mm or greater and located within a flowpath were modelled in 1D. Culverts with diameters smaller than 600 mm and/or not located within a flowpath were not included since they convey insignificant flows during large events and are often blocked by debris in such events anyway. Inflows were included from the major tributaries to the main creek and at several locations downstream to represent flows from local catchments. Building footprints were obtained from aerial photography and site inspection and modelled as impervious flow barriers where it was considered that this level of model detail was required. The majority of these buildings are in the Erina Industrial Area adjoining Barralong Road where any flow across the area will generally be confined to the road network.

The downstream boundary conditions for the hydraulic model were the water levels at Brisbane Water. For each calibration and verification event, the water level time series used was obtained from the Brisbane Water gauge. For design runs, the water level was assumed to be static at 0.74 mAHD which corresponds to the 1% Probability of Exceedance level – this level is not equivalent to the 1% AEP flood level in Brisbane Water and indicates the water level that is equalled or exceeded 1% of the time. A static tide was adopted as a varying tide introduces issues with the timing of the peak water level and the peak flow from Erina Creek. This approach assumes the design rainfall over Erina Creek occurs when Brisbane Water is not in flood. This is to be expected as a design rainfall event over Erina Creek would not cause any significant elevation of Brisbane Water and it is unrealistic to expect that a rainfall event producing flooding on Brisbane Water (say 2 days of rain) would also include a much shorter (9 hour) rainfall intensity of the same design magnitude over Erina Creek.

An envelope approach of the combination of the peak design levels from rainfall runoff and design Brisbane Water level was adopted which means that the higher of the two mechanisms was adopted as the design flood level. Thus at the Punt Bridge the design level is the Brisbane Water level but at some point upstream, and the point changes with the design event, the rainfall runoff level is greater.

This issue of joint probability of the two mechanisms should be investigated further when sufficient data is available. It should be noted that Brisbane Water is a wave dominated estuary and is flooded by storm surge / ocean inundation rather than catchment flooding. However the current approach is considered reasonable and consistent with current best practice.

3.2.2. Year 2013 Design Flood Levels

One of the key considerations in modelling river systems that enter estuaries close to the ocean is the probability of occurrence of a combined ocean and rainfall event and the relative magnitude of both. It is considered to be overly conservative to assume a 1% AEP ocean event will occur concurrently with a 1% AEP rainfall event, however there are no data available to accurately define a suitable approach. For this reason, two scenarios were analysed: a **Rainfall Dominated** scenario which assumes the design rainfall over the catchment in conjunction with a Brisbane Water level of 0.74 mAHD and an **Ocean Dominated** scenario which assumes the design Brisbane Water event.

As part of the updating of the 2012 Erina Creek Flood Study Review (Ref 1) the coincidence of the two events (ocean and rainfall) was considered and the following conditions were adopted:

- the design rainfall events occurred in conjunction with a constant water level of 0.74 mAHD in Brisbane Water which corresponds to the level in Brisbane Water that is equalled or exceeded 1% of the time;
- nine hour critical rainfall storm duration inflows for all design events in the lower part of the catchment, except the PMF, in conjunction with the 0.74 mAHD level in Brisbane Water; and
- design water levels in Brisbane Water (see Table 5) were taken from the 2009 Brisbane Water Foreshore Flood Study (Ref 14).

Table 5: Brisbane Water Design Flood Levels at the mouth of Erina Creek

AEP	Peak Water Level (mAHD)
20%	1.35
10%	1.42
5%	1.50
2%	1.59
1%	1.67
0.5%	1.75
PMF	2.08

An envelope approach was adopted which assumed the maximum of the Brisbane Water design event and the corresponding design rainfall event over the catchment. The results indicated that generally downstream of Avoca Drive (Figure 1), the Brisbane Water design event is dominant producing the higher flood levels while upstream of Avoca Drive, the catchment rainfall event produces the higher flood levels. However, the exact location of the change between the dominant flood mechanism varies for each of the design flood events.

The main reason that the levels in the 2012 Erina Creek Flood Study Review (Ref 1) have changed from those in the Erina Creek Flood Study Review 1990 (Ref 2) are:

- changed assumptions on initial losses for historical events (particularly 7th February 1990);
- use of a different hydraulic model (2 Dimensional rather than 1 Dimensional). For example the 2D model is able to more accurately incorporate the funnelling effect under the Barralong Road bridge and provide a more accurate assessment of temporary floodplain storage;
- the inclusion of ALS survey data has meant more accurate definition of the floodplain;
- re-assessment of flow through the twin culverts under the Entrance Road (Central Coast Highway) from Worthing Road Creek; and
- different modelling assumptions, particularly the inclusion of blockage in culverts.

In summary the results from the present 2012 Erina Creek Flood Study Review (Ref 1) incorporates current best practice in design flood estimation but it is acknowledged that changes in the future will cause changes to design flood levels, for example, the collection of rainfall data which forms the basis of design flood estimation. As additional rainfall data is collected and analysed the Bureau of Meteorology will be providing new estimates of design rainfalls and design temporal patterns over NSW. An updated Australian Rainfall and Runoff or similar guideline documents will also introduce new approaches which may change design flood levels.

Analysis of recorded peak heights from future major flood events may also cause a re-evaluation of design flood events in the future.

3.2.3. Gosford Council's Sea Level Rise Policy

Council in August 2013 adopted climate change scenarios for Gosford which endorsed the HCCREMS regional projections as shown in Table 6.

Table 6: HCCREMS Climate Change Scenarios

Table 1: Climate Change Scenarios for Gosford (HCCREMS, 2010 -Sourced from: Blackmore & Goodwin, 2009, 2010; CSIRO, 2007; Macadam, McInnes and O'Grady, 2007; CSIRO, 2007b)

Climate Variable	Current[1] (indicative)	Indicative change[2] (relative to current)		Comments
		2050	2100	
1. Sea level rise and storm surge				
Sea level		↑ 0.4m	↑ 0.9m	Latest projections indicate SLR of up to 1.4m by 2100
Storm tide – max height, 1:100 ARI (average recurrence interval)	1.4m	1.8m	2.3m	Based on NSW design still water levels - excludes wave setup
Storm tide – ARI (1.4 m)	1:100	1:1	na	Limited regional modelling of recurrence intervals has been undertaken to date
2. Extreme rainfall, flooding and storms				
24 hr rainfall intensity (max)	250mm	↑ up to 20%	↑↑	Based on NSW models - Hunter region not well represented. Greatest intensity increases likely in Summer
Extreme rainfall frequency (95th %ile)		↑	↑↑	Increases in Summer and Autumn, decrease in Winter.
Flooding - Average recurrence intervals (ARI)		↓ flash	↓↓ flash	Specific projections not available
		↓ riverine	↓↓ riverine	

The NSW Government's benchmarks in the 2010 Flood Risk Management Guide (Ref 6) for sea

level rise by the year 2050 (+0.4 m) and the year 2100 (+0.9 m) were adopted and included in the hydraulic modelling (see Section 2.6.1). Climate change may also increase the ocean storm surge and wave setup components incorporated in establishing the design ocean levels adopted in the 2009 Brisbane Water Foreshore Flood Study (Ref 14). These issues have been investigated in that study.

Design flood levels for the year 2050 and year 2100 have been modelled in the current 2012 Erina Creek Flood Study Review (Ref 1) with the results summarised in Table 17. As noted in Section 2.6.1 Gosford City Council adopted new sea level rise bench marks in their meeting of 10th March 2015. In general these were a rise of 0.2m by the year 2050 and by 0.74m by the year 2100 and these have also been included in Table 17.

In addition, the 2012 Erina Creek Flood Study Review (Ref 1) undertook an assessment of a 10%, 20% and 30% potential climate change increase in design rainfall intensities. However no increase in rainfall intensity has been included in the projections for 2050 and 2100 at this time as there is no certainty that such an increase will occur. The Bureau of Meteorology is undertaking on-going research in this field and once definitive advice is provided this should be considered with a view to amending the year 2050 and year 2100 design flood levels either upwards or downwards. The results from the 2012 Erina Creek Flood Study Review (Ref 1) indicate that a 10% increase in rainfall would raise the 1% AEP event flood levels by up to approximately 0.2 m although this varies across the catchment. The Bureau of Meteorology also completed a review of the design rainfall intensities in 2013 and when incorporated in design flood estimation techniques this may change design flood levels in the catchment and throughout NSW.

The 0.5 m freeboard above the 1% AEP design flood level that is used to establish the minimum floor level of a residential building (see Section 6.4.9) caters for uncertainty in design flood estimation, wind and wave action and local hydraulic effects. The effect of sea level rise cannot be included within this freeboard as it has been established with a reasonable degree of certainty that it will occur (2010 Flood Risk Management Guide - Ref 6).

3.3. Works Undertaken in the Catchment that have Affected the Flood Regime

Human activities have had a significant effect on the flood regime in the catchment. These affects can be broadly categorised into two types, those that increase the quantity of runoff entering the floodplain areas and those that affect the hydraulics of the floodplain. The type of land use can also have implications on the flood behaviour. Pre LEP 2014 land use zones are shown in Figure 2.

Works such as land clearing have increased the rate and quantity of runoff and thus increased peak flows downstream. Similarly, urban development will have increased the amount of impervious area and produced a similar impact. These activities have been occurring since the time of European settlement, however it is probably only in the last 50 years that the quantity of the activities has been such that it has been of significance. Unfortunately there is no accurate means of assessing these impacts, though technical papers provide a general indication.

No large land clearing has occurred since the early 1990's but major urban growth areas have

occurred adjacent to Terrigal Drive and Karalta Road which drain into Worthing Road Creek. However some compensation measures such as the retarding basin in the lands of the Tarragal Glen Retirement Village have been designed to mitigate the peak flow increases and will also provide some water quality benefit.

All works on the floodplain such as filling, stream clearing, re-vegetation, road works and other works which may alter ground levels or restrict flows, will have affected the hydraulics of the floodplain. These impacts can generally be evaluated with the use of hydraulic models. Since completion of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C), Gosford City Council has ensured that all major works on the floodplain require a flood study to evaluate the potential hydraulic impacts. Considerable minor works are continually being undertaken and the following provides a description of the major works known to have occurred since the early 1990's.

3.3.1. Barralong Road Levee

Following on from the Erina Creek Flood Study Review 1990, the Erina Creek Floodplain Management Study and Plan were completed in 1991 (Refs 3 and 4). One of the recommendations was construction of the Barralong Road levee system. The earthen and concrete wall levee was completed in the late 1990's and protects the majority of the urban areas near Barralong Road, Winani Road, Bonnal Road and Aston Road (refer to Photo 3). A bridge was also constructed across Erina Creek connecting Barralong Road to Wells Street.

The 1991 Erina Creek Floodplain Management Study (Ref 3) indicated that the 1% AEP flood levels would be increased by approximately 0.1m due to its construction. Four houses upstream of the Central Coast Highway in the Worthing Road Creek catchment were purchased as part of the works so that the owners would not be affected by increased flood levels as a result of the works.

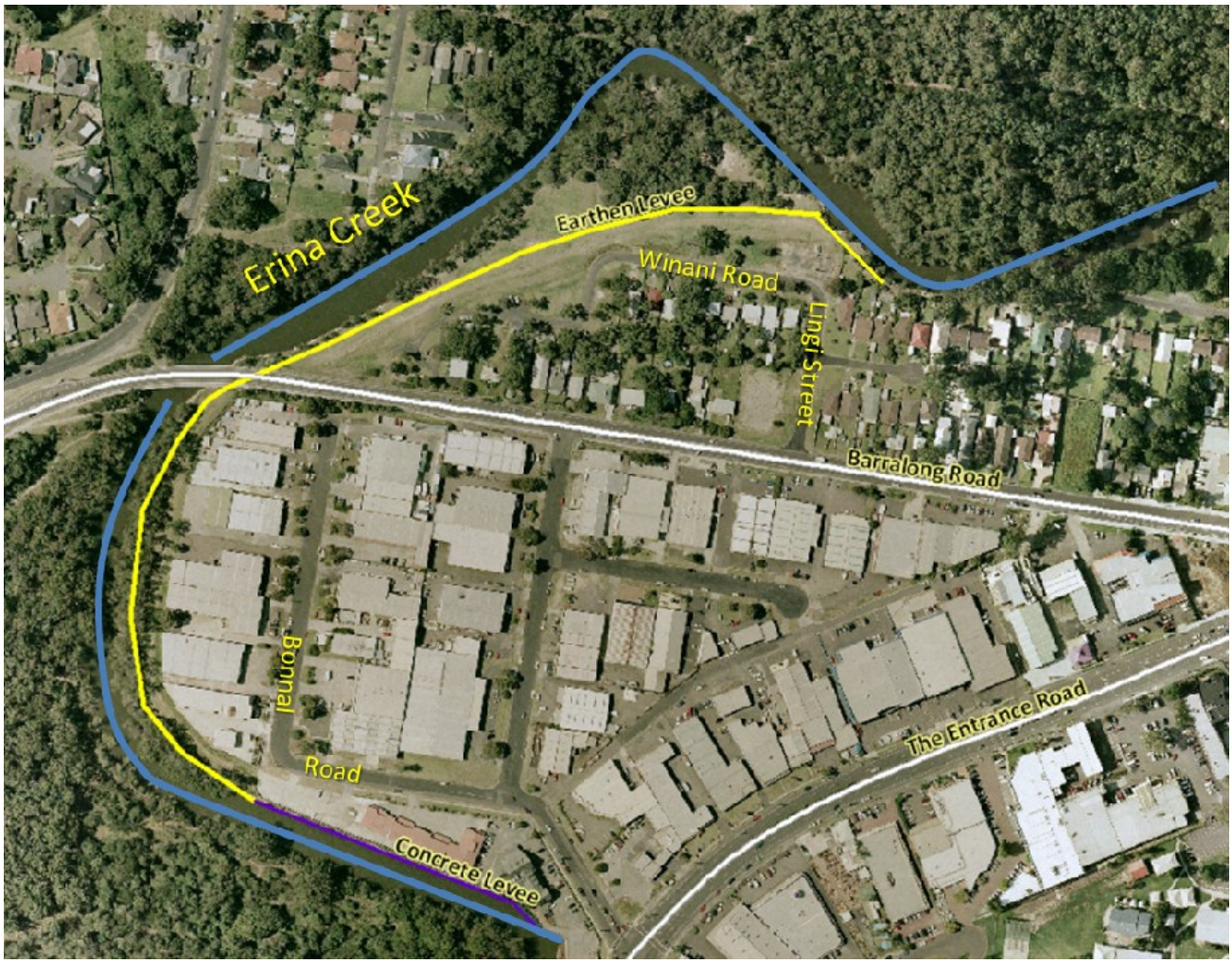


Photo 3: Earthen and concrete levees close to Barralong Road

3.3.2. Works Upstream of Terrigal Drive

Significant urban development has occurred in this southern tributary of the Worthing Road Creek catchment (refer to Photo 4) including;

- Erina Fair;
- Tarragal Glen retirement village;
- residential developments; and
- landscaping of the creek.



Photo 4: Urban development in the vicinity of Worthing Road Creek

Hydrologic studies were undertaken prior to the construction of these works to ensure that any increases in peak flows were mitigated through construction of a retarding basin near the retirement village.

3.3.3. Redevelopment along Nunns Creek

Nunns Creek enters Erina Creek under the Central Coast Highway immediately downstream of Karalta Road. Extensive residential, commercial and tourist developments (refer Photo 5) have occurred along this tributary since the 1990's. Flood studies have also been undertaken to assess the possible impacts upon downstream developments and where required mitigation works have been constructed.



Photo 5: Re-development along Nunns Creek

3.3.4. Re-development along the Central Coast Highway

The northern side of the Central Coast Highway (refer to Photo 6) is occupied by large commercial and light industrial sites. There has been pressure to build out into the floodplain of Erina Creek but this has been limited to a Development Line established in the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) (see Photo 6).

Addendum No. 3 to the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) provided a similar Development Line for the properties to the immediate west of those shown in Photo 6 and is shown as Photo 7.

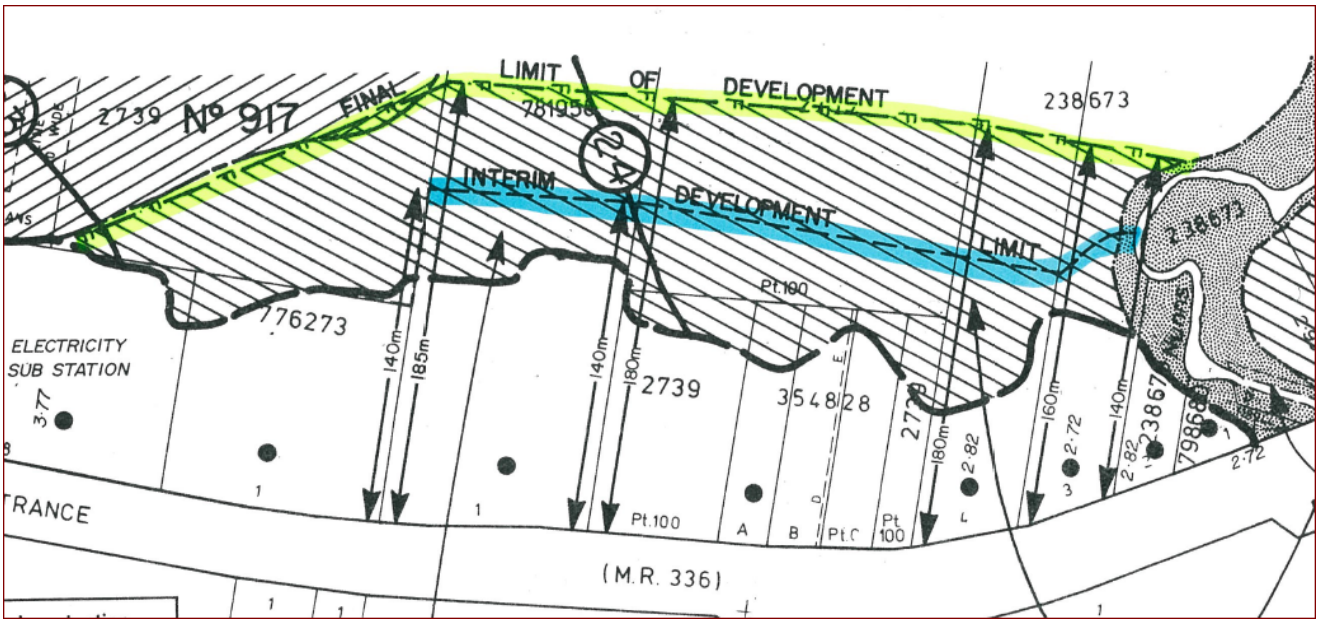


Photo 6: Development Lines established in the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C)



Photo 7: Development Lines established in Addendum 3 of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C)

3.3.5. Other Major Works on the Floodplain

Upgrading works on the Central Coast Highway (refer Photo 8) by the Roads and Maritime Services (RMS) involved addressing the potential flood impacts. As a result mitigation measures have been incorporated in the design for events up to the 1% AEP flood. However in a flood that overtops the road, thus larger than the 1% AEP, the concrete safety barriers that were installed could prevent the overflow of floodwaters. For events that just overtop the road the barriers will restrict floodwaters from entering Erina Creek on the western side of the Central Coast Highway. However in much larger events, such as the PMF, it is possible that the barriers may fail or divert floodwaters. The precise consequences of events larger than the 1% AEP have not been accurately assessed as part of this study as this would require a detailed review of the structural integrity of the barriers and is outside the scope of this study. This is an example where consideration of floods greater than the 1% AEP is required to ensure that the proposed works are compatible with the flood hazard and if not are modified accordingly.

The RMS should be made aware of the possible implications to flood levels by their road works in events greater than the 1% AEP and be requested to minimise potential and existing impacts that have or could be created by their road works.

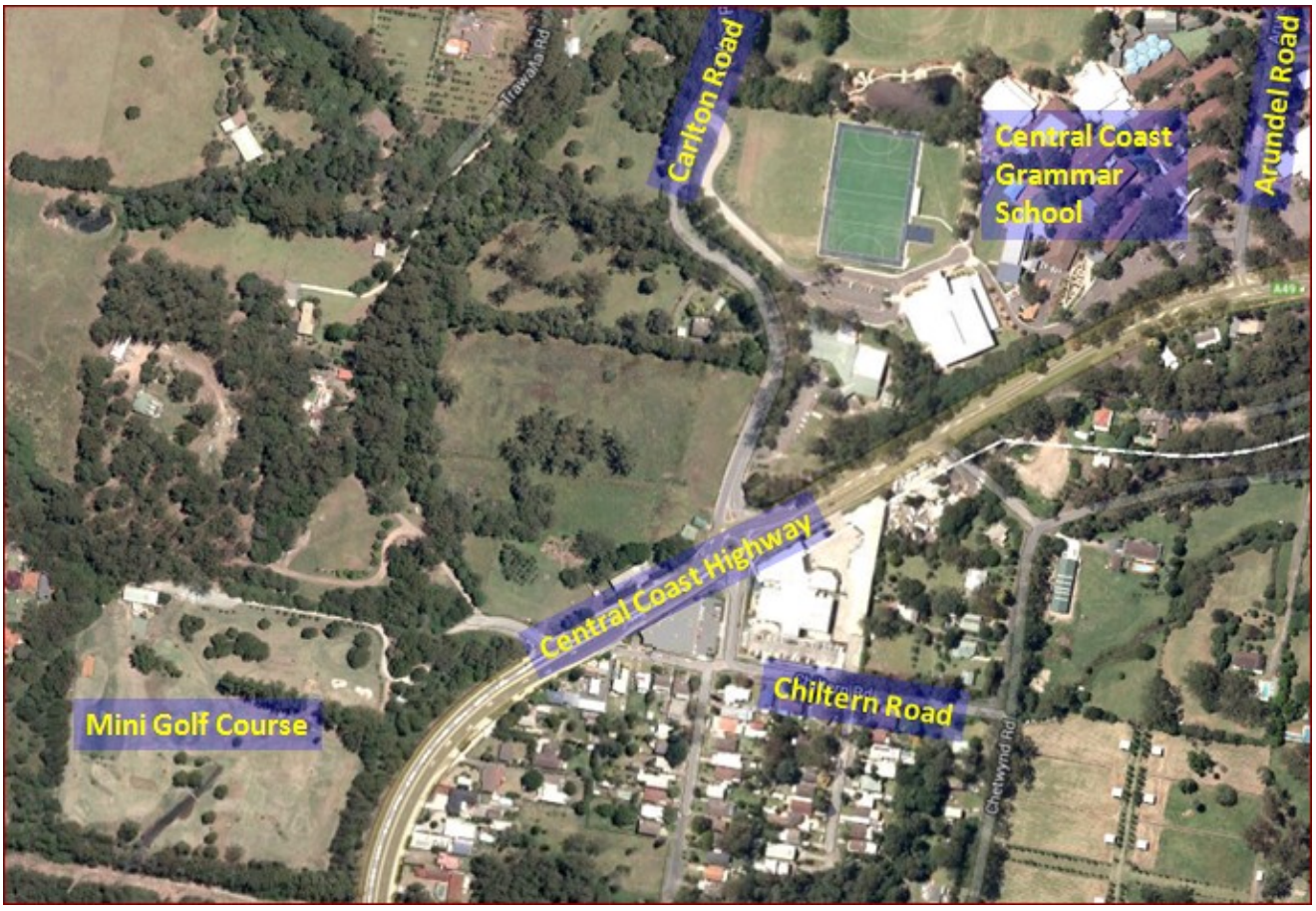


Photo 8: Significant Works on the Floodplain Since 1991

The Central Coast Grammar School grounds off Arundel Road (refer Photo 8) have also been modified, however no detailed survey is available to quantify the impacts on flood levels. Development of the school playing fields ensures that an appropriate use is made of the floodplain

and also means that the land is not available for other forms of less flood compatible usage. Continued use of the floodplain for this purpose should be supported as long as the works do not increase flood levels or adversely affect surrounding floodplain users.

A mini golf course has been constructed on the floodplain immediately north of Erina Creek at Karwin Avenue (refer Photo 8). These works are generally of a nature that will have minimal effect on flood levels however it appears that the access road may have been raised and this may have produced a localised effect on flood levels upstream of this location. In the absence of a detailed pre works survey it is not possible to accurately define the true impact (if any) of the works.

For the modelling of the historical events in the 2012 Erina Creek Flood Study Review (Ref 1) the models represented the catchment at the time of the flood event rather than as the catchment is today. For the design events, all major works on the floodplain, as described above and in the following sections, have been incorporated in the hydrologic/hydraulic modelling process as part of the 2012 Erina Creek Flood Study Review (Ref 1) as far as is possible. However, as there was no detailed survey of the floodplain undertaken prior to the 2012 Erina Creek Flood Study Review (Ref 1), it is impossible to accurately define the floodplain and catchment at the time of the historical flood events. For example, minor changes within the catchment such as changes in the density of vegetation or fences in the floodplain can affect localised flood conditions.

The modelling process, whilst the most up to date that is available, is limited in its ability to accurately represent small scale or subtle changes to the catchment.

3.4. Building Floors

A floor level database was prepared as part of this present study based on the floor levels surveyed for the 1991 Erina Creek Floodplain Management Study (Ref 3) and three additional field surveys undertaken as part of the present study in 2010, 2013 and 2014. It should be noted that the amount of data collected for each property has varied with the last two surveys providing the most comprehensive data. The floors surveyed are summarised in Table 7 and were identified as buildings on land inundated up to the PMF event as defined in the Erina Creek Flood Study (Ref 1).

Table 7: Floor Level Survey

Survey Date	Surveyed Residential Buildings	Surveyed Industrial / Commercial Buildings	Total Surveyed
1991	78	51	129
2010	4	16	20
2013	177	8	185
2014	470	0	470
TOTAL	**729**	**75**	**804**

Since the survey in 1991 some properties have been demolished and the sites cleared, such as those purchased for the Barralong Road levee. Other properties have been demolished and rebuilt meaning floor levels and indicative ground level data surveyed in 1991 and in parts are not correct. Where it is known that properties have been demolished these were removed from the floor level

data base. For the industrial area protected by the Barralong Road levee (Area E3) most properties were included in the 1991 survey. Significant redevelopment has occurred since the survey including raising of floor and yard levels.

The 2014 survey included many buildings that were surveyed in previous studies with the result that the floor level database used in this study includes only 650 relevant properties for inclusion in the database out of the 804 that had been surveyed.

The floor level survey was used in establishing potential flood damages (see Section 4.5).

3.5. Floodplain Management Areas

The previous 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) established eleven Management Areas based on areas of similar flood behaviour characteristics (see Section 2.6.2). However, for the purposes of this investigation, the study area was subdivided into ten Management Areas as shown in Figure 3 based on catchment boundaries to be consistent with Council's requirements. Table 8 describes each of the ten Floodplain Management Areas while Table 10 shows the number and type of buildings in each area which were included in the floor level survey. Table 9, showing the same information for the 1991 floodplain management areas has been included for comparison.

Table 8: Floodplain Management Areas

Name	Number	Description
Upper Erina Creek	C2/A	Rural small holdings
Oak Road	C2/B	Rural small holdings
Fires Road	C2/C	Rural small holdings
Milina Road	C2/D	Mainly rural small holdings but also includes the Campus of the Central Coast Grammar School off Arundel Road
Erina Valley Road Creek	C2/E	Rural small holdings in the upper parts with residential in the lower parts
Worthing Road Creek	C2/F	Has been extensively redeveloped in the last 20 years and is occupied by residential developments and the Tarragal Glen Retirement Village
Barralong Road	C2/G	Contains residential, commercial and light industrial areas. The key features are the Barralong Road levee and bridge completed since 1991.
Nunns Creek	C2/H	Extensive development in the last 20 years with van parks in the upper catchment and open space and commercial developments in the lower parts. In 2013 there is an application to redevelop the sports fields on the north side. On the south side of the creek adjacent to The Entrance Road (Central Coast Highway) there are several large commercial developments.
Springfield	C2/I	Largely urban areas with a few rural small holdings on the floodplain.
East Gosford	C2/J	Entirely residential with sports fields and open space on the floodplain.

Table 9: Surveyed Buildings within the 1991 Study Floodplain Management Areas

1991 Area	Total Surveyed	Surveyed Residential	Surveyed Industrial / Commercial
E1	2	0	2
E2	18	3	15
E3	43	0	43
E4	60	59	1
E5	5	5	0
E6	22	22	0
E7	24	23	1
E8	8	8	0
E9	30	30	0
Other Areas	435	389	46
TOTAL	**647**	**539**	**108**

Note: The above table is based on the database of surveyed floor levels of buildings.

Table 10: Surveyed Buildings within the current study Floodplain Management Areas

Current Areas	Total Surveyed	Surveyed Residential	Surveyed Industrial / Commercial
C2/A	20	20	0
C2/B	6	6	0
C2/C	7	7	0
C2/D	28	27	1
C2/E	79	76	3
C2/F	55	52	3
C2/G	206	132	74
C2/H	40	15	25
C2/I	58	56	2
C2/J	148	148	0
TOTAL	**647**	**539**	**108**

Note: The above table is based on the database of surveyed floor levels of buildings.

Table 9 and Table 10 indicates that the majority of residential, commercial and industrial buildings are in the Barralong Road, Erina Valley Road and Worthing Road Creek areas. The Barralong Road catchment (C2/G) has the most surveyed properties. Commercial properties are mainly found in Barralong Road (C2/G) and Nunns Creek (C2/H) areas. Few surveyed properties are found in the upper catchments of C2/A,B&C.

4. EXISTING FLOOD ENVIRONMENT

4.1. Flood Behaviour

Flooding in Erina Creek may occur as a result of a combination of factors including:

- an elevated ocean level due to an ocean storm surge, wave setup at the entrance to Erina Creek, a high astronomic tide and or an increase in mean sea levels;
- rainfall over Brisbane Water, the Erina Creek catchment and its tributaries;
- wind wave action causing wind setup and runup on the foreshore near the entrance to Brisbane Water; and/or
- permanent and tidal inundation as a result of rising sea levels.

One of the key considerations in modelling coastal systems is the probability of occurrence of a combined ocean (Brisbane Water) and rainfall event and the relative magnitude of both. Therefore results of a rainfall dominated and ocean dominated scenario were enveloped and the highest peak levels from each scenario used. Further details of this approach are provided in the 2012 Erina Creek Flood Study Review (Ref 1) and summarised in Section 3.2.

4.2. Hydraulic Classification

The 2005 NSW Government's Floodplain Development Manual (Ref 5) defines three hydraulic categories; floodway, flood storage or flood fringe.

> ***Floodways*** are *"those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels"*. Floodway areas have been defined according to a criteria based on the depth and velocity of floodwaters.
>
> ***Flood storage areas*** are "*those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.*".
>
> ***Flood fringe*** is *"the remaining area of flood prone land after floodway and flood storage areas have been defined"*.

There is no precise definition of floodway, flood storage, flood fringe or accepted approach to differentiate between these areas. The 2012 Erina Creek Flood Study Review (Ref 1) defined hydraulic categorisation for the 5% AEP, 1% AEP and PMF events. Floodway was defined based on a velocity and depth criteria:

$$\textit{Floodway} = \quad \textit{Velocity} * \textit{Depth} > 0.25\ m^2/s\ \textbf{AND}\ \textit{Velocity} > 0.25\ m/s \quad \textbf{OR}\ \textit{Velocity} > 1\ m/s$$

Justification for the use of this definition and further details are provided in the 2012 Erina Creek Flood Study Review (Ref 1).

The remainder of the floodplain outside the Floodway becomes either Flood Storage or Flood Fringe. Flood Storage was defined as the land outside the Floodway if the depth is greater than 0.5 m and Flood Fringe if the depth is less than 0.5 m. The 2005 NSW Government's Floodplain Development Manual (Ref 5) states *"it is impossible to provide explicitly quantitative criteria for defining floodways and flood storage areas, as the significance of such areas is site specific"*. The approach and resulting maps are provided in the 2012 Erina Creek Flood Study Review (Ref 1).

4.3. Flood Hazard Classification

Hazard is a measure of the overall harm caused by flooding and should consider a number of factors including depth of flooding, velocity of flood waters, access to escape routes, duration etc. In the first instance provisional hazard categories can be defined based on the depth and velocity of floodwaters. Provisional flood hazard categories were defined in the 2012 Erina Creek Flood Study Review (Ref 1) in accordance with the *Floodplain Development Manual - Figure L2* (Ref 5) as indicated in Photo 9 for the full range of design events.

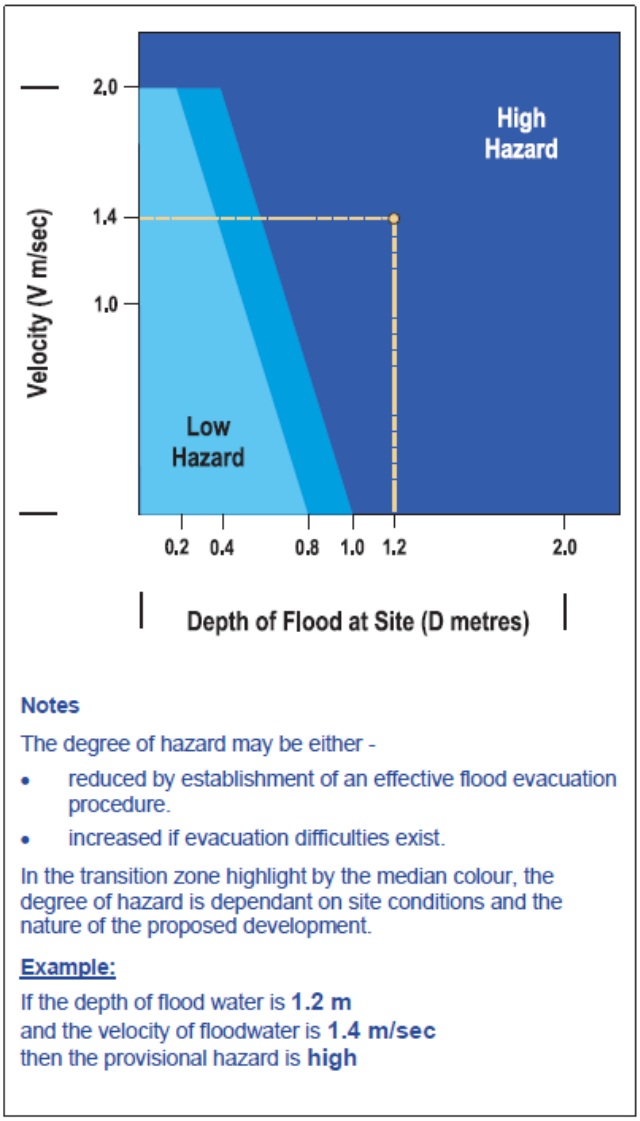


FIGURE L2 - Provisional Hydraulic Hazard Categories

Photo 9: Provisional Hydraulic Hazard Categorisation (2005 Floodplain Development Manual (Ref **5**))

The hazard classification is considered provisional because only the hydraulic aspects of flood hazard are considered. Using the hydraulic model results the hazard was calculated from the envelope of the occurrences of maximum velocity multiplied by depth results calculated for each time step. High and low provisional hazard areas were defined for the range of design flood events and provided in Appendix D of the 2012 Erina Creek Flood Study Review (Ref 1). The Floodplain Development Manual (Ref 5) requires that other factors be considered in determining the "true" hazard such as size of flood, effective warning time, flood readiness, rate of rise of floodwaters, depth and velocity of flood waters, duration of flooding, evacuation problems, effective flood access, type of development within the floodplain, complexity of the stream network and the inter-relationship between flows.

However, to assess the full flood hazard all adverse effects of flooding have to be considered. As well as considering the provisional (hydraulic) hazard it also incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production. As with provisional (hydraulic) hazard, land is classified as either *low* or *high*

hazard for a range of flood events.

An additional consideration is now required for areas that might become permanently inundated. While this is not a catastrophic event, it presents a high hazard to property and infrastructure over time. The classification is a qualitative assessment based on a number of factors as listed in Table 11.

Table 11: Hazard Classification

Criteria	Weight [1]	Comment
Size of the Flood	High	Up to approximately a 10% AEP event the damages are confined to isolated properties. In larger floods the damages are increased as more properties are inundated. Overtopping of the Barralong Road levee in the 1% AEP event and greater significantly increases the number of commercial and light industrial properties affected as well as general disruption to the community.
Flood Awareness of the Community	High	Whilst residents are aware that flooding along Erina Creek occurs and many will have experienced the relatively small June 2007 event the resulting extent of inundation and effect on the community in a 1% AEP event will be much greater than what is expected by the majority of the community. However the January 2011 floods in south east Queensland and in Victoria and NSW has heightened awareness of the general public to flooding issues although this diminishes over time.
Depth and Velocity of Floodwaters	Low	Shallow depths generally less than 0.5 m and low velocity means that the risk to life is not as great as in other flood liable communities.
Effective Warning and Evacuation Times	High	Probably less than 4 hours. There is only a very small likelihood that residents would be caught completely unaware but they are unlikely to have the foresight to react appropriately to the situation, particularly if the event happens during the night. Residents protected by the Barralong Road levee will probably think that even in a large flood it will never be overtopped which can have implications should they be asked to evacuate.
Evacuation Difficulties	Low to Medium	For the majority of residents evacuation should be relatively easy as there is nearby high ground for vehicles and the majority of goods can be saved by raising them 1 m off the ground within the building. However, the number of buildings/people requiring assistance will severely extend the usual requirement for services of the rescue services (SES, Police, etc.). Particularly as it is likely that associated issues (roofs blown off, strong winds, car crash etc.) mean that the emergency services will be stretched.
Rate of Rise of Floodwaters	Medium	The rate of rise of floodwaters is relatively rapid, particularly in the small tributary catchments. This may be an issue for Carlton Road or other roads that become inundated and access is cut.
Duration of Flooding	Low	The duration of inundation is relatively shorter than on a large river system. Permanent inundation is of indefinite duration and will be addressed in a future adaptation plan.
Effective Flood Access	Low to Medium	The vehicular and pedestrian access routes are all along sealed roads and present no unexpected hazards if the roads have been adequately maintained. SES boats can effectively be used to ferry residents to high ground. In events up to the 1% AEP event four wheel drive access (by the SES) is possible. The main problem will be congestion due to the number of vehicles due to evacuating residents.

Criteria	Weight [1]	Comment
Additional Concerns such as Bank Erosion, Debris, Wind Wave Action, Sewage overflows	Low	The impact of this factor will vary between events and even within a flood event. The impact of debris is unlikely to be a factor except in the most extreme cases where major floating objects come into contact with structures, buildings or residents. Erosion or sedimentation during a flood event is also unlikely to be a significant factor. Sewage overflows may occur and present a health hazard. Wind wave action is unlikely to be a significant issue except for the areas fronting Brisbane Water.
Provision of Services	Low	In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones. Services are usually restored relatively quickly (within 24 hours).

Note: [1] Relative weighting in assessing the hazard.

Based on the above assessment, the provisional flood hazard categorisations for Erina Creek as provided in the 2012 Erina Creek Flood Study Review (Ref 1) will not change to any significant extent. Generally no land within the high hazard areas can be reduced to low hazard as could really only occur if there were effective flood warning and evacuation procedures.

To manage the long term hazard from permanent inundation as sea levels rise, a new high Brisbane Water hazard or similar category is suggested, as management responses to deal with the hazards from permanent inundation will be somewhat different from those used to deal with flooding. This should be reviewed in a future adaptation plan. Further consideration of sea level rise is provided in Section 6.4.4.2.

These general hazard classifications will have to be reviewed against specific local conditions such as around critical infrastructure and services or high density or particularly vulnerable population centres such as schools or care homes for the elderly and/or where there is a risk of isolation and difficulties for evacuation.

In floods greater than the 1% AEP event the hazard will increase as the depth increases. In a PMF event the main areas of high hazard are generally the same as for the 1% AEP event and there are no significant areas that would suddenly become high hazard in the PMF as opposed to a gradual increase as the flood level rises.

4.4. Flood Risk and the Social Impacts of Flooding

Properties suffer damages from flooding in a number of ways. Direct damages include loss of property contents or damage to the structure of the property. Indirect damage costs can be incurred by property occupiers from having to move away from the property while repairs are being made. Flooding can also have significant impacts on critical infrastructure such as access routes, supplies of water, electricity, gas and sewerage services.

A damages assessment has been undertaken for the properties included in the floor level survey and is discussed in Section 4.5.

4.4.1. Inundation of Building Floors

The results of the hydraulic modelling in the 2012 Erina Creek Flood Study Review (Ref 1) and the floor level surveys which includes only building floors inundated up to the PMF were compared to identify the event in which the building on the property is first inundated above floor level. The results are presented in Figure 4 and in Table 12.

Table 12: Number of Buildings Inundated above Floor Level

Event	Residential	Commercial	Total
2-year ARI	11	7	18
5-year ARI	26	10	36
10% AEP	30	11	41
5% AEP	36	13	49
2% AEP	42	30	72
1% AEP	58	36	94
0.5% AEP	79	43	122
0.2% AEP	99	57	156
PMF	268	99	367

Note: only those properties included in the floor level survey are included within this table. Other properties, not included in the floor level survey may be subject to over floor inundation.

The suburb with the greatest number of houses inundated in the more frequent flood events is East Gosford (refer Figure 4) followed by Erina. There are only 8 houses with floors inundated in Springfield in the 1% AEP event.

A large number of properties in the Barralong Road area are protected from flooding up to slightly less than the 1% AEP event by the Barralong Road levee. When overtopping from the north occurs nine floors are inundated above floor level in the 1% AEP event. However, there is some flooding in these areas behind the levee as flows from Nunns Creek and other local drainage become trapped behind the levee as outfalls are restricted by high water levels in Erina Creek. This results in one building floor inundated in the 5% AEP event, with another 15 inundated above floor level in the 2% AEP event.

It is not feasible to solve the flood inundation to habitable floor levels for all properties with appropriate works. Only properties in the worst affected areas (i.e. in high hazard areas, in the floodway or in flood storage areas) have been addressed with suitable works. The remaining properties will be required to address individual issues upon redevelopment.

4.4.2. Impacts of Flooding on Residential Properties

Residential properties suffer damages from flooding in a number of ways. Direct damages include loss of property contents or damage to the structure of the property. Indirect damage costs can be incurred when occupant may have to move away from the property while repairs are being made or loss of work due to cleaning up afterwards.

A potential flood damages assessment has been undertaken and this, along with the impact of

flooding on residential properties, is considered in Section 4.5.

4.4.3. Impacts of Flooding on Commercial and Industrial Activities

The damages to a commercial or industrial property are much more variable than those of residential dwellings, as they are heavily influenced by the type of business being carried out and the amount and expense of stock on site. A number of commercial and industrial properties in the study area have the potential to be affected by flooding, either directly by flood damage or indirectly by loss of business. A major component of indirect flood losses to the commercial and industrial sector is the loss of production and trade and a key area of concern is the developments within Area E3 protected by the Barralong Road levee which will be subject to flooding in a levee failure or overtopping event as well as those in Area E2.

The duration of flooding and flood depths can affect businesses differently. For example shorter duration flooding of just several hours may allow businesses to re-open to trade again. However, if the short duration flooding is deep and causes property and stock damage then it may take some time for businesses to re-open. On the other hand businesses may still be able to operate through shallow long duration flooding of several days. Some businesses may also be able to operate temporarily from a different location, albeit often at a reduced capacity, such as office type businesses. Whether the staff are able to get to work or have had home flooding issues also plays a part in recovery for commercial practices. The type of business also plays a major part in the impacts of flooding, for example a high quality goods electrical store may suffer more damages in terms of loss of physical stock compared to an office.

Loss of business confidence can also affect commercial activities which have been closed due to flooding. Whilst the business has closed customers have moved their business elsewhere and do not return, although this can be more of an issue for larger urban areas where there may be more competition between businesses and also in instances where businesses may be closed for a substantial amount of time and this is unlikely to be an issue in the Erina Creek area.

Where sufficient warning is available businesses may be able to move stock and assets to higher levels to prevent flood damages although depending on the type of commercial or industrial activity this may not always be possible. The relatively small size of the catchment means there is little or no warning time to move stock and assets.

As re-development occurs measures to mitigate the impacts of flooding can be incorporated into building design encouraged through planning controls, for example flood proofing (as discussed in Section 6.4.2) which can slowly reduce impacts over time.

4.4.4. Impacts of Flooding on Public Infrastructure

Public sector infrastructure damages include; recreational/tourist facilities; water and sewerage supply; gas supply; telephone supply; electricity supply including transmission poles/lines, sub-stations and underground cables; roads and bridges including traffic lights/signs. Public sector damages can contribute a significant proportion to total flood costs but are difficult to accurately calculate or predict. Fixed infrastructure such as roads and sewer are particularly vulnerable to permanent inundation as sea levels rise although this is not considered to be a major issue for the

study area.

Costs to local government authorities from flooding typically comprise;

- clean-up costs;
- erosion and siltation in creeks;
- removing fallen trees;
- inundation of council works depot or other buildings;
- direct damage to roads, bridges and culverts;
- removing vehicles washed away;
- assistance to ratepayers with clean up and advice;
- increases in insurance premiums;
- closures of streets; and
- loss of working life of road pavements.

Appendix B details when road crossings are affected by flooding. There are a number of crossings which would be flooded in small events and this can have significant implications for evacuation and emergency response. Unfortunately it is not possible to provide the time taken from the start of rainfall until the road is cut as this varies between events. In some storms the peak rainfall occurs early, such as in June 2007 whilst in others it occurs after a couple of days of rain, as occurred in February 1990. In summary the time is likely to be less than an hour from the rain falling in the upper catchment.

4.4.5. Impacts of Flooding on the Environment

Flooding is a natural phenomenon that has been a critical element in the formation of the present topography of Erina Creek, thus erosion, sedimentation and other results from flooding should be viewed as part of the natural ecosystem. It is only when these effects impact on man-made elements that they are of concern, and similarly, when development impacts or exacerbates these natural processes.

However, as natural areas become permanently inundated by rising sea levels, and tidal and flood regimes change, ecosystems will be affected by the changes to hydrology. Foreshore ecosystems such as mangroves, saltmarsh, and wetlands may be inundated, or suffer from changes in salinity, groundwater, and tidal inundation.

Assessment of the environmental impact of property protection and flood modification measures needs to consider changes in baseline environmental conditions, such as permanent inundation of tidal saltmarsh. For example, protection works such as levees could affect ecosystems such as saltmarsh, and/or block off possible areas for ecosystem retreat. Filling and changes to local drainage patterns could also affect ecosystems dependent on a particular hydraulic pattern of wetting and drying. This may be relevant downstream of the Barralong Road levee area.

Strategic planning for areas affected by permanent inundation and increased flooding should include consideration of ecosystem adaptation and retreat, particularly for tidal saltmarsh, and coastal wetlands.

4.5. Assessment of Flood Damages

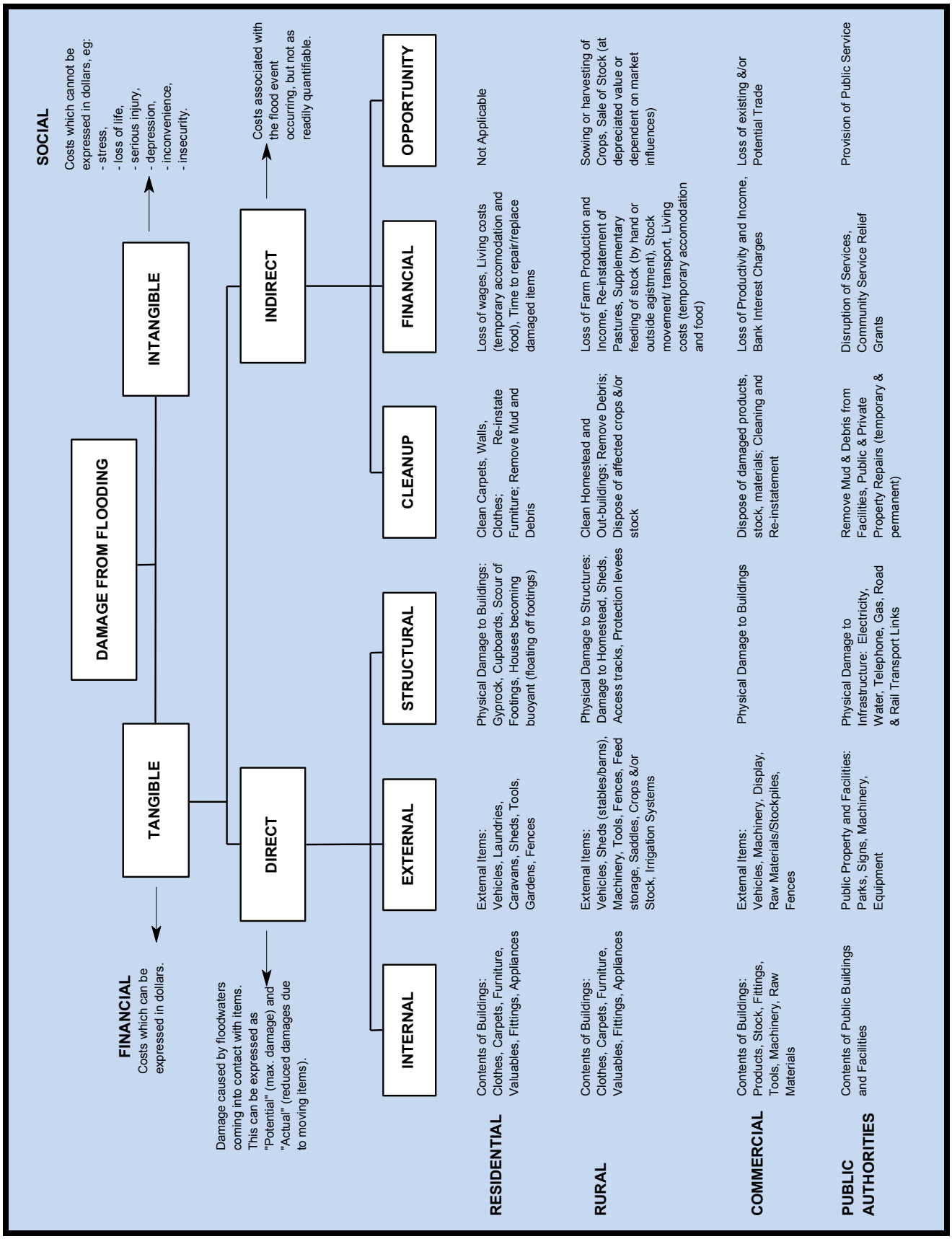
Flood impact can be quantified in the calculation of tangible flood damages. Flood damage calculations do not include all impacts associated with flooding only those which a monetary value can be put to. They do however, provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation. The quantification of flood damages is an important part of the floodplain risk management process and by quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. The costs of flood damages (a summary of the types of flood damages is shown on Table 13) and the extent of the disruption to the community depend upon many factors including:

- the magnitude (depth, velocity and duration) of the flood;
- land usage and susceptibility to damages;
- awareness of the community to flooding;
- effective warning time;
- the availability of an evacuation plan or damage minimisation program;
- physical factors such as erosion, failure of services (sewerage), flood borne debris, sedimentation; and
- the types of asset and infrastructure affected.

In order to quantify the effect of inundation on the existing development a floor level database was prepared for use in this study. This database was originally developed in 1991 at the time of preparation of the 1991 Erina Creek Floodplain Management Study (Ref 3) but has been extended as part of the present study in two subsequent floor levels surveys (refer Section 3.4).

Table 13: Flood Damages Categories (excluding damages and losses from permanent inundation)



4.5.1. Tangible Flood Damages

Direct and Indirect Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (Table 13). Direct damages are caused by floodwaters wetting goods and possessions thereby resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood, for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. Considering damages estimates is useful when studying the economic effectiveness of proposed mitigation options and in comparing flood damages in different areas of the floodplain. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process for floodplain management.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD is equal to the damage caused by all floods over a period of time divided by the number of years in that period and represents the equivalent average damages that would be experienced by the community on an annual basis. This means that the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

Flood Damages Assessment

A flood damages assessment was undertaken for residential and commercial\industrial properties in accordance with the latest guidelines and OEH residential damages spreadsheet FRM Guideline – Residential Flood Damages and OEH Residential Flood Damages Spreadsheet V.3.01 (Refs 15 and 16) which was adjusted to be appropriate for the study area. Damages were calculated with use of height-damage curves which relate the depth of water above the floor with tangible damages. The floor level database (see Section 3.4) is used in establishing the potential damages for each property. The height-damage curves are based on a range of standard assumptions. As commercial damages are often higher than those of residential properties the floor area factor for commercial properties was increased to take account of this.

The flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account the thresholds into any basements or under floor areas or the basements or under floor areas themselves. Therefore where properties have these structures flood damages can be under estimated.

A flood damages assessment was undertaken for existing development and is summarised on Table 14 and Table 15.

Table 14: Commercial Damages

Event	No Flood Affected	Inundated Above Floor	Total Damages	Damage Per Property
PMF	102	99	$9,758,300	$95,700
0.2%	66	57	$4,104,500	$62,200
0.5%	57	43	$3,157,300	$55,400
1%	50	36	$2,568,000	$51,400
2%	41	30	$2,109,700	$51,500
5%	24	13	$1,085,600	$45,200
10%	17	11	$879,200	$51,700
20%	14	10	$781,200	$55,800
50%	12	7	$572,900	$47,700
		AAD	**$588,800**	**$5,800**

Table 15: Residential Damages

Event	No Flood Affected	Inundated Above Floor	Total Damages	Damage Per Property
PMF	358	268	$ 23,643,500	$ 66,000
0.2%	189	99	$ 8,059,500	$ 42,600
0.5%	175	79	$ 6,675,100	$ 38,100
1%	147	58	$ 5,226,600	$ 35,600
2%	116	42	$ 3,997,400	$ 34,500
5%	100	36	$ 3,425,900	$ 34,300
10%	85	30	$ 2,659,500	$ 31,300
20%	71	26	$ 2,262,600	$ 31,900
50%	47	11	$ 1,349,500	$ 28,700
		AAD	***$ 1,518,300***	*$ 4,200*

For residential properties there is little increase in the number of properties inundated above floor level between the 20% and 2% AEP events. The total damages for residential properties are significantly higher than for commercial due to the large number of residential properties affected.

Total and Average Damage per Property

Total damage in Table 14 and Table 15 refers to the total damage estimated for a given design flood event. Average damage per property is the total damage estimated for a particular flood event divided by the number of properties flood affected in this event; either by flooding on the yard and/or above floor level of a building. These are useful to compare damages likely to occur as a result of a particular design event and identify whether there are high damages for smaller events or just the larger less frequent events. It is also very useful to consider both total AAD and AAD per flood affected property, particularly when comparing different areas of the floodplain.

Average Annual Damages

The AAD per flood affected property is the average AAD for each property affected by flooding whether that flooding is over building floor level or only within the property boundary such as flooding of a yard. Total AAD gives an indication of the total costs of flooding while AAD per property gives an idea of the costs to individual property owners. It may be that the total AAD is low as there are

few properties in an area whilst the AAD per property for the same area can be high as all of these properties are significantly flood affected. On the other hand, it may be that the total AAD is high as there are a large number of flood affected properties in an area but the AAD per property could be low as these properties are only subject to minor flooding which may not be above building floor levels. Therefore, in comparing different areas of a floodplain, total AAD gives an idea of where flooding could have significant costs but AAD per property is better at assessing the cost (and therefore benefit of any improvements) to individual properties. Council may want to focus mitigation works in areas subject to a high total AAD or may wish to focus in areas where the AAD per property is high.

4.5.2. Intangible Flood Damages

The intangible damages associated with flooding are inherently more difficult to estimate. In addition to the direct and indirect damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood, from a negligible amount to several hundred times greater than the tangible damages, and depend on a range of factors including the size of flood, the individuals affected, community preparedness, etc. However, it is important that the consideration of intangible damages is included when considering the impacts of flooding on a community. An overview of the types of intangible damages likely to occur in the Erina Creek catchment is discussed below.

Isolation

Isolation (the ability to freely exit and enter your house) during flood events is unlikely to be a significant factor in the catchment but may occur in the upper parts of Erina Creek where small bridges are washed away or damaged.

Population Demographics

Analysis of the latest Census data indicates that there are unlikely to be any particular features (e.g high percentage of elderly residents, non-English speaking residents, high unemployment and thus lower resilience) of the population demographics of the community that would contribute to additional intangible damages, particularly community resilience.

Stress

In addition to the stress caused during an event from concern over property damage, risk to life for the individuals or their family, clean up etc., many residents who have experienced a major flood are fearful of the occurrence of another flood event and its associated damage. The extent of the stress depends on the individual. To some extent, this does not appear to be a significant issue in Erina Creek as a number of residents experienced both the February 1990 and June 2007 events and this issue has not become apparent in post flood surveys.

Risk to Life and Injury

During any flood event there is the potential for injury as well as loss of life.

4.6. Flood Awareness and Flood Warning

The flood awareness of the community and the available flood warning time are important factors in reducing the likely flood damages. Based on experience in other areas and discussions with local residents and others it is likely that the flood awareness of the community is medium to low.

The extent or success of damage mitigation measures employed by the residents during the February 1990 or June 2007 events is unknown. However the relatively shallow depth of above floor inundation means that it is easy to lift portable items above the water level. However carpets and fixed items, such as kitchen and cupboards, cannot generally be saved. Since the February 1990 event the Barralong Road levee has been constructed and will have significantly reduced damages in the June 2007 event.

Flooding in Erina Creek occurs within a matter of hours. If the peak rain burst occurs within a period of heavy rainfall (as occurred in February 1990) residents will be aware of the potential for flooding. However in some events the peak burst occurs in isolation and some form of flood warning will assist. The catchment is too small for a state operated flood warning system however there are state and federal government funded SMS (Short Message Service) warning systems as well as privately operated systems which incorporate information from a variety of sources to produce a warning. These services can provide a valuable service, however they are still in their infancy and their use in recent floods and other disasters has shown up many problems. In time as these services improve they will provide greater and more reliable warning to residents. However SMS warnings will always have limitations (no batteries in phone, no phone, phone silent, phone in car etc.) and thus cannot be relied upon to contact all residents.

4.7. Flood Emergency Response Classification

To assist in the planning and implementation of response strategies, the SES in conjunction with DECCW (now OEH) has developed the FRM Guideline – Flood Emergency Response Classification of Communities (Ref 17) to classify communities according to the impact that flooding has upon them. Flood affected communities are considered to be those in which the normal functioning of services is altered, either directly or indirectly, because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, resupply and rescue.

Based on the guidelines, communities are classified as either, Flood Islands, Road Access Areas, Overland Access Areas, Trapped Perimeter Areas or Indirectly Affected Areas (see Table 16). From this classification an indication of the emergency response required can be determined.

Table 16: Emergency Response Classification of Communities

Classification	Resupply	Rescue/Medivac	Evacuation
High Flood Island	Yes	Possibly	Possibly
Low Flood Island	No	Yes	Yes
Area with Rising Road Access	No	Possibly	Yes
Areas with Overland Escape Routes	No	Possibly	Yes
Low Trapped Perimeter	No	Yes	Yes
High Trapped Perimeter	Yes	Possibly	Possibly
Indirectly Affected Areas	Possibly	Possibly	Possibly

The guideline was applied for the community with the results provided on Figure 5. The main features of the study area are that:

- there are homes and access roads below the PMF,
- vehicle evacuation routes are generally cut before homes are inundated,
- there are generally “dry” areas for refuge as well as within the homes themselves (i.e the depth of inundation is generally less than 1m within the house),
- the homes are first partly or completely surrounded by floodwaters and then inundated, and
- thus vehicle evacuation must generally be completed before the escape route is closed.

Areas within the catchment which fall within the flooding areas from both Erina Creek and its tributaries are shown in Figure 5. A majority of the flooded areas within the Erina Creek catchment fall within the classification of having rising road access, particularly off the larger tributaries and the upper section of Erina Creek. Of note is that flooding creates high trapped perimeter areas in the southern areas of the catchment, most notably around the council depot adjacent to Brisbane Water, Erina Fair and the housing areas to the south of Erina Fair. In addition to this, a high flood island appears to exist along the border of the suburbs of Holgate and Matcham, between Wattle Tree Road and Oak Road, south of McGarrity Avenue. A low flood island exists within the area bounded by the Barralong Road levee, The Entrance Road and Nunns Creek.

In summary, a local flood plan should be prepared by the SES using the information from this study for each management area and communicated to the community. Due to the extensive area and number of people requiring the services of the SES, the main focus for many residents will be on self-help during a flood.

5. IMPLICATIONS OF CLIMATE CHANGE AND SEA LEVEL RISE

5.1. Background

Climate change is projected to cause an increase in sea level and possibly changes to design rainfall intensities. The likely impacts of a rise in sea-level include:

- an increase in the intensity and frequency of storm surges;
- increased foreshore erosion and inundation of low lying coastal lands;
- further loss of important coastal wetland ecosystems; and
- damage to and destruction of human assets and settlements.

In developed areas such as those around Brisbane Water, changes in the climate, such as an increase in storm activity, together with a rise in sea level (Figure 6) are likely to influence future building design, standards and performance as well as energy and water demand and in particular coastal/estuary planning.

The 2005 Floodplain Development Manual (Ref 5) and 2010 Flood Risk Management Guide (Ref 6) requires that Flood Studies and Risk Management Studies consider the impacts of sea level rise and climate change on flood behaviour. Since the year 2000, current best practice for considering the impacts of climate change (sea level rise and rainfall increase) have been evolving rapidly. Key developments and results are provided in the 2012 Erina Creek Flood Study Review (Ref 1) and also a summary discussion below.

Council in August 2013 adopted climate change scenarios which endorsed the HCCREMS regional projections as shown in Table 6. However the sea level rise projections were amended by Gosford City Council in March 2015 (Section 2.6.1).

5.2. How will Climate Change Affect Water Levels in the Lower Parts of Erina Creek?

Climate change has the potential to alter the water level in both non-flood and flood times.

5.2.1. During Non-Flood Times

The main impacts in non-flood times will be:

- The normal water level in Brisbane Water will rise. The projected increase is the same as the expected sea level rise (by 0.2 m in 2050 to 0.3 mAHD and by 0.74 m in 2100 to 0.84 mAHD), in accordance with Council's adopted projections of March 2015. This may change in future to comply with state and government guidelines and directives or any further decisions by Council.
- Through-out the year, a series of elevated ocean levels, a combination of high astronomic tides and/or storm surges over a few days will “pump up” water levels in Brisbane Water. Thus each year the peak Brisbane Water levels will rise by the amount of sea level rise.
- It is possible that the tidal range and seasonal variation in water level within the Brisbane Water (i.e change in the *Tidal Prism* which is the total volume of water flow into or out of the estuary with the rise and fall of the tide) may change in response to rainfall or

temperature changes but the extent is unknown at this time.

The increase in the normal water level in the Brisbane Water in non-flood times may result in increased maintenance costs and/or modifications costs for existing developments and infrastructure due to more frequent inundation in non-flood times. For example, low lying roads will be more frequently inundated. Inflows of water from the Brisbane Water to sewer surcharge vents in backyards may also occur more frequently. The increased cost for residents and Gosford City Council to maintain the existing developments and infrastructure is unknown. A separate study is required to quantify the effect in non-flood times but it is likely that at some time in the future the existing services, in particular low lying areas, will become unable to be maintained and will have to be relocated or re-built. This may affect service standards to existing developments.

The increase in water levels during non-flood times may also see some areas of land that are currently dry become flooded most of the time or even permanently inundated. This will affect the current use of that land and strategic planning is necessary to reduce the economic impact resulting from this flooding. This may affect Council's depot facilities and the surrounding developments.

Any change in the normal water level regime will also impact on the ecology of Erina Creek. The implications of this are largely outside the scope of this Study and Plan.

5.2.2. During Flood Times

There are several broad ways in which climate change and sea level rise will affect water levels in Erina Creek during floods, namely:

- *The increase in ocean level* will raise the normal water level in Brisbane Water as well as the assumed ocean level adopted for design flood analysis in the 2012 Erina Creek Flood Study Review (Ref 1). In this study an ocean dominated and rainfall dominated design flood scenario were examined. For each of these design scenarios the adopted ocean levels will rise due to climate change. The results are provided in the 2012 Erina Creek Flood Study Review (Ref 1).
- *The increase in peak rainfall intensity and storm volume* will increase design flood levels in the catchment. The sensitivity of the flood levels to increased rainfall was investigated and the results are provided in the 2012 Erina Creek Flood Study Review (Ref 1).
- *A change in entrance conditions to Erina Creek* may occur due to a change in erosion or sedimentation regime. This has been not been investigated as the effects of any change is likely to be relatively small.
- *A change in wind activity* at the Entrance to Erina Creek will change the wave runup flood level around the foreshores. At this time the impact of this effect is unknown and reference should be made to the 2009 Brisbane Water Foreshore Flood Study (Ref 14).

Figure 6 and Table 17 shows the potential increase in flood extents due to potential sea level rise.

5.3. Are the Implications of Climate Change Significant?

A rise in the normal Brisbane Water level, annual peak water level and the design flood levels will have an impact on the affected ecosystems and existing development in the area. The extent of

affectation will depend on the magnitude of the sea level rise and rainfall increase. As a result land uses, development controls and future developments will have to be modified to accommodate any increases in water levels. Table 17 indicates results from the current 2012 Erina Creek Flood Study Review (Ref 1) which were 0.4m and 0.9m as well as a 0.2m and 0.74m sea level rise.

Table 17: Climate Change Results from Erina Creek Flood Study Review (Ref **1**)

		Relative change in level in m						
Location - refer Figure below	**1% AEP (mAHD)**	**10% rainfall increase**	**20% rainfall increase**	**30% rainfall increase**	**0.2m ocean rise**	**0.4m ocean rise**	**0.74m ocean rise**	**0.9m ocean rise**
Nunns Ck U/S The Central Coast Highway	3.53	+0.04	+0.07	+0.11	0.00	0.00	0.00	0.00
Worthing Rd Ck Retarding Basin	7.99	+0.02	+0.10	+0.16	0.00	0.00	0.00	0.00
Terrigal Dr. @ Worthing Rd Ck	7.72	+0.05	+0.08	+0.13	0.00	0.00	0.00	0.00
Worthing Rd. Ck U/S The Central Coast Highway.	4.03	+0.22	+0.41	+0.57	0.00	0.00	+0.02	+0.03
Erina Ck U/S Barralong Rd	2.95	+0.11	+0.26	+0.37	+0.01	+0.02	+0.04	+0.04
Erina Ck corner Bonnal Rd and The Central Coast Highway	2.69	+0.09	+0.22	+0.33	+0.01	+0.03	+0.04	+0.05
Erina Ck U/S Punt bridge	1.14	+0.01	+0.06	+0.10	+0.12	+0.36	+0.46	+0.59
Drainage channel U/S Ilya Ave	8.25	+0.01	+0.02	+0.06	0.00	0.00	0.00	0.00





6. RISK MANAGEMENT MEASURES CONSIDERED

6.1. General

The 2005 NSW Government's Floodplain Development Manual (Ref 5) separates risk management measures into three broad categories:

Flood modification measures modify the physical behaviour of a flood (depth, velocity and redirection of flow paths) and include flood mitigation dams, retarding basins and levees. On Erina Creek this would also include any works that modify the entrance to Brisbane Water.

Property modification measures modify land use and development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), strategic planning (such as land use zoning), building regulations (such as flood-related development controls), or voluntary purchase.

Response modification measures modify the community's response to flood hazard by educating flood affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table 18 below provides a summary of the floodplain risk management measures that could be considered for the Erina Creek catchment.

Table 18: Floodplain Risk Management Measures

Property Modification	Response Modification	Flood Modification
Land zoning	Community awareness/preparedness	Flood mitigation dams
Voluntary purchase	Flood warning	Retarding basins
Building & development controls	Evacuation planning	Bypass floodways
Flood proofing	Evacuation access	Channel modifications
House raising	Flood plan / recovery plan	Levees
Flood access	Flood insurance	Temporary defences

6.1.1. Relative Merits of Management Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. It is a standard method for using the time value of money to appraise long-term projects of the reduction in flood damages (benefit) compared to the cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles (such as anxiety, risk to life, ill health and other social and environmental effects).

The potential environmental or social impacts of any proposed flood mitigation measure must be considered in the assessment of any management measure and these cannot be evaluated using the classical benefit/cost approach. For this reason a matrix type assessment has been used which enables a value (including non-economic worth) to be assigned to each measure. Details of the

matrix are provided in Section 8.

6.2. Measures Not Considered Further

It was apparent that after a preliminary matrix assessment that a number of risk management measures were not worthy of further consideration. These are summarised in Table 19.

Table 19: Risk Management Measures Not Considered Further

	Reduction in Flood Level	Social Effect	Environ-mental Impact	Cost to Implement	Benefit/ Cost Ratio
FLOOD MODIFICATION MEASURES:					
Flood Mitigation Dams	Yes	Moderate	Very High	Very High	Low
Change the existing entrance or construct another entrance – as a mitigation measure though may be viable if future road works undertaken	Minor	Minor	Moderate	Very High	Low
Catchment Treatment	Minimal	Nil	Low	Low	Nil

6.2.1. Flood Mitigation Dams

Flood mitigation dams have frequently been used in rural areas of NSW to reduce peak flows downstream. Dams are rarely used as a flood mitigation measure for existing development or in urban areas on account of the:

- high cost of construction;
- high environmental damage caused by the construction;
- possible sterilisation of land within the dam area;
- high cost of land purchase;
- risk of failure on the dam wall;
- likely low benefit cost ratio; and
- lack of suitable sites as a considerable volume of water needs to be impounded by the dam in order to significantly reduce flood levels downstream.

Based on an assessment of the catchment and taking into account the above factors flood mitigation dams were not considered further for this catchment.

6.2.2. Change the Existing Entrance or Construct another Entrance

Enlarging the entrance of Erina Creek to Brisbane Water will reduce flood levels when Brisbane Water is not unduly elevated in events that do not overtop The Entrance Road (Central Coast Highway). Constructing another opening from the Erina Creek to Brisbane Water to the east of the existing entrance would have the same benefit. However, the main drawback of this measure, apart from the high cost, is that the reduced flood levels accruing from this measure (less than 50mm based on preliminary modelling results) would quickly dissipate within a few hundred metres of the mouth. Any benefit would not extend to the junction with Nunns Creek at The Entrance Road (Central Coast Highway). Within this area there are few houses inundated above floor level. In

larger events (> 0.2% AEP) when overtopping of The Entrance Road (Central Coast Highway) occurs the benefit is much reduced as The Entrance Road (Central Coast Highway) acts as a very efficient overflow structure.

If The Entrance Road (Central Coast Highway) was upgraded to include additional openings or widening of the existing opening at Punt Bridge this would provide a nominal reduction in flood level of up to 50mm. An additional opening would likely require destruction of mangrove beds and possible implications for coastal affectation. These and other environmental issues would need to be investigated and resolved before this measure can be justified. For these reasons this measure has not been pursued further under this study. However any upgrading of the Central Coast Highway should investigate the need for raising the road and providing additional culverts so as to reduce upstream flood levels and to improve flood access.

6.2.3. Catchment Treatment

Catchment treatment modifies the runoff characteristics of the catchment to reduce inflows to the Erina Creek and ultimately Brisbane Water. For an urban catchment, this involves planning to minimise the amount of impervious area, maintaining natural channels where practical and the use of on-site detention (also known as Water Sensitive Urban Design or WSUD). For a rural catchment, this involves limiting deforestation or contour ploughing of hill slopes. These measures can reduce the volumes of storm water run-off in relatively small, frequent events, typically up to about the 20% AEP event. However, they often have little effect in larger, less frequent events, above say a 5% AEP event.

As a general concept, catchment treatment techniques and WSUD should be encouraged for all new developments within the catchment regardless of whether or not in the Flood Planning Area (eg. on-site detention, limit on-site imperviousness for developments, controls on rural land use). Along with water quality and other environmental controls as these approaches provide significant local drainage and non-flooding benefits. However purely as a management measure to reduce flood levels in Erina Creek they are ineffectual.

6.3. Flood Modification Measures

Flood modification involves changing the behaviour of the flood itself, by reducing flood levels or velocities, or excluding floodwaters from areas under threat. This includes:

- dams (not considered further – see Section 6.2.1);
- entrance modifications (not considered further – see Section 6.2.2);
- levees, flood gates and pumps;
- identification and review of local drainage issues;
- channel works;
- retarding basins.

Discussion on each of these measures is provided in the following sections.

6.3.1. Levees, Flood Gates and Pumps

DESCRIPTION

Levees are built to exclude previously inundated areas from flooding or inundation from the Brisbane Water up to a certain design event. They are commonly used on large river systems (eg. Hunter and Macleay Rivers) but can also be found on small creeks in urban areas. They often comprise earthen embankments but can also be constructed as concrete walls or other similar structures.

Flood gates or rubber flap valves allow local runoff to be drained from an area (say an area protected by a levee) when the external level is low, but when the river is elevated, the gates prevent floodwaters from the river entering the area (they are commonly installed on drainage systems within a levee area and are present in the Barralong Road levee system).

Pumps are generally also associated with levee designs. They are installed to remove local runoff behind levees when flood gates are closed or if there are no flood gates. Unless designed for the PMF, levees will be overtopped. Under overtopping conditions the rapid inundation may produce a situation of greater hazard than exists today. This may be further exacerbated if the community is under the false sense of security that a levee has "solved" the flood problem (as happened with Hurricane Katrina in New Orleans, USA).

DISCUSSION

Within the study area, the Barralong Road levee (Photo 10) was constructed as a result of a recommendation of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C). This levee comprises mainly an earthen embankment which ties in with a concrete wall in the south (Photo 3). The levee was built to provide protection from inundation in the 1% AEP event in Erina Creek. However, recent hydraulic modelling shows that the levee overtops in the north in the 1% AEP event. Furthermore, there are some properties protected by the levee from Erina Creek flooding which are still subject to flooding from overland flows. These emanate from the local catchments and from Nunns Creek, as the outfall from Nunns Creek is effectively blocked by the high water levels in Erina Creek and also due to the size of the road culverts.



Photo 10: Barralong Road Levee (earthen embankment and concrete wall)

Additional levees have been considered for areas along Erina Creek. However there are no obvious areas where a levee similar to the Barralong Road levee could be constructed. This is due to an inability to tie into high ground, the levee would likely have a low cost benefit ratio due to the length

of the structure required and there are no management areas in the catchment where a levee could be built that would not introduce some adverse increase in flood levels to others not protected by the levee. This adverse increase in flood levels occurred with construction of the Barralong Road levee and had to be addressed as part of the design with several properties being purchased to mitigate the impacts. The other main concerns are social, and to a lesser extent, environmental issues.

Pumps have been suggested as a means of addressing the internal drainage problem but are not widely used in levee type situations in NSW. Some of the drawbacks of employing pumps are:

- high capital cost. In many instances two sets of pumps are installed in case one set is being repaired or maintained when the flood occurs;
- high maintenance cost. The pumps have to be regularly maintained and tested by trained personnel; and
- relatively high risk of failure. Experience in other areas has shown that as the pumps are used only infrequently there is a relatively high risk of failure due to:
    - inadequate maintenance of the pumps causing seals or valves to deteriorate;
    - power cuts caused by the storm; and
    - failure of the device which activates the pumps.

The pumps are only required to operate for a short time (several hours) possibly only once or twice in a five year period. If they fail to start or fail during the event there is practically no likelihood that service personnel will be able to restart them prior to the peak level being reached. An alternative to pumps is to install additional flap gated culverts and these can be more cost effective though also can fail (mainly due to vandalism or vegetation "jamming" the mouth open). There is no pump system within the Barralong Road levee and this latter approach was adopted for the existing Barralong Road levee system. Manually operated gate valves were also installed in pits behind the flap gated culverts to act as a backup in case the flap gated culverts failed.

Some of the key issues regarding levees are summarised in Table 20.

Table 20: General Key Features of Levee Systems

ISSUE	COMMENT
ADVANTAGES:	
"Environmentally Sensitive Measure"	A well-designed vegetated earthen embankment set back far enough from the creek and that does not interrupt local drainage, can have minimal environmental impact. However, in many locations it is hard to meet all these criteria. Levees cannot have large trees planted on them because if the trees fall over in a storm it may affect the structural integrity of the levee.
Protects a large number of buildings	Whilst this is generally the case due to the relatively scattered nature of the flood liable properties it is impossible to construct a new levee that would protect a large number of buildings.
Low maintenance cost	A levee system needs to be inspected annually for erosion or failure. In addition there is ongoing weekly or monthly maintenance (grass cutting, vegetation trimming). The annual cost of inspections for erosion or failure will generally be small (for example less than $5,000 per annum per levee). However this amount can vary considerably depending upon the complexity and size of the structure.

ISSUE DISADVANTAGES:	COMMENT
Visually obtrusive to residents	Residents enjoy living near the creek system because of the visual attraction of the water or bush and a high embankment could significantly affect their vista. Anything which reduces the vista is unlikely to be accepted by the majority of residents. A freeboard of usually 0.5 m should be added to the design flood level of the levee (level of protection afforded by the levee) to account for wave action, slumping of the levee or other local effects.
High cost	The cost to import fill, compact and construct an earthen levee is dependent on the availability of good quality fill and the associated transport costs, these will vary depending upon the locality. However, generally it is the purchase of land and associated costs (possible services re-location and access) which add considerably to the cost.
Low to medium benefit cost ratio	Whilst the levee system may protect a several buildings from being inundated in a given event, for example the 1% AEP event, it is likely to have a low to medium benefit cost ratio as there are few buildings floors inundated (and so being able to be protected) in the more frequent floods (less than a 10% AEP event).
Local runoff from within the "protected area" or upstream may cause inundation	The ponding of local runoff from within the protected area may produce levels similar to that from the creek itself. At present local runoff already causes problems in several low lying areas. Constructing a levee will compound this problem. It can be addressed by the installation of pumps or flap valves on pipes but these add to the cost and the risk of failure.
May create a false sense of security	Unless the levee system is constructed to above the PMF level it will be overtopped. When this occurs the damages are likely to be higher as the population will be much less flood aware (as happened in New Orleans, USA in August 2005). A regularly used quote regarding levees is that there are only two types of levees. Those that have failed or those that will fail in the future.
Relaxation of flood related planning controls	Most residents consider that following construction of a levee the existing flood related planning controls (minimum floor level, structural integrity certificate) should be relaxed. However, many experts consider that this should not be the case unless the levee is built to the PMF level and the risk of failure is nil. The general opinion is that a levee should reduce flood damages to existing development but should not be used as a means of protecting new buildings through a reduction in existing standards.
Restricted access	A levee will provide restricted access to the area and/or the bush or riverine areas. This can be addressed by (expensive) re-design of entry points.

Barralong Road Levee

The results in the 2012 Erina Creek Flood Study Review (Ref 1) indicate that overtopping of the Barralong Road levee near Lingi Street will occur in the 1% AEP event. In addition at other locations there may be less than 0.5 m freeboard. The levee was designed approximately 20 years ago and was based on the most up to date hydraulic modelling at the time. However as detailed in the above reference significant advances have been made in this field and particularly with the availability of detailed ground survey termed ALS or LIDAR.

Hydraulic modelling was undertaken to assess the reduction in flood damages that would occur if the levee was raised to the 1% AEP flood level plus appropriate freeboard. This analysis indicated that the AAD would reduce by $2,000 or less than 0.1%. The benefit cost ratio of upgrading the levee depends upon the cost to upgrade. An indicative cost to upgrade is $100,000 and thus would give a benefit/cost ratio of approximately 0.3.

SUMMARY

A review of the flood liable areas indicates that there are no areas where a levee system, similar to the Barralong Road levee could be constructed to protect existing buildings.

A review of the structural integrity and crest level plus appropriate freeboard of the Barralong Road levee system should be undertaken in light of the results from the 2012 Erina Creek Flood Study Review (Ref 1). Minor changes to the crest level or other works may be required to ensure that the levee is in accordance with current best practice. Survey should be undertaken to establish if slumping has been an issue and whether further monitoring is required. Levees generally have a low spot where inflow will first occur in an overtopping event. This is to prevent overtopping across a wide area and so provide some warning of overtopping and reduce the risk of levee failure. This issue should be investigated in the review.

6.3.2. Investigate and Review of Local Drainage Issues

DESCRIPTION

Local stormwater flooding is probably the flooding mechanism which is most widely identified by the community as being of concern, the only exception being where the residents actually experienced the February 1990 or the June 2007 floods. Local flooding occurs in nearly all suburbs where there are relatively flat grades. Many residents consider that local flooding is a significant issue and possibly some may view this as a greater issue than the more infrequent flooding of Erina Creek and report this to Council.

DISCUSSION

Local flooding results from rainfall over the local catchment being unable to quickly drain away. Generally it only occurs after several hours of rain and will not cause above floor inundation. Upgrading the sub-surface drainage system to improve yard to road drainage would improve the situation in the short term but is unlikely to solve the problem and would not be cost effective on the basis of a reduction in tangible damages.

Debris (litter, vegetation) in the piped system is always a contributing factor to the efficiency of a drainage system. Council has a pit cleaning program based on past experiences reported by residents. Unfortunately much of the blockage occurs during a heavy rainfall event which means that any pre-cleaning may not result in the expected benefit.

Whilst the main objective of this study is to manage large flood problems the study area also includes areas where local drainage flooding is an issue. One of the key areas identified is upstream of Hylton Moore Park (Photo 11). This area has been filled in the past and has created or accentuated drainage problems upstream. On Coburg Street and Adelaide/Russell Streets runoff collects at low points and does not quickly drain. At both these locations new or additional pipes should be constructed to ensure adequate drainage.

Frequent inundation of Wells Street (midway between Springfield and Avalon Roads - Photo 11) occurs to a depth of approximately 200mm resulting in traffic disruption and delays. The problem cannot easily be solved as lowering the kerb and reserve on the creek side provides little gain and raising the road will increase water levels upstream and potentially inundate private properties.

Furthermore, detailed investigation is required for all areas within the 1% AEP floodplain and should be undertaken as part of Council's local drainage works program. Notable examples include (refer Photo 11): Wells St, Coburg St, Maitland Rd, Newcastle St, Althorp St, Russell St, Wattle Tree Rd, Carlton Rd, Milina Rd, Chetwynd Rd, Oak Rd, Lakala Ave, Willow Rd, and Clarence Rd. In particular a feasibility study to investigate the possibility of raising Willow Road, Springfield should be undertaken.

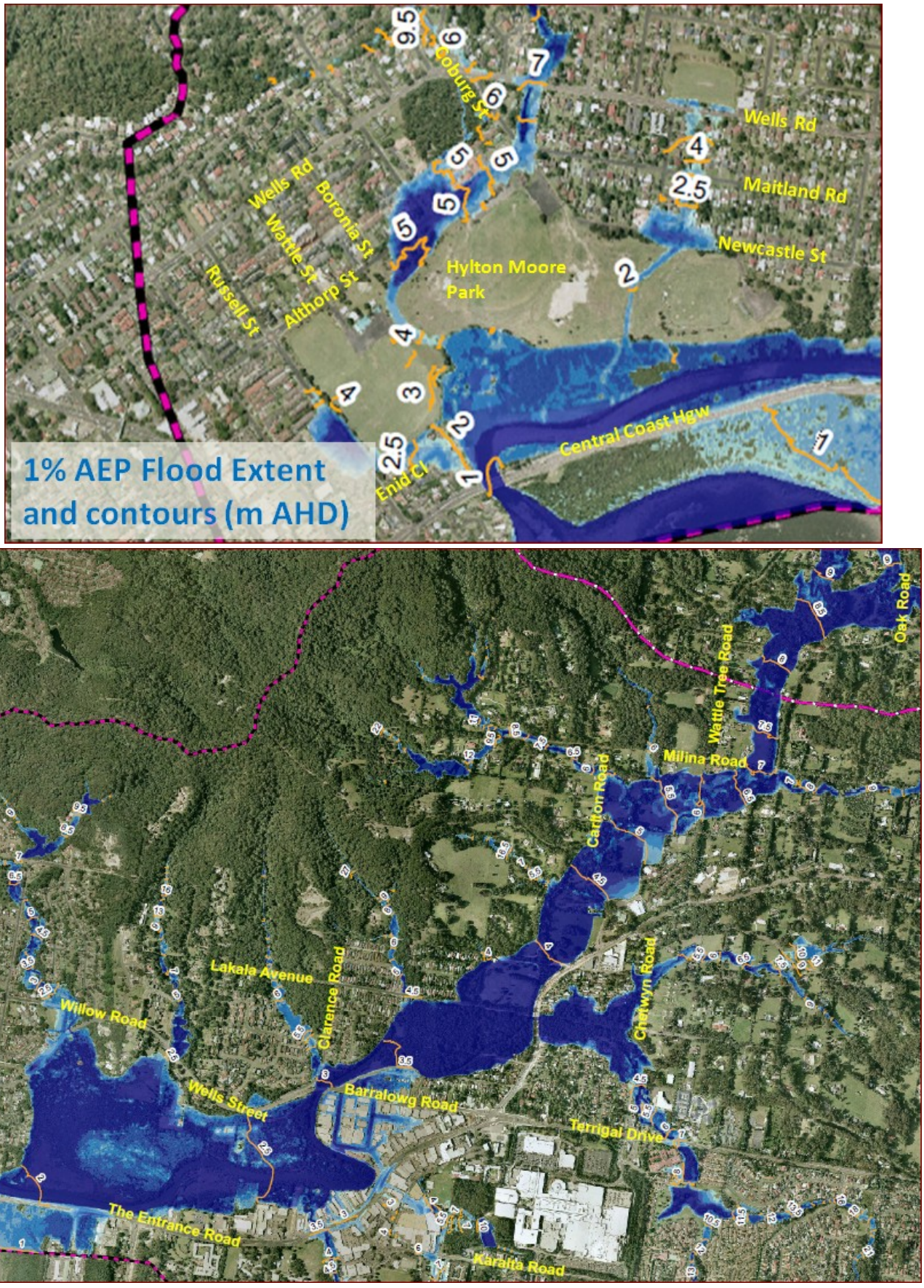


Photo 11: Hylton Moore Park and Wells Street near the mouth of Erina Creek (upper) and Erina Heights (lower)

SUMMARY

Local flooding is a significant issue for many residents but preliminary investigation indicates that there is no viable economic solution. One approach would be to more closely identify the worst affected areas and provide a newsletter suggesting how residents could minimise the impacts of nuisance flooding themselves. If residents are willing to participate, this could be combined with assistance from Landcare groups to control exotic vegetation in the watercourses. A community based approach with input from Council, is likely to be the most successful, with Council using the level and credibility of community information to inform its maintenance priorities for drainage works. This should be accompanied by a public education program to explain the difference between local and Erina Creek flooding and how the public can be involved in reducing the local flooding problem. An overland flow study for each sub catchment would more accurately define the key flood affected areas.

On Coburg Street and Adelaide/Russell Streets in East Gosford (refer Photo 11) runoff collects at low points and does not quickly drain. At both these locations new or additional pipes should be constructed to ensure adequate drainage into Hylton Moore Park. Details of these works are summarised in Section (2.6.4).

6.3.3. Channel Works

DESCRIPTION

Channel works include any measure that increases the hydraulic efficiency of the main channel or immediate overbank areas. In this way flood levels are reduced by either increasing the waterway area or increasing the velocity of flow. Measures include:

- vegetation or other forms of clearing;
- channel widening;
- dredging;
- concrete lining;
- creek shortening;
- removal, raising or upgrading of hydraulic structures (bridges, roads).

DISCUSSION

The 1991 Erina Creek Floodplain Management Plan (Ref 4- Appendix C) found that provision of a flood channel, stream clearing and dredging were not considered effective. All the above measures have been employed at various times on different river systems in NSW. However, apart from local areas, these measures are now generally not considered environmentally and economically sustainable. In addition they are relatively costly to undertake and may introduce additional problems such as bank erosion, sedimentation, land ownership and permission; increases in flood levels downstream and require an on-going maintenance regime. Council has limited funding for resources and maintenance works and cannot guarantee that all creek works can be maintained to a high level of service.

An example where this measure has been employed in the Gosford LGA is on Cut Rock Creek at Lisarow to reduce flood levels for existing developments. This measure has been reasonably successful and was the only means of protection for many flood liable houses.

Enlarging culverts under roads would reduce the extent of frequency of overtopping and lower flood levels upstream. One location that has been suggested is the crossing of Nunns Creek at The Entrance Road (Central Coast Highway). Currently there is a triple box culvert which at the time of inspection was partially blocked by silt. Certainly adding additional culverts would reduce flood levels upstream but the main issues are:

- high cost;
- significant traffic disruption;
- the reduction in flood level upstream will be minor (< 0.1m) and benefits only commercial properties;
- overtopping of The Entrance Road (Central Coast Highway) occurs infrequently and while it causes traffic disruption the hazard is relatively low as the overflow occurs in a relatively shallow and wide path;
- there is only limited channel capacity downstream to accommodate a more concentrated flow from upstream;
- blockage will significantly reduce any additional culvert capacity.

In summary for the reasons given above this measure is generally not supported. However, to reduce overflows inundating the Bonnal Road area and to reduce the overtopping of the Central Coast Highway, channel works and enlarging the culverts are supported in Nunns Creek.

SUMMARY

In Erina Creek there are no places where such channel works could be undertaken that would provide a significant reduction in flood levels to many existing flood liable properties, with a reasonably high benefit cost ratio and without a significant adverse social or environmental impact.

However where dense vegetation builds up in the creek due to fallen trees then it would be appropriate for Council to consider its removal to prevent a further build up which otherwise might cause an increase in flood levels upstream or other adverse impacts such as bank erosion. If this is undertaken then a written and photographic description should be placed in Council's records justifying the works. As a general guide removal of sedimentation in the creek system should not be undertaken as this will be moved by the next flood. Any non-natural debris such as fencing, vehicles or similar should be removed to prevent an unnatural debris build up. Trash racks (Photo 12) that deflect debris over the road (cost approximately $20,000) should be considered at important crossings such as at Nunns Creek.

To reduce overflows inundating the Bonnal Road area and to reduce the overtopping of the Central Coast Highway, channel works and enlarging the culverts are supported in Nunns Creek.



Photo 12: Example of a trash rack deflecting debris over the road

All gross pollutant traps or other debris collectors and culverts should be under a regular maintenance program to ensure all sediment and debris are removed.

6.3.4. Retarding Basins

DESCRIPTION

Retarding basins are small-scale flood mitigation dams commonly used in urban catchments for the same reasons. One of the major impediments in their use as a flood mitigation measure for existing development is the lack of suitable sites. For new greenfield developments (such as in western Sydney) there is the opportunity to incorporate the retarding basins into site design which is not possible for existing development. Retarding basins can also provide significant water quality benefits, though in a heavily built up urban environment it is difficult to maintain these systems for this purpose.

DISCUSSION

Whilst retarding basins appear to be a fairly simple and effective means of controlling runoff and water quality in urban catchments there are a number of potential issues that need to be resolved. These are summarised in Table 21 below.

Table 21: Considerations For Retarding Basins

ISSUE	COMMENT
Size:	In order to be effective at reducing peak flows and benefiting water quality the basin area must cover a reasonably high percentage of the upstream catchment. The larger the basin, the more effective it will be. The outlet controls are also important in the design of the basin.
Cost:	Whilst construction costs of the basin and wall in a rural or urban environment will be high, additional costs are associated with any alterations to services (gas, electricity, telephone, water, sewerage, roads, etc.) that are within or in close proximity to the proposed basin. There will also be some ongoing maintenance cost. Some sites in urban areas, which at first glance may appear suitable, are unviable due to the deposition of inappropriate fill material in the past (ex rubbish site, buried asbestos or other forms of

ISSUE	COMMENT
	waste).
Benefit:	Whilst any basin will provide some peak flow reduction and water quality benefit this must be balanced against the cost, and whether there are more cost effective methods. For example, it is generally acknowledged that public education and awareness and point source reduction provides the greatest benefit from a water quality perspective. The benefit for peak flow reduction is subject to the size of the basin and the outlet works. These are not easily defined at a concept stage, as detailed survey and design is required. Small basins generally provide the greatest peak flow reduction in small more frequent events, when the basin volume is a high percentage of the total flood volume. However, in these events there is often only minor above floor damage or significant hazard to mitigate. In large events, basins (unless very big) are largely ineffectual from both a water quality and peak flow reduction perspective. Also, for multi-peaked rainfall events the basin may provide some benefit in the initial peak but very little when the second or third peak arrives. The use of a basin for dual purposes (water quality and peak flow reduction) generally means that a compromise of the benefits for each purpose has to be reached. This is because the water quality purpose is best achieved by containing all the frequent inflows. For flood mitigation purposes, these flows are generally not contained to allow the volume in the basin to be "empty" at the time of the peak inflow.
Loss of Land Use and Availability of Land:	In a rural or some urban areas the loss of land for basin construction is acceptable. However in a relatively dense rural and urban catchment such as in the Erina Creek catchment, where areas of open space are very valuable, the loss of previously useable land is significant. Basins can have multi-uses, such as being used as sports fields when dry, but this can be difficult to achieve.
Environmental Impact:	In both rural and urban areas there is likely to be a high environmental impact with removal of vegetation and construction of an embankment wall. In relatively dense rural and urban catchment such as in the Erina Creek catchment the lack of a potential basin site obviously restricts the use of this mitigation measure. The most preferred sites are within golf courses or any sports ground where many of the above issues can be negated. Examples in Sydney are in Fox Hills (Prospect) and Muirfield (North Rocks) golf courses or in a soccer field at Bateau Bay.
Safety:	This is one of the most important factors to be considered when constructing a basin with a downstream urban area. Council will be changing an open space area with a low hazard potential during rainfall events to an area with a greater hazard. Apart from the risk of wall failure and consequently a sudden rush of floodwaters, there is the risk that people may drown or be swept into the basin. This can be negated by using fencing but this then precludes the use of the basin for other purposes. Generally basins deeper than say 1.2 m are unacceptable as a person cannot wade out of them. Some basins can be designed to have shallow and gradual depths closer to the edges but this means less potential storage volume over the same land area. The benefit of a reduction in hazard downstream must be balanced with the potential increase in hazard at the basin site. Constructing a basin places a significant potential liability on Council should it cause harm to persons in flood (or even non-flood) times. Signs can be placed advising of the hazard, however in a legal environment it is difficult to argue that this removes Council's responsibilities. Also children, older residents and non-English speaking background residents may not understand the signs.

Retarding basins are unlikely to be a cost effective measure to negate flooding problems in the catchment. However all basins will provide some flow mitigation and water quality benefit. The benefit that can be achieved must be balanced against the loss of use of the land and concerns about Council's liability if construction of a basin increases the flood hazard in the area. A retarding basin was constructed at Tarragal Glen Retirement village (by the private land owner) to mitigate the

impacts of increased impermeable surface area due to the development. Ensuring measures such as retarding basins are used in all large developments to restrict runoff can reduce the cumulative impacts of development. However in larger than design events or where there is an event that produces a large amount of preceding rain prior to the peak, or a double peak, the ability of a retarding basin to make a significant reduction in the peak flow is considerably reduced.

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) concluded that retarding basins were not recommended for reducing existing flood levels along the mainstream of Erina Creek, however were recommended for minimising the cumulative effects of future upstream development.

Construction of a chain of retarding basins on Erina Valley Road Creek, which leads onto Chetwynd Road, could provide some reduction in the peak flow arriving at the properties on Chetwynd Road and further downstream. However the main benefit would be to the four properties on Chetwynd Road as further downstream the peak level is more determined by the ponding effect from the culverts under The Entrance Road (Central Coast Highway) and runoff from the Terrigal Drive catchment. Whilst the basins would reduce the peak flow they would not eliminate flooding. For three of the four homes the reduction in flood level would only be to their under floor areas as they are of pole construction (Photo 14). For these three properties the main issue is risk to life and yard damages both of which would only be marginally improved with reductions in peak flow.

As noted above there are many issues with construction of retarding basins. For use as a management measure to lower downstream water levels the overall benefits do not outweigh these in the Erina Valley Road Creek catchment. However they may be appropriate for mitigating the increase in peak flows resulting from urbanisation of the catchment. A detailed study would be required to evaluate their effects.

SUMMARY

A detailed assessment of all possible sites cannot be undertaken as part of the present study as this would require details of land ownership, discussion with land owners and compensation. Nevertheless Council should, where viable, investigate the use of retarding basins in the catchment as a means of providing some flow mitigation and water quality benefit for mitigating the adverse effects of upstream catchment development.

6.3.5. Catchment Treatment, Water Cycle Management

DESCRIPTION

Generally where retarding basins are used on large developments or as part of the public drainage system, water cycle management which includes on-site detention (OSD) is used on individual lots. OSD does not necessarily mean surface water must be attenuated in a below ground structure; storage areas can include flooding above ground to shallow depths over paved areas, such as parking areas, or garden features. Storage can also be provided in underground systems.

Water cycle management does not just apply to areas within a flood prone area but to all areas as it ultimately reduces the rate of runoff reaching flood prone areas.

Catchment treatment is linked with water cycle management and modifies the runoff characteristics of the catchment to reduce flows. For an urban catchment, this involves planning to maximise the amount of pervious area, maintaining natural channels where practical and the use of Water Sensitive Urban Design (WSUD). These measures can reduce the volumes of storm water runoff in relatively small, frequent events, typically up to approximately the 20% AEP events but they have less effect in larger, less frequent events. These measures can be effective on the small tributary catchments but have a negligible impact on large catchments such as Erina Creek itself.

DISCUSSION

Although water cycle management can prevent development exacerbating flood risk, it is not without its issues. The OSD systems will require maintenance. Lack of maintenance can allow blockages to form and therefore ponded water does not drain away and can even cause increased damage to property. Care should be taken when considering OSD depths and locations in relation to property and property access. Also provisions need to be made should the property ownership change. The new owners will need to be made aware of the water cycle management systems on their property and their responsibility to maintain it. In some LGAs it has been argued that poorly maintained/drained OSD systems have contributed to the mosquito problem.

Finished floor levels of properties should be considered where OSD is installed. If water storage is allowed above ground near to the building, care should be taken in setting floor levels so that in case of failure of the system, the surcharges would not adversely affect the property. Council should include specific requirements for water cycle management in any DCP.

Smaller systems such as community gardens in public areas can be encouraged through local planning. By increasing the permeable surface area such schemes can reduce runoff and may be suitable in mitigating areas of localised flooding. For example, enforcing simple policies, such as standard treatment within public space to include kerbside catchment treatment and limiting the imperviousness of proposed development unless accompanied by offset works, will reduce flood volumes and hence reduce flooding. However, the effects of small scale catchment treatment and WSUD features are hard to quantify exactly through hydraulic modelling and depend on a range of factors such as permeability of soil, the conditions prior to the event (antecedent conditions), intensity of rainfall, size of the garden etc.

SUMMARY

Providing water cycle management on all new developments should be encouraged and can have beneficial effects in preventing increases in urban flooding in the future. However, to aid developers Council should continue to provide advice on appropriate water cycle management and also require the long term maintenance of water cycle management works to be considered.

As a general concept, catchment treatment techniques and WSUD should be encouraged for example, OSD, limiting on-site imperviousness for developments, controls on land use, along with water quality and other environmental controls. Although the effects may seem minimal on the individual development, the cumulative adverse effects from several developments will be significant and the use of water cycle management approaches will reduce this.

6.3.6. Blockage Prevention Devices

DESCRIPTION

The impact of blockage of bridges and culverts by debris (vegetation, cars etc.) will increase flood levels however our scientific understanding of this issue can be summarised by the following statement in the February 2013 AR&R Project 11, Stage 2 report.

"Understanding the issue of blockage has been found to be a difficult problem, and there are many aspects and differing opinions expressed across Australia and internationally on how blockages should be accommodated or even if they are a problem. There is also very limited recorded or observed data to allow a quantitative estimate of the risks of blockage at a given location, even though a significant number of photographs exist of blockages taken after flood events. This lack of relevant recorded data is one reason for the lack of national agreement on the best approach to the estimation and management of structure blockages."

DISCUSSION

There is little history of large blockages occurring in the Erina Creek catchment in the February 1990 and smaller June 2007 events. However as noted in the AR&R Project 11 reference the occurrence of blockage can vary significantly between events in the same catchments. For frequently blocked culverts or bridges many Councils, including Gosford, have installed various types of debris deflector devices. There is no technical data on the success or otherwise of these devices. However anecdotal advice from Gosford City Council suggests that these devices have been beneficial in reducing blockage at several sites in the LGA. This system may work successfully for large debris carried during a flood but would not reduce the effects of siltation (Photo 12).

At many locations, such as at the Nunns Creek crossing at The Entrance Road (Central Coast Highway), the effect of blockage in a road overtopping event is not significant as the roadway can accommodate a significant increase in peak flow for a relatively small increase in peak level due to its relatively large width and overtopping occurs in relatively frequent events. At other locations where road overtopping will only occur in events larger than the 1% AEP, such as at Worthing Road Creek, then blockage will impact significantly on the damages upstream. Results from an investigation into blockage at Worthing Road Creek is provided in Table 22 and indicates that the effect of blockage varies depending upon the magnitude of the event but may increase flood levels by up to 0.7 m. As indicated some conservatism has been included in the 2012 Erina Creek Flood Study Review (Ref 1) by assuming a 50% blockage at several structures (refer 2012 Erina Creek Flood Study Review - Ref 1 for details).

Table 22: Worthing Road Creek – Effect of Blockage (base assumes 50% blockage)

	Design Event (change in peak level in m)				
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Blockage at 25%	-0.17	-0.17	-0.17	-0.20	-0.27
Blockage at 75%	0.53	0.67	0.74	0.75	0.49

There is no debris deflector device that will guarantee that blockage of a culvert or bridge will not occur. It is possible that such a device may even accentuate flooding in some circumstances. Thus no guidelines can be provided at this time.

On-going inspection and maintenance to remove non-natural debris build up, such as fences, should be removed as soon as practical by Council, as should a major build up of vegetative debris due to fallen trees or similar. However a minor build up of debris or silt is likely to be removed in any subsequent flood.

SUMMARY

On-going inspection and maintenance will reduce but not eliminate the potential for blockage. Debris deflector devices should be considered where appropriate.

The most vulnerable structure, in terms of potential increase in damages, in the catchment is the culverts under The Entrance Road (Central Coast Highway) on Worthing Road Creek.

The impact of blockage at all structures should be investigated immediately following all future flood events.

6.4. Property Modification Measures

6.4.1. House Raising

DESCRIPTION

House raising has been widely used throughout NSW to eliminate or significantly reduce flooding of habitable floors. However it has limited application as it is not suitable for all building types. Also, it is more common in areas where there is a greater depth of flooding than in many places in this catchment and raising the houses allows creation of an underfloor garage or non-habitable area (though it is essential that this underfloor area and its contents will not incur flood damages, as if it is infilled this may negate the benefits of house raising). House raising is not suitable for properties that are affected by permanent inundation as, while the building may be above flood levels, the land and infrastructure will be affected by the rising waters.

DISCUSSION

House raising is suitable for most non-brick single storey houses on piers and is particularly relevant to those situated in low hazard areas. The exact number of houses suitable for raising and within a high hazard area is likely to be less than 20. The benefit of house raising is that it eliminates flooding to the height of the floor and consequently reduces the flood damages. It should be noted that larger floods than the design flood (used to establish the minimum floor level) can still inundate the house floor. It also provides a safe refuge during a flood, assuming that the building is suitably designed for the water and debris loading. However the potential risk to life is still present if residents choose to enter floodwaters or are unable to leave the house during a medical emergency, or larger floods than the design flood occurs.

Funding is available for house raising in NSW and has been widely undertaken in rural areas (Macleay River floodplain) and urban areas (Fairfield and Liverpool). It has been used on one occasion in the past in the Worthing Road Creek catchment on Nerissa Road as an outcome of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C).

An indicative cost to raise a house is $80,000 though this can vary considerably depending on the

specific details of the house. House raising was the traditional method of eliminating tangible flood damages but is less prevalent today in NSW as:

- the majority of suitable buildings have already been raised;
- the houses that can be raised are nearing the end of their useful life;
- house styles and requirements (ensuites, cabling, air conditioning) means that the piered homes are less attractive than in the past;
- most households indicate that they would prefer to use the funding to construct a new house;
- re-building rather than renovations are becoming more cost effective. In many suburbs in Sydney 30 year old brick homes are being demolished as the cost per m^2 to renovate is up to twice the per m^2 cost of re-building. Thus if 50% of the house is to be renovated it is more cost effective to re-build.

As house raising relies on assistance from government funding, only the houses with exceptionally low floor levels and those that are located within a high hazard, floodway or flood storage area would qualify for government assistance.

The house raising potential cannot be accurately assessed with absolute certainty due to the lack of specific detail in the floor level database. However it is acknowledged that there will be many that could be raised though many may be impractical or the owners are unwilling.

A house raising/re-building subsidy scheme has been considered whereby the home owner can put the payment towards the cost of a replacement house constructed in a flood-compatible way rather than raising the existing building. Such a scheme has been promoted in other flood prone communities in NSW where there are large numbers of houses that could be raised but many owners wish to re build and/or consider it more cost effective. This scheme would provide a financial incentive to undertake house raising or re-building works and would be available to all house owners whose house is flood liable. However such a scheme is not expected to receive funding from the federal or State Government's flood mitigation program and thus is unlikely to be affordable.

Slab-on-ground construction is probably the current most common method of housing construction. A significant issue with this mode of construction is that the building floor is generally not much higher than the ground level, thus there is a risk with overland flow or shallow depths of flooding that some above-floor flooding will occur. House raising has been undertaken for slab on ground houses in the past at Fairfield but is not generally undertaken.

SUMMARY

For the majority of currently flood affected buildings house raising is not a viable means of flood protection, largely because the house is not suitable for raising or is nearing the end of its life. However if advertised and favourable responses are obtained from the owners a house raising subsidy scheme should be further investigated for houses outside floodways and high hazard areas.

In addition a house re-building subsidy scheme should be initiated in order to provide an incentive to all house owners whose house floor is flood liable.

Council should also consider whether slab-on-ground construction is an appropriate form of house construction in areas that will be subject to increased flooding. An alternative is to require houses that can have service connections adjusted, their floors easily raised in the future, or be re-located if the risk becomes too great.

6.4.2. Flood Proofing

DESCRIPTION

An alternative to house raising for buildings that are not compatible or not economically viable, is flood proofing or sealing off the entry points to the building. This measure can be used for all building use types and it is possible to retrofit an existing building. Flood proofing requires sealing of doors and possibly windows (new frame, seal and door); sealing and re-routing of ventilation gaps in brick work; sealing of all under floor entrances and checking of brickwork to ensure there are no gaps or weaknesses in mortar.

Flood proofing can also include the fitting of non-return valves to all inlet / outlet pipes to reduce the risk of floodwater, possibly mixed with sewage, entering the building. Ensuring that electrical and other service ducts are appropriately sealed and/or raised above a flood level is also a form of flood proofing. For new developments, consideration of appropriate water resilient material is important.

Alternatively, temporary flood proofing can also be achieved by the use of sandbags in conjunction with plastic sheeting or private flood gates which fit over doors, windows and vents and are deployed by the occupant before the onset of flooding. A major issue with this measure is the limited warning time available for owners to install the temporary devices. Flood proofing should also be encouraged for all new development in flood prone areas.

DISCUSSION

Flood proofing has the advantage that it is generally less expensive than house raising and causes less social disruption. Generally an existing house can be sealed for approximately $10,000. The cost for commercial properties can vary depending on its use and the level of protection required. It is generally only suitable for brick buildings with concrete floors and it can limit ingress from outside depths of up to one metre. Greater depths may cause structural problems from too much hydrostatic pressure unless water is allowed to enter. It is generally impossible to keep water entirely out of a building, particularly during deep and longer duration floods. However, measures can be taken to reduce as much water as possible from entering.

New development and extensions allow the inclusions of flood appropriate materials and designs meaning the actual cost of flood proofing can be significantly less when compared to buildings requiring retro-fitting of flood proofing measures. However flood compatible building or renovating techniques should be employed for extensions or renovations where appropriate. Guidelines are provided in a booklet *"Reducing Vulnerability to Flood Damage"* prepared in 2006 for the Hawkesbury-Nepean Floodplain Management Steering Committee (Ref 18).

The use of temporary measures such as flood gates which occupants fit over their doors and other possible water inlets can be useful in areas where there is shallow flooding (Photo 13). These methods are better employed when flooding is of short duration otherwise people may become

stranded in their homes. Alternatively they can be used to make a property more flood resistant before evacuation. However, temporary flood proofing measures rely on sufficient warning time to be effective so that they can be installed before the onset of flooding. A likely cause of failure is that they are only employed every few years and thus parts may be lost meaning that they cannot be installed.

For commercial and industrial units this is a good technique to use where stock, machinery or other goods cannot be moved before the onset of flooding and also suitable where flood depths may be shallow but have potential to cause significant damages. The greatest benefit is achieved when the flood proofing is implemented as a door and thus the measure is activated every night.



Photo 13: Floodgate at a property (left) and custom made professional flood gate (right)

Permanent flood proofing measures are generally more suitable for commercial and industrial buildings where there are only limited entry points and aesthetic considerations are less of an issue compared to residential dwellings. Issues of compliance with regulations such as fire safety as well as access issues mean that flood proofing the building with exception of the main access which is then flood proofed by a temporary flood gate before the onset of flooding is a popular option. This measure has been adopted on the creek side of the restaurant/bar at the intersection of Bonnal Road and The Entrance Road (Central Coast Highway).

In some instances, although a building may have been constructed to be flood proof, flooding can cause backing up of sewage systems and flood water mixed with sewage can backup into a property through toilets and waste water pipes. Fitting non-return valves to plumbing can help reduce this, particularly in areas where drainage during floods is a problem.

Minimising the chance of electrocution by turning off the electricity supply during a flood should be standard practice for both residents and commercial owners during floods. For new buildings, flood proofing should also consider suitable electrical installation so as to avoid the risk of electrocution. It is generally recommended that all new properties in flood prone areas be fitted with a circuit breaker. Although, for all new developments, ideally all unsealed electrical circuits should be at the FPL.

For new development the materials for construction and even internal fixtures should be suitable for

the level of flood risk. Building materials chosen need to be able to retain their structural integrity under inundation and facilitate drying. For example reinforced concrete or block work can withstand hydrostatic pressure and can dry quickly whereas untreated timber and other woods such as plywood can affect the structural integrity of a building during flooding. Furthermore, slow drying materials can cause further issues such as damp and some materials may warp or swell when subjected to water and will not recover. Internal finishes and fittings should also be considered. For example tiled floors are easier to clean and or replace if damaged from flooding and lime based plaster or cement on lower walls allows them to dry out quicker.

Additionally, flood proofing can involve the raising of easily damage/high cost items such as commercial stock, equipment and machinery.

SUMMARY

Flood proofing is a good solution for reducing flood risk to commercial and industrial properties. Flood proofing techniques, be they permanent or temporary, could be utilised for the properties in the flood affected industrial areas. Temporary systems are more likely to be effective for the more frequently flooded properties as infrequency of use will lead to the system being poorly maintained, leading to a greater chance of failure during a flood event. However, the lack of flood warning or flood events occurring out of business houses may limit their efficiency.

Flood proofing for residential dwellings is considered less appropriate as there can still be risk to life if people remain in the building; raising floor levels above flood levels is considered to be safer. However, as existing houses cannot be raised, flood proofing is useful for existing properties.

Grant funding is usually not available for flood proofing. Although Council cannot be responsible for flood proofing existing properties, they can enforce flood proofing for any new development within flood prone areas through planning controls. Furthermore, Council can, through a flood awareness campaign targeted at both commercial and residential property owners, make available information on flood proofing existing buildings such as temporary flood barriers and fitting non-return values.

6.4.3. Voluntary Purchase

DESCRIPTION

Voluntary purchase involves the acquisition of flood affected residential properties (particularly those frequently inundated in high hazard areas) and demolition of the residence to remove it from the floodplain. Generally the land is returned to open space.

Voluntary purchase is mainly implemented in high hazard areas as a means of removing isolated or remaining buildings and thus freeing both residents and potential rescuers from the danger and cost of future floods. It may also help to restore the hydraulic capacity of the floodplain.

Voluntary purchase of all the buildings inundated above floor level in the 1% AEP flood (62 houses are shown on Table 12 as being inundated above floor level with a current market value of > $500 000 per building) cannot be economically or socially justified. Generally, Government funding is only available for voluntary purchase of buildings that are frequently flooded in a high hazard area. Voluntary purchase may also introduce a number of social problems (residents are unwilling to sell,

or are unable to find alternative accommodation with similar attributes) which can be difficult to resolve.

Although it is not considered feasible to purchase all flood prone buildings, in some flood liable areas individual buildings may be suitable for voluntary purchase due to their particular circumstances (isolation, high hazard, regularly flooded).

DISCUSSION

As indicated in Section 6.4.3 voluntary purchase of all existing buildings inundated in the PMF cannot be justified on economic grounds. However the three pole houses at 96, 98 and 100 Chetwynd Road (Photo 14) and raised house (92), experienced significant flood damages in the relatively small flood event of 15th February 2013 (Photo 15). According to the available rainfall data this event was less than a 10% AEP, however the flood marks indicate a much larger event at these properties. This could be that the localised rainfall is greater than registered at the rain gauges.



Photo 14: Pole homes on Chetwynd Road



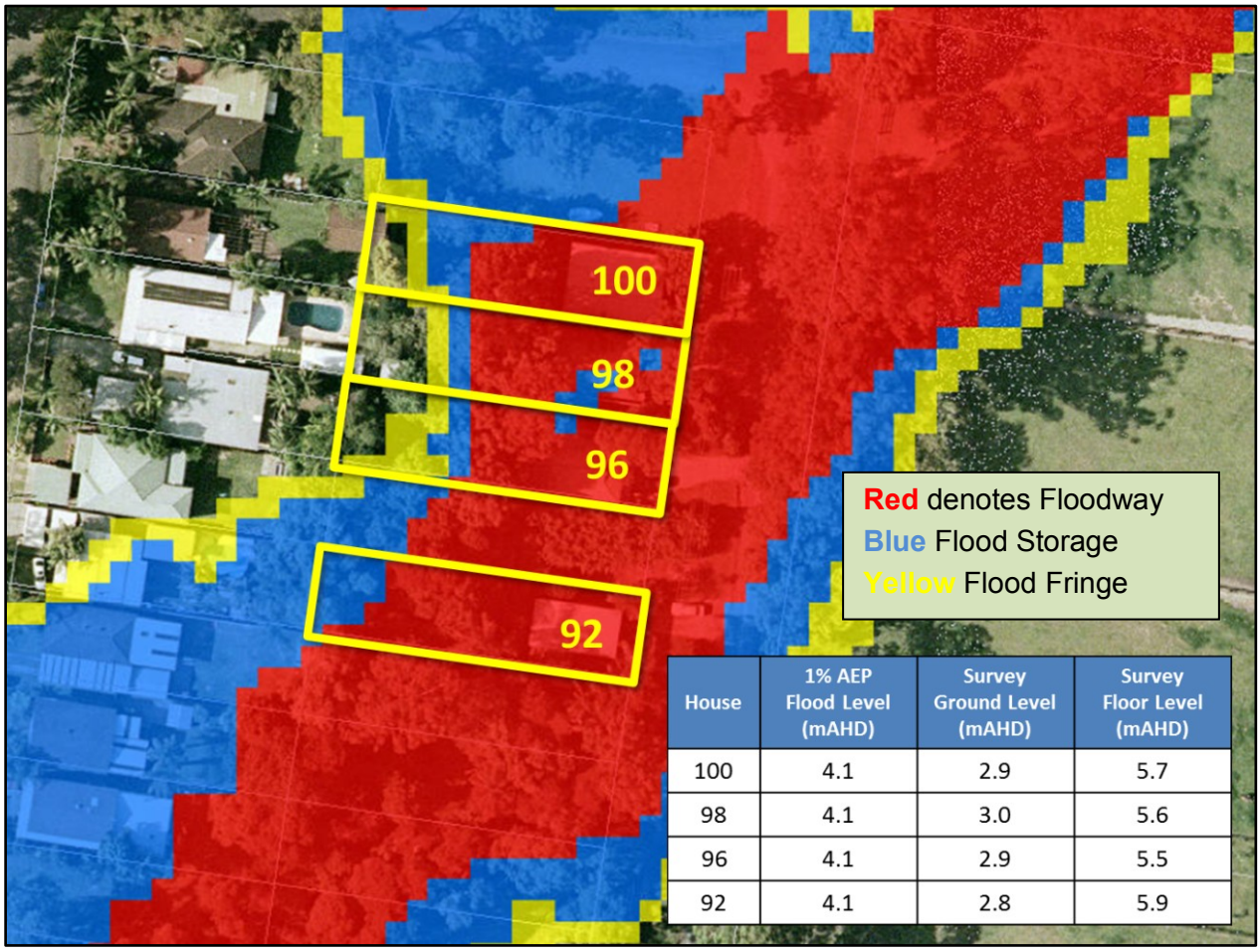
Photo 15: Below floor damage in February 2013 event

The four pole/raised homes at Chetwynd Road have also experienced below floor damage in several other floods since they have been built. Whilst no above habitable floor damages occurs and if the residents do not leave their home, there is minimal risk to life, there is always a risk that residents might enter the relatively deep (over 1 m) and fast flowing floodwaters. In addition the houses may be structurally damaged if debris collects against a house during a flood and dams up flood waters to the extent where it is in danger of being pushed off its foundations and washed away. Residents have also indicated that scour damage due to flooding has affected the structural integrity of the poles.

Four buildings have been identified for potential voluntary purchase; 92, 96, 98 and 100 Chetwynd Road. Although these properties are not flooded above floor level in the 1% AEP event, they lie within the high hazard floodway (area shown as red in Photo 16 below) and the only means of eliminating this risk to life is to offer voluntary purchase. These properties are subject to inundation in events as small as the 2-year ARI when flood depths are approximated to be over 1 m. The benefit cost ratio of this measure if assessed entirely on the reduction in direct tangible damages is likely to be very low (less than 0.1) as the only direct tangible damages are external. However monetary quantification of indirect tangible damages (loss of work, cleanup costs) together with intangible damages (risk to life, inconvenience, injury - for which a monetary value cannot be assigned) would significantly increase the benefit cost ratio. For this reason a financial benefit cost ratio should not be used as the sole criteria for determining the merits of this measure.

Voluntary purchase has no environmental impacts although the economic cost and social impacts can be high. Many residents do not accept voluntary purchase because it would have significant impact on their community and way of life. Among these concerns are:

- it can be difficult to establish a market value that is acceptable to both the State Valuation Office and the resident;
- in many cases residents may not wish to move for a reasonable purchase price;
- progressive removal of properties may impose stress on the social fabric of an area;
- it may take several years before funding becomes available and in that time it is difficult for the owners to sell their properties privately as they would likely have to advise potential purchase of the voluntary purchase scheme.



House	1% AEP Flood Level (mAHD)	Survey Ground Level (mAHD)	Survey Floor Level (mAHD)
100	4.1	2.9	5.7
98	4.1	3.0	5.6
96	4.1	2.9	5.5
92	4.1	2.8	5.9

Photo 16: Properties for Suggested Voluntary Purchase – Chetwynd Road

However voluntary purchase is the only means of removing houses from the floodplain that present a regular and significant risk to life and flood damages that cannot be protected by other means.

SUMMARY

The property owners at 92, 96, 98 and 100 Chetwynd Road should be placed in a voluntary purchase scheme. There are no other houses in the studied area of the floodplain which meet the criteria for voluntary purchase.

6.4.4. Summary of Strategic Planning Issues

DESCRIPTION

The division of flood prone land into appropriate land use zones can be an effective and long term means of limiting danger to personal safety and flood damage to future developments. Zoning of flood prone land should be based on an objective assessment of land suitability and capability, flood risk, environmental and other factors. In many cases, it is possible to develop flood prone lands without resulting in undue risk to life and property.

The strategic assessment of flood risk (as part of the present study) can prevent new development occurring in areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce the potential damage to new developments likely to be affected by flooding to acceptable levels. Development control planning includes both zoning and development controls.

With any increase in flooding the continued habitation or re-development of an area may become increasingly difficult to sustain, as the risk increases, and the maintenance of services and infrastructure becomes increasingly expensive. There are several flood liable areas in NSW where past floods have caused relocation to higher ground (Terara village to Nowra on the Shoalhaven River following the 1860 and 1870 floods) or the gradual decline of an area with limited potential for re-development (Horseshoe Bend at Maitland following the February 1955 flood).

The two issues of continued habitation or approval for re-development must be considered in light of future elevated flood levels or rise in the normal Brisbane Water level.

DISCUSSION

Flood extent mapping from the 2012 Erina Creek Flood Study Review (Ref 1) has been undertaken as part of this study, based on the best available information (airborne laser scanning and accurate to ±0.15 m) and should be used by Council to identify properties subject to flood related development controls.

6.4.4.1. Filling in the Floodplain

Filling of flood liable land is generally not considered an acceptable means of permitting future development as it damages the ecology of the area, reduces the temporary floodplain storage capacity or the hydraulic capacity of the creek system resulting in an increase in flood levels and affects local drainage.

An investigation was undertaken to see if filling of all the land deemed flood fringe in the 1% AEP event would significantly increase flood levels. The results of this indicated that even a small amount of filling in a sensitive area may increase flood levels both upstream and downstream. The impacts for filling to a depth of up to 500mm within flood fringe areas are shown on Figure 7.

Thus no areas can be approved for filling without a detailed hydraulic modelling assessment being undertaken and where appropriate consideration of Council's adopted climate change policy. It is not possible to provide guidelines which can be applied to permit even a small amount of filling on the floodplain as the impact will vary depending upon the location and levels and form of any filling that is undertaken. Although small areas may have minimal impact the overall cumulative filling of several areas should be considered. Therefore if filling of any flood fringe area is to be allowed the offsite impacts should be none.

The broad conclusions of this assessment are:

- filling in a floodway or flood storage area is not recommended and any works require a detailed hydraulic study;
- all flood assessments must be undertaken by a suitably qualified professional engineer who can demonstrate current experience in this field;
- filling in a flood fringe area may be approved but this depends on the extent and location of the proposed filling. The results of a broad based assessment of filling to 0.5 m depth in all flood fringe areas in the 1% AEP event is shown on Figure 7. This indicates that no substantial amount of filling can be approved in even flood fringe

areas without some form of hydraulic assessment. It is preferable that a detailed hydraulic study be undertaken to support any filling and the TUFLOW model from the 2012 Erina Creek Flood Study Review (Ref 1) can be made available;

- any filling within the 1% AEP floodplain must be initially assessed by council officers or an independent expert to determine if a hydraulic modelling assessment is required or not. Use of the modelling approach developed in the 2012 Erina Creek Flood Study Review (Ref 1) enables a rapid and cost effective means of assessing the hydraulic impacts;
- the proponent must consider the cumulative effects of approving any filling. As a general guideline filling that increases flood levels on surrounding properties by greater than 0.01 m in the 1% AEP event would not be approved unless some mitigating circumstances apply;
- it is suggested some allowance be made for minor increases to filling on existing lots with existing development to allow for increases in area required for sewer management dissipation systems above the 1% AEP flood level;
- filling by a cut and fill approach within the 1% AEP extent so no importation of fill is involved is generally acceptable and in some circumstances Council may preclude the need for a detailed hydraulic study;
- filling within the existing building footprint is permitted for all new developments that have approval for habitation on the ground floor and the ground floor is either on the ground or on piers with the floor no greater than 0.5m above the ground. Approval for filling beneath other existing building floors may be acceptable subject to more detailed investigation;
- filling on land above the 1% AEP flood extent will generally be supported but consideration must still be given to the possible impacts in larger events up to the PMF (in case there is a significant change in impacts) and
- filling must take into account the potential impacts of sea level rise (refer Section 6.4.4.2). The main developed areas affected by sea level rise (refer Section 6.4.4.2 and Figure 6) are on the west bank of Erina Creek immediately upstream of the Punt Bridge (Enid and Sierra Crescents). Filling within these areas to mitigate the effects of sea level is acceptable.

6.4.4.2. Sea Level Rise (Figure 6)

It is possible that some existing developed areas will be impacted by sea level rise in future based on the best regional, national and international projections of sea level rise along the NSW coast of the order of 20 to 40 cm by 2050 and up to 90 cm by 2100. These impacts may include the potential for regular tidal or permanent inundation of vulnerable properties (refer to Figure 6). For design runs, the water level was assumed to be static at 0.74 mAHD which corresponds to the 1% Probability of Exceedance level – *this level is not equivalent to the 1% AEP flood level in Brisbane Water and indicates the water level that is equalled or exceeded 1% of the time*. This level will rise by approximately the same rate as sea level rise.

Adaptation strategies to mitigate the impacts of sea level rise are not included in this Management Plan however each area identified as being potentially impacted will need to be examined in detail as part of any future adaptation plan for the Gosford LGA. These adaptation plans will initially only

include land downstream of Punt Bridge but subsequently can be extended upstream to affected areas. While measures may not be necessary for many years, planning needs to begin now to allow sufficient time to develop suitable adaptation plans, funding models, and market mechanisms to make the transition as easy and equitable as possible for when land becomes unsuitable for habitation due to frequent inundation.

Permanent inundation, increased flooding, and foreshore recession as a result of rising sea levels may make some land unsuitable for future development or re-development. However there is uncertainty regarding the projected sea level rise or its timeframe. Thus it may be possible to permit development in some areas with the proviso that if the projected sea level rise eventuates then the development must meet specific conditions developed as part of the adaptation plan.

The strategies could include house raising, mitigation works and a suite of conditions, or thresholds, including groundwater levels, inundation in non-flood times, continued provision of services and infrastructure, or availability of access allowing residents to stay until site conditions are considered unsuitable. Future development in low lying areas could be restricted to the lowest density residential and thus dual occupancy, sub division or increasing the site coverage (increasing the size of the building) would need to be considered very carefully. In affected areas already zoned for medium density residential or urban centres, this could mean back-zoning to a lower development density, which may have legal and financial ramifications for Council.

Legislative and financial options for Council and property owners to help deal with these situations should be raised with the NSW and Federal Governments, as the problem will occur in all coastal LGAs. There is also the possibility of establishing transferable development rights or similar schemes to encourage voluntary changes to inappropriate property zonings. These controls could be further refined through local area adaptation plans.

Any hydraulic modelling undertaken in areas subject to potential sea level rise impacts of greater than 0.1m as noted on Figure 6 must consider sea level rise in the assessment including the boundary condition of 0.74 mAHD for the 1% Probability of Exceedance level adopted in the Flood study. Figure 6 provides the expected rise in flood level that will occur with various sea level rise projections and forms the basis for determining flood planning levels.

In conclusion local area adaptation plans must include all areas affected by sea level rise in the Erina Creek catchment.

6.4.4.3. Ensuring Adequate Evacuation for Future Developments

For most of the existing flood liable areas there is reasonably safe access to high ground in a flood (see Section 4.7). However many residents are likely to remain in their houses unless at risk. Whilst in a medical emergency a helicopter or flood boat could access the area many residents might attempt to cross the floodwaters to collect children and family members, leave the house, stock up on supplies etc for example. This represents a burden on the SES to rescue residents and a risk to life to the residents who cross floodwaters unprepared. Appendix B provides information as a guide to the SES or others understanding where and when roads will become first inundated.

As a general approach all access roads and particularly the Central Coast Highway (Appendix B)

should be upgraded over time to ensure accessibility in events up to the 1% AEP and reduce the regular inundation of key access routes such as Wells Street and Carlton Road. Alternatively other access routes across the floodplain could be developed such as at Arundel Road if a bridge was constructed. The cost of this option would be in excess of $1 million and require resolution of a number of traffic and other issues.

6.4.4.4. Discontinuities with the Identification of Floodways

The hydraulic categorisations maps provided in the 2012 Erina Creek Flood Study Review (Ref 1) show that the floodways are not shown as continuous areas. This is because floodways are defined based on the following criteria (refer Section 4.2):

*Floodway = Velocity * Depth > 0.25 m^2/s* ***AND*** *Velocity > 0.25 m/s*
OR *Velocity > 1 m/s*

Thus when a creek exits from a confined channel into a relatively unconfined area with a small ill defined channel, if no part of the unconfined area satisfies the above criteria the area is classified as either flood fringe or flood storage. This presents a problem when applications are submitted for development in the unconfined area as there is no floodway area defined and potentially the flowpath across the area might be excessively restricted. To overcome this limitation the maps provided in the 2012 Erina Creek Flood Study Review (Ref 1) have been prepared to assist in assessing development (see example in Photo 17 - for further details refer Ref 1).

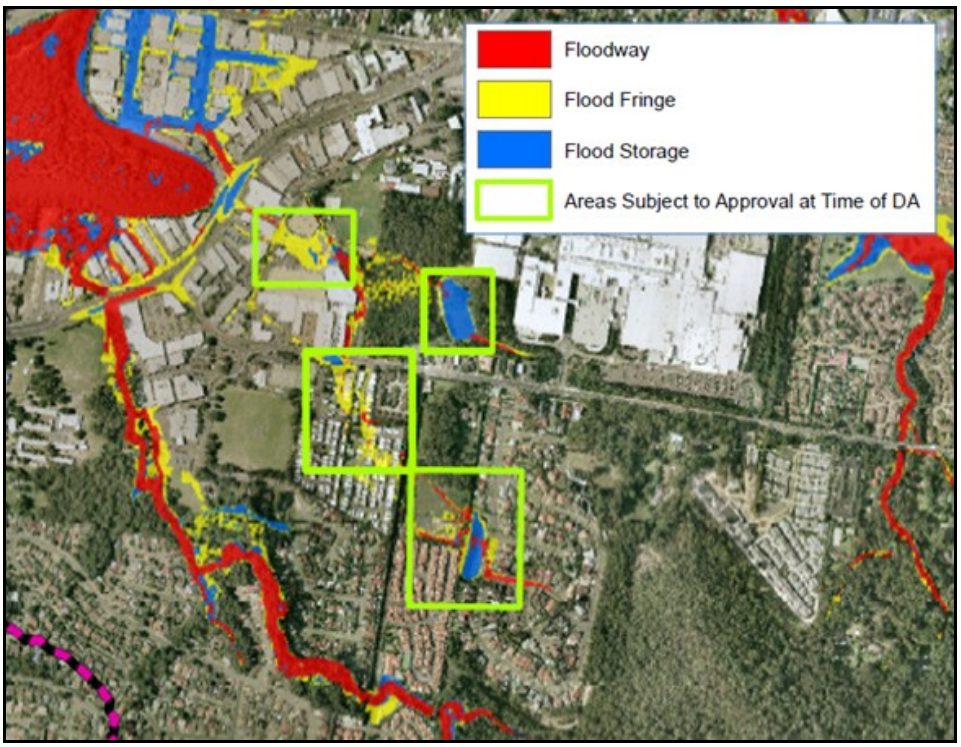


Photo 17: Example of discontinuities with identification of Floodways

6.4.4.5. Consideration of Impacts in Events Greater than the 1% AEP for Development Control

Council generally only considers the potential adverse impacts of a development in events up to the 1% AEP. For larger events no assessment is undertaken, although Council does consider

emergency access up to the PMF. For the majority of developments this is appropriate but an example occurred with the upgrading of The Entrance Road (Central Coast Highway) at the crossing of Worthing Road Creek (Photo 18) where the installation of safety barriers could significantly increase flood levels in overtopping events. With hindsight this situation could have been resolved using more flood compatible barriers. In conclusion, with all future road works and potentially other large infrastructure works further consideration to events greater than the 1% AEP should be considered and any impacts managed to within Council's standards by all infrastructure providers. Once the reconstruction of the barrier was complete, Council held discussions with the RMS to reduce the impact or remove the barriers at The Entrance Road (Central Coast Highway) at the crossing of Worthing Road Creek under a future works program.



Photo 18: Safety barriers on The Entrance Road (Central Coast Highway) at Worthing Road Creek (photo courtesy of Google maps)

6.4.4.6. Construction on or near Levees

The Barralong Road levee is the only levee within the catchment (Photo 10). This earthen and concrete wall levee was completed in the late 1990's and protects the majority of the urban areas near Barralong Road, Winani Road, Bonnal Road and Aston Road within the Barralong Road catchment area (1991 Floodplain Management Areas E3 and E7 areas (refer to Photo 3)). To ensure that future works are not built on or near to the levee which may impact on the ability to modify the structure Council should implement controls to limit development on or near any levee such as an offset/building line from the levee; restrictions on planting etc.

6.4.4.7. Intensification of Development in the 1% AEP Floodplain

There will always be continued pressure to develop in the floodplain as the land is relatively flat and thus suitable for development. The Erina Creek catchment and the Gosford LGA is vulnerable to an increase in flooding if inappropriate development occurs and therefore further intensification of development, particularly for residential development, should be limited within the 1% AEP floodplain

and detailed consideration still given to all proposals within PMF extent.

SUMMARY

Strategic planning is the main approach for reducing flood damages to future developments and in particular to adapt to the implications of the sea level rise benchmarks.

A number of strategic planning issues relating to the following issues have been investigated and guidelines provided:

- filling in the floodplain;
- sea level rise;
- ensuring adequate evacuation;
- discontinuities with the identification of floodways;
- consideration of impacts in events greater than the 1% AEP for development control;
- construction on or near levees;
- intensification of development in the 1% AEP floodplain.

6.4.5. Rezoning of Land

DESCRIPTION

In general rezoning of flood liable land to a less intense usage and thus less damage potential has not been undertaken in NSW as this would involve compensation for loss of development potential. However with the potential for sea level rise to significantly affect coastal lands this issue needs to be re-examined.

DISCUSSION

The 2010 NSW Coastal Planning Guideline: Adapting to Sea Level Rise (Ref 19) sets out principles for strategic and statutory land use planning in coastal areas. Principle 3 of the Guideline is to "avoid intensifying use in coastal risk areas" and Principle 4 is to "consider options to reduce land use intensity in coastal risk areas where feasible". While it seems common sense to prevent additional development in vulnerable areas this could, in effect, freeze new development in all flood affected foreshore areas. This is contrary to the aim of the NSW Government's 2005 Floodplain Development Manual (Ref 5) which seeks to allow new development in flood affected areas, provided the risk is adequately assessed and managed.

In general, it is likely to increase the risk to persons and property, if more buildings, infrastructure and people are located in areas that have an increased risk due to sea level rise when compared to the current flood hazard and also areas vulnerable to permanent inundation. So, land in the increased flood hazard areas as a result of sea level rise should not be re-zoned if it increases development intensity. Individual developments that increase development intensity within current zonings, should be assessed against the increased risk to persons and property as a result of the development to ensure there is no increase in risk.

In some specific circumstances, rezoning of flood liable land for higher density development could encourage people to purchase and demolish existing flood liable property and redevelop the area in accordance with Council's design floor level policy. This strategy is difficult to implement, as

generally the surrounding residents, who are not flood affected, consider that the quality of the area would be adversely affected by the increased building density. Furthermore the high cost to purchase the existing land and building is unlikely to make this measure financially attractive to developers. Additional concerns are the cost to provide and maintain on-going services (particularly with increased flooding risk) as well as the need to ensure adequate flood access. Such proposals should be, at least, considered against the criteria of "no increase in risk compared to current risk" for the life of the development.

SUMMARY

The wholesale rezoning of all flood liable lands is not appropriate, but this measure could be considered on a local scale as a means of removing or improving flood liable buildings, such as in the residential area bounded by Barralong Road, Winani Road and Lingi Street, Erina. Current land zonings of open space and natural areas within the floodplain should be maintained to prevent development in the floodplain.

6.4.6. Modification to the s149 Certificates

DESCRIPTION

Councils issue planning certificates to potential purchasers under Section 149 of the Environmental Planning and Assessment Act of 1979. The function of these certificates is to inform purchasers of planning controls and policies that apply to the subject land. Planning certificates are an important source of information for prospective purchasers on whether there are flood related development controls on the land. They need to rely upon the information under both Section 149(2) and 149(5) in order to make an informed decision about the property. Under Part 2 Council is required to advise if it is aware of the flood risk as it is of any other known risk (bush fire, land slip etc.).

Council revised the flood related information on s149 (2) certificates in 2013 to reduce confusion caused when some properties had more than one flood message attached. The current wording shown on Section 149(2) and 149(5) certificates provides limited wording on the flood affectation to the property, however its purpose is to draw attention of the enquirer to contact Council or refer to Council's website for more information on flood affectation.

DISCUSSION

Because of the wide range of different flood conditions across NSW, there is no standard way of conveying flood related information. As such, Councils are encouraged to determine the most appropriate way to convey information for their areas of responsibility. Gosford City Council modified the flood related messages in 2013 due to the confusion that was arising through multiple flood messages appearing on certificates. The message simply alerts the applicant to the fact that the land is subject to flood related development controls. The Section 149 certificate only relates to the subject land and not any building on the property.

New technology allows for the possibility of this information to be made available through on-line property inquiries. Council's website provides detailed flood mapping for areas where flood studies have been undertaken and all current flood studies are available on-line. The information provided under Part 2 of the certificate is determined by legislation and, unless specifically included by the Council, provides no indication of the extent of inundation.

Under Part 5 there is scope for providing additional information. Residents in many areas have suggested that insurance companies, lending authorities or other organisations may disadvantage flood liable properties that have only a very small part of their property inundated by floodwaters. Some councils have addressed this concern by adding information onto Part 5 to show the percentage of the property inundated as well as floor levels and other flood related information. In addition the hazard category could be provided and also advice regarding climate change increases in flood level.

SUMMARY

Flood information for s149 certificates is obtained mainly from computerised databases and maps and Council should investigate ways to make property-based flooding information more accessible via its web-site. Council will revise the flood related information on the s149 (2) and (5) certificates in accordance with the findings of this study.

6.4.7. Provision of Public Services

DESCRIPTION

The ability of public services (sewer pipes, pumps and treatment plants; water pipes and pumps; electricity; gas; roads; traffic facilities; cycleways; footpaths and bridges; recreational and sporting facilities; stormwater drains; stormwater pits and treatment devices) to accommodate increased water levels due to climate change is unknown. Probably the most critical (if failure during a flood occurs) is provision of sewerage. This loss of service affects both flood liable and non-flood liable properties if they are connected to a pump station that fails.

DISCUSSION

All public services are potentially affected in storm events producing flooding (wind or rain damage) however disruption due to inundation by floodwaters will generally not be of concern until events larger than the 0.2% AEP event (except for road and stormwater services). The only existing services for residential buildings potentially directly affected by inundation are private septic tanks.

If Brisbane Water levels rise as a result of climate change some services will be affected by permanent inundation and/or increased frequency of inundation, increased tidal inundation, and rising water tables. This is likely to increase maintenance costs (roads and other services such as drainage, sewer, water, gas and electricity), as assets are affected by salt water corrosion and saturation, and access for maintenance becomes more difficult and expensive. Local stormwater drainage infrastructure will become less effective, and may have to be redesigned and replaced. The public may also consider that the level of public services is reduced to below what is generally expected as reasonable.

The areas of permanent inundation that are on existing developable land are small (Figure 6) and mainly to the west and upstream of Punt Bridge. The remainder of the land is either wetland or open space.

This will add to the maintenance budget of Gosford City Council, RMS, and other supply authorities and may mean that, for example, the road standard will be reduced to a lesser standard in order to

maintain a level of service. A reduction in service levels may have ongoing ramifications for public safety and amenity.

When the impacts of an increase in inundation are considered with regard to the existing service levels, such as sewer outlets and manhole levels, significant works and costs may be required to maintain the service at working condition.

SUMMARY

Council and supply authorities need to undertake reviews of the projected impact of increased flooding due to climate change on the supply and maintenance of the services provided. This could be done as part of their asset management planning.

6.4.8. Minimise the Risk of Electrocution

DESCRIPTION

Minimising the chance of electrocution by turning off the electricity supply during a flood should be 'standard practice' for residents and commercial owners during floods. The risk of electrocution can also be reduced by installing electrical circuits above, at least, the flood planning level (1% AEP flood level plus 0.5 m freeboard plus sea level rise).

DISCUSSION

There is always the risk of electrocution in times of flood and whilst this has occurred elsewhere there is no record of injury or loss of life due to electrocution in the Erina Creek catchment. In order to reduce the risk of electrocution a flood education program (see Section 6.5.3) should be undertaken in vulnerable communities, especially with older housing stock.

SUMMARY

There is a risk of electrocution during flooding throughout the Gosford LGA which needs to be addressed. At a minimum, flood education programs should encompass this issue and there may be a role for specific programs targeting tradesmen, for example, to encourage safer installations.

All new developments and re-developments should have requirements to locate unsealed electrical circuits at least 0.5 m above the 1% AEP flood level. Older buildings should be encouraged to retro-fit measures such as incorporating circuit breakers and all new buildings should comply if constructed in accordance with best practice guidelines. A minimum aim should be to have all buildings with footprints within the 1% AEP flood level + 0.5m to, at least, be fitted with a circuit breaker.

6.4.9. Flood Planning Levels

DESCRIPTION

Flood Planning Levels (FPLs) are an important development control in floodplain risk management. Through planning controls Council has requirements for all new development to set finished floor levels above a given flood level. The Floodplain Development Manual (Ref 5) provides a comprehensive guide to the purpose and determination of FPLs. The FPL is a useful mitigation measure for future flood risk and is derived from a combination of flood level results from a flood event of specific probability, usually the 1% AEP, and freeboard of usually 0.5m. FPLs do not apply

to existing development, but through development controls are enforced on generally all new development.

DISCUSSION

Stipulating FPLs for all new development is one of the most effective measures in reducing flood damages to new properties without preventing development in a flood prone area entirely. Defining the appropriate FPL involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life caused by flooding against the social, economic and environmental costs of restricting land use and development in flood prone areas and of implementing management measures.

Developments more vulnerable to flooding such as hospitals, electricity sub stations, and housing for the elderly or less physically mobile, should consider rarer events greater than the 1% AEP when determining their FPL. However, the FPL does not address the full range of issues when considering flood and permanent inundation risk such as access and failure of essential services which should also be considered.

The 0.5 m freeboard should be included in the FPL and, as recommended in the 2010 Flood Risk Management Guide (Ref 6), it should not be assumed that the freeboard can take full account of climate change. According to the 2005 Floodplain Development Manual (Ref 5) the *purpose of the freeboard is to provide reasonable certainty that the reduced flood risk exposure provided by selection of a particular flood as the basis of a FPL is actually provided given the following factors*:

- uncertainties in estimates of flood levels;
- differences in water level because of local factors;
- increases due to wave action;
- the cumulative effect of subsequent infill development on existing zoned land; and
- climate change.

In a real flood some of these factors may reduce the flood level (local factors) or not apply at all (no wave action). Whilst climate change is included as one of the above factors there is no advice as to what the contribution for each factor should be. The 2010 Flood Risk Management Guide (Ref 6) states "*Freeboard should not be used to allow for sea level rise impacts; instead these should be quantified and applied separately*". The 0.5 m freeboard allowance allows for uncertainties, thus, if the best advice is that sea levels will rise by say 0.7 m by the year 2100, the FPL should be calculated to include this rise in the modelled flood heights. The climate change component in the 0.5 m freeboard allowance accounts for any uncertainty in estimation of the say 0.7 m sea level rise, and other climate change factors that are more difficult to predict, such as changes in rainfall intensities and storm frequencies.

A freeboard allowance above the design standard which is generally the 1% AEP flood level is to provide reasonable certainty that other hydraulic effects do not compromise the adopted standard. There is no technical reason that a 0.5 m freeboard and not some other value (lower or higher) is applicable for the Gosford LGA. A review of the hydraulic effects included in the freeboard indicates:

- uncertainties in design flood levels: Whilst there is always uncertainty in design flood estimation the magnitude of any error for Erina Creek varies along the creek system

depending on the quality and quantity of nearby calibration data. There is greater confidence if historical levels from a gauge and/or a large event are nearby;

- the effect of local hydraulics, such as flow between buildings raising levels may be a significant factor in places;
- climate change: sea level rise has been considered separately and is not within the 0.5 m freeboard as it has been established with a reasonable degree of certainty that it will occur as stated in the 2010 Flood Risk Management Guide (Ref 6). Other possible climate change effects are assumed to be included within the freeboard as there are no guidelines on the certainty to which they may occur and possibly some may reduce flood levels.. For example a decrease in rainfall intensities may occur; and
- continued assessment of developments on the floodplain by Gosford City Council should mean that increases in flood level due to further development are minimised as far as possible.

On the basis of the above assessment a freeboard of 0.5 m is reasonable.

The FPL can be varied depending on the use, and the vulnerability of the building/development to flooding. For example residential development could be considered more vulnerable due to people being present whilst commercial development could be considered less vulnerable in terms of risk to human life and health, or it could be accepted that commercial property owners are willing to take a higher risk with regard to flood damages. Likewise, critical services such as hospitals, fire stations and other services which would need to operate during a flood event would be considered more vulnerable to flood damage and could be encouraged to have even higher FPLs; or even better to be situated outside of the floodplain where possible. Flood proofing a building can be considered where raising floor levels is not an option or feasible and can be appropriate for the less vulnerable commercial and industrial developments but would not be appropriate for residential properties or high vulnerability buildings such as schools, hospitals or even essential services.

Under Council's current LEP and DCP floor levels required within those lots marked on flood planning maps are 0.5 m above the 1% AEP flood level for residential properties. Current controls do not make reference to finished floor levels for other land uses. Some Councils have chosen to allow commercial and industrial development to have lower floor levels. This can be a sensible approach which does not hinder development or the economy of an area.

The FPL can also be used to set requirements for flood proofing a building. New developments and re-developments within a flood prone area should have requirements to locate unsealed electrical circuits at least above the FPL for the area to reduce the risk of electrocution.

Although the FPL can reduce damage costs to a property it does not address the full range of issues when considering flood risk such as access and failure of essential services. Whilst raising the floor levels will ensure that the floors are not flooded in the design event there is still the issue of whether adequate services (sewer, roads) can be provided and therefore having raised floor levels does not mean that people should not be evacuated from their homes during extreme flooding in case services are cut and they become trapped.

The above discussion assumes what is generally termed mainstream flooding, i.e when the capacity of the open channel is exceeded and the excess runoff occupies the surrounding floodplain. However since the year 2000 a number of Sydney councils have undertaken what are called overland flow studies. Overland flow covers those areas where inundation occurs and generally there is no defined open channel system. However the boundary between the two categories is imprecise and therefore to reduce confusion Council should make the determination based on a logical criteria that is applicable throughout the LGA.

A different FPL criteria is generally applied in overland flow areas, due to the relative shallow nature of flooding and reduced risk to life, in order to categorise a property as flood liable on the 149 Part 2 planning certificate. The criteria needs to signify when the magnitude of floodwaters is sufficient to warrant categorising the property as flood liable, otherwise all properties would be categorised as all receive the 1% AEP rainfall in such an event.

SUMMARY

Council should review its methods for determining the FPL for various waterways as soon as possible to ensure standard methodology can be applied throughout the LGA, and not just the Erina Creek Catchment, and to also ensure that all landowners are up to date with the latest information. The procedure must be a written document outlining the reasons why Council has developed such a procedure and the criteria that have been adopted expressed in simple terms.

The policy should take into consideration all flood situations (mainstream, overland and estuary / lagoon flooding) as well as incorporating climate change (sea level rise, rainfall increase and wave action). The policy should also make clear distinctions between the land uses of residential and commercial / retail and the methodology to be applied to each land use.

The resultant policy must be supported by Council legal officers and involve a community engagement program that appropriately responds to issues that arise.

The following provides some suggested criteria for identifying properties to be encoded with an s149 message and the resulting FPL:

- flood levels should only be quoted to 1 decimal place;
- the criteria must be simple to apply and thus generalisations may have to occur in places;
- a consistent approach is required across the LGA;
- the criteria must be easily understood by residents;
- the criteria must be able to be easily amended if issues arise;
- different FPLs are required for different activities (residential, industrial, commercial, basement car parking etc.);
- the approach must recognise that different modelling approaches (direct rainfall as opposed to the more traditional approach) may require a different criteria to be adopted;
- different criteria may be required for mainstream creeks, overland, fronting Brisbane Water/lagoons and possibly for very flat areas such as Woy Woy which have local issues;

- the criteria must identify the design event on which it is based, the freeboard applied, any climate change sea level rise and/or rainfall increase components and the timeframes for implementation of climate change;
- the majority of LGAs in NSW adopt a FPL of the 1% AEP + 0.5m freeboard for residential properties affected by mainstream inundation (Cooks River, Hunter River) but adopt a lesser standard for overland flooding as the mainstream criteria may include properties that will only experience inundation in the PMF. Also refer to Council's DCP;
- for commercial/ industrial properties many Councils adopt a lesser FPL standard than for residential floors or even a flexible approach based on the nature of the business. For example a concrete batching plant should not have the same FPL as a carpet warehouse. For small commercial/industrial properties general FPLs may be suggested but can be changed depending upon the circumstances (which will need to be documented). One of the main reasons of difference between residential and non residential use is that nobody sleeps in the non-residential buildings (there may be exceptions) thus the risk to life is low;
- climate change sea level rise should be listed in 0.1m increments with < 0.1m assumed to be in freeboard;
- for rainfall increase further information is required to determine the assumed increase in temperature before the criteria of 5% increase/deg C can be applied. However if the increase is less than 0.1m this can be assumed to be within freeboard;
- one suggestion is to nominate in the DCP that all floors should be 0.3m above the surrounding ground.

The proposed FPL levels for residential floors are provided in Table 23. Climate change may also result in increases in rainfall intensity and thus increased flood levels which need to be considered in FPLs. The most current advice on climate change rainfall increase are contained in the 2014 Discussion Paper: An Interim Guideline For Considering Climate Change In Rainfall And Runoff, (Ref 21).

The amount of SLR applied to development, other than residential, needs to take into consideration the type of development and its asset life. Under Council's recently adopted Brisbane Water Foreshore Floodplain Risk Management Study 2015, the study recommended that the 2050 SLR prediction of 0.2m increase would account for a 35 year lifespan for residential development. This is a minimum and would be renewed under the CCAPS proposed to be prepared.

The use of Figure 6B for 0.2m SLR would be appropriate for residential development. Furthermore, vulnerable or longer term development types such as critical infrastructure should consider the application of the 2100 projected sea level rise as part of the FPL determination. These critical types of development would use the 2100 SLR increase of 0.74m and therefore Figure 6B with the 0.74m SLR would be used to apply the appropriate SLR. The updating of Council's DCP following the adoption of the Management Study and Plan would provide further detail on this issue.

Table 23: Proposed Flood Planning Levels for Residential Floors

FPL	For Mainstream Flows	For Overland Flows
Flood level	1% AEP flood level	1% AEP flood level
+ General Freeboard (GF) (includes rainfall intensity)	+ 500mm	+ 300mm
+ Sea level rise for projected increase (refer Figures 6A and 6B)	+ Level above 1% AEP in 0.1m increments as shown on Figure 6B for the specific area waterway	+ Level above 1% AEP in 0.1m increments as shown on Figure 6B for the specific area waterway

6.4.10. Review and Update LEP and DCP

DESCRIPTION

Updated and relevant planning controls are important in flood risk management and have been outlined in several of the above sections. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to guide new development away from high flood risk locations, ensure that new development does not increase flood risk elsewhere or ensure development in flood prone areas would be suitably designed, for example raised floor levels. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

DISCUSSION

The primary objective of the NSW Government's Flood Policy is "*to reduce the impact of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding, utilising ecologically positive methods wherever possible*".

Appropriate development controls involve consideration of the social, economic, environmental and risk to life of consequences associated with the occurrence and management of floods. This involves trading off various benefits of reducing the impacts of flooding on development, against the costs of restricting land use in flood prone areas and of implementing appropriate management measures.

The outcomes of this study should feed into an updated DCP in respect to flood related development controls or, alternatively, the existing documents can simply refer to this study and plan.

SUMMARY

A review of the available documentation and particularly the flood prone land and flood planning area maps should be updated following this study. Property identification should be undertaken for properties within the Flood Planning Area (FPA) (those properties subject to the 1% AEP flood level plus 0.5 m freeboard plus sea level rise) and can be considered for properties in the flood prone area and/or properties liable to flooding due to the impacts of future climate change or within the PMF

(refer Section 6.4.9). Controls for development other than residential should also be included within any updated DCP.

6.5. Response Modification Measures

6.5.1. Flood Warning

DESCRIPTION

The amount of time for evacuation depends on the available warning time. Providing sufficient warning time has the potential to reduce the social impacts of the flood as well as reducing the strain on emergency services.

Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. Adequate warning gives residents time to move goods and cars above the reach of floodwaters and to evacuate from the immediate area to high ground. The effectiveness of a flood warning scheme depends on:

- the maximum potential warning time before the onset of flooding;
- the actual warning time provided before the onset of flooding. This depends on the adequacy of the information gathering network and the skill and knowledge of the operators;
- the flood awareness of the community responding to a warning.

For smaller catchments a Severe Weather Warning (SWW) is provided by the Bureau of Meteorology (BOM) but this is not specific to a particular catchment.

DISCUSSION

The BOM is responsible for flood warnings on major river systems such as the Hawkesbury River. Flood warning systems are based on stations which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location. This information is then provided to the SES who undertake evacuations or flood damage prevention measures (sand bagging or raising goods). Studies have shown that flood warning systems generally have high benefit/cost ratios if sufficient warning time is provided. In this regard all residents should be made aware of the types of warnings issued by the BOM (refer flood awareness in Section 6.5.3).

The 2012 Erina Creek Flood Study Review (Ref 1) examined a range of rainfall durations from less than one hour to 12 hours, to determine the design storm duration which produces the highest water levels and concluded that the nine hour duration was critical, although shorter durations were only slightly lower. However, it is misleading to consider that the duration of the design rainfall event is necessarily related to the available warning time. A much shorter duration storm (1 hour) may produce a peak very similar but slightly smaller than the adopted design duration.

An alarm on Narara Creek was installed in 1979 to warn residents in the area of impending flooding from Narara Creek during periods of heavy rainfall. The siren provides approximately half an hour of warning before flood waters start to cut off road access from the houses in the area. Initially there were some vandalism issues but these were addressed. Similar alarms could be installed on Erina Creek at the most critical location(s) which would need to be determined by the respective authorities

taking into account access and other issues.

With all flood warning systems there is a need for ongoing education to constantly keep the residents adequately informed. This can be a challenge with a rapid turnover of land owners or a high proportion of renters.

SUMMARY

The BOM does not have a flood warning system for the Erina Creek catchment as the response time between the rainfall and flooding occurring is a few hours and thus too short a time to issue a warning. This is typical of all small catchments (generally less than 100km^2). The BOM does issue a storm warning or similar but this is not catchment specific and cannot be relied upon for flood evacuation purposes. However the warning does provide some guidance to the community that heavy rainfall is likely to occur and diligent residents may take appropriate actions.

A similar alarm to that previously installed on Narara Creek could be installed on Erina Creek. Regular information regarding the alarm system should be sent out to the current residents explaining the existence and need for the warning system, plus explanations on how it operates. The responsibility of enacting this education program rests with Council.

Council has installed several new rainfall and water level gauges in the last 20 years, thus providing a more accurate assessment of flooding. Council should continue with this program and ensure that some of the gauges are linked to the BOM system so that some real time rainfall recording is available. This would complement any new BOM storm forecasting system proposed for the Central Coast and thus provide catchment specific information to residents and emergency services.

In 2014 Council installed a mobile SMS warning system in Lisarow and if successful the system could be extended elsewhere. Council has received funding (2015) to undertake a study to review all its rainfall and water level recorders within the LGA which provides an opportunity to potentially link them with an overall flood and storm forecasting strategy.

6.5.2. Flood Emergency Management

DESCRIPTION

As mentioned above, it may be necessary for some residents to evacuate their homes in a major flood. This would be undertaken under the direction of the SES who are the lead agency under the Emplan (Emergency Management Plan). Some residents may choose to leave on their own accord based on flood information from the radio or other warnings, and may be assisted by local residents. The main problems with all flood evacuations are:

- they must be carried out quickly and efficiently;
- there can be confusion about ordering evacuations, with rumours and well-meaning advice taking precedence over official directions which can only come from the lead agency, the SES;
- there are hazardous conditions for both rescuers and the evacuees;
- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers; and
- people (residents and visitors) do not appreciate the dangers of crossing floodwaters.

For this reason, the preparation of a Community Flood Emergency Response Plan (CFERP) helps to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. It is the role of the SES to develop a CFERP for vulnerable communities.

DISCUSSION

It may be necessary for a number of residents to evacuate their homes during or following a major flood, such as the February 1990 and June 2007 events, though it is understood that most residents stayed in their homes and possibly moved goods and themselves to an upper floor or onto tables.

The SES has the skills and experience to undertake the necessary evacuations. Appendix B provides information as a guide to the SES or others understanding where and when roads will become first inundated. This should be updated as necessary.

A key concern with the ability of the SES (and other authorities such as the Rural Fire Service and Council) to respond in flood times is that their headquarters is located off The Entrance Road (Central Coast Highway) (Photo 19) within the Council depot, which means that in large events the access from The Entrance Road (Central Coast Highway) will be cut. A flood safe access must therefore be made available from Avoca Drive. Preliminary advice indicates that an endangered ecological community is located where a potential access route to Avoca Drive is proposed. Alternatively the headquarters could be relocated to a site outside the floodplain to ensure that Council, SES and other authorities have access in times of flood.

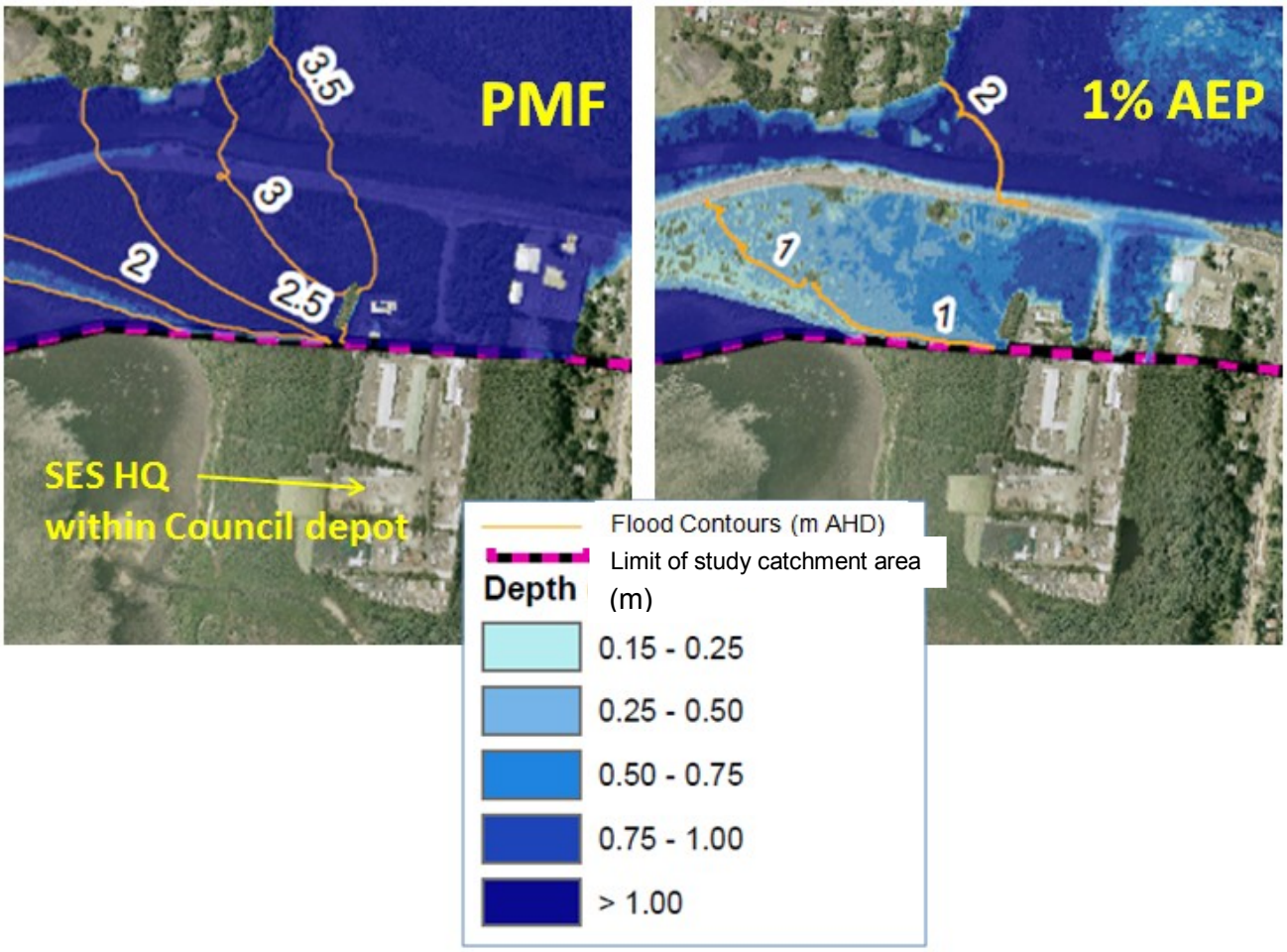


Photo 19: Council and Emergency Services Depot off The Entrance Road (Central Coast Highway) and 1% AEP and PMF Flood Extents

Generally all rural properties will have access to their properties inundated at one or a number of locations. Whilst access may only be unavailable for probably less than six hours residents will attempt to cross flood waters to help others, collect children, get to work or for some other reason they believe is essential. The SES advice is never to drive through floodwaters but recent past events in Queensland, NSW and Victoria in 2011 demonstrated that many people do not adhere to this advice. Cars can float in as little as 0.3 m depth of water and consequently a number of lives have been lost and the lives of rescuers put at risk in rescuing stranded motorists (Photo 20).



Photo 20: Cars drive through floodwaters at Milina and Carlton Roads even though a police vehicle is present

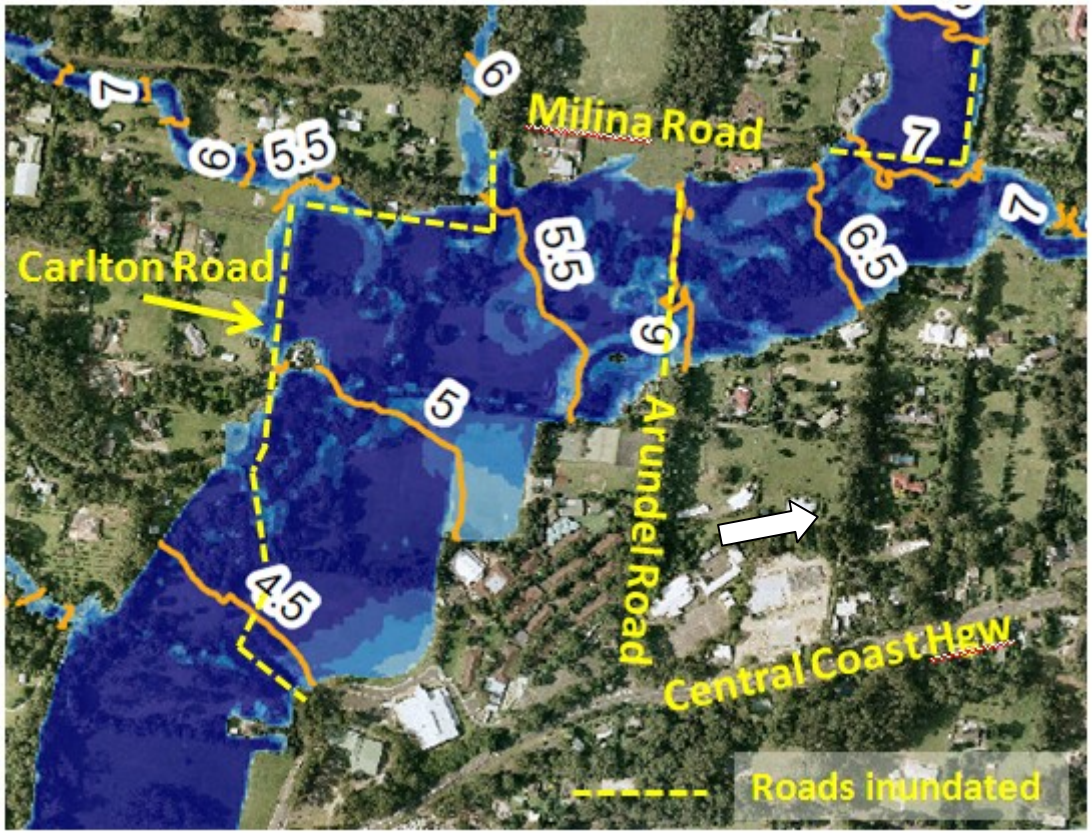


Photo 21: 1% AEP flood extent and contours (mAHD) between Carlton and Milina Roads)

Photo 21 indicates the main access routes across and adjoining the 1% AEP floodplain between Carlton and Milina Roads. Carlton and Milina Roads cross the floodplain but Arundel Road does not connect across the floodplain between Milina Road and the Central Coast Highway.

There are a number of measures that can be employed to reduce the risk to life, these include:

- provide alternate access routes where this is possible, however in many cases this is not possible without major infrastructure works. These works would be developed with consideration of flooding but also based on many other factors outside the scope of floodplain management such as ecology or land ownership issues;
- construct a bridge or culvert crossing at a low level causeway. As an example Council has received complaints regarding the causeway crossing on Oak Road, Matcham. The main issue with this measure at this and many other locations is the significant cost of construction compared to the relative infrequency of use and number of residents that would benefit;
- provide warning signs such as depth markers on every inundated road. This is a cost effective measure that would at a minimum advise motorists of the flood depth. In addition warning signs advising motorists of the risk of driving through floodwaters could be provided;
- provide automated warning “traffic lights”. This measure would probably provide greater guidance than simple depth markers, certainly at night, but it is highly likely that many motorists would disobey these and these are costly to install and maintain.

SUMMARY

The SES should ensure that there is a Local Flood Plan for the Erina Creek catchment. This might include floor level and ground level details provided in this report and the 2012 Erina Creek Flood Study Review (Ref 1). In addition, input from the local community including Council, RFS, and community representatives, through a Community Flood Emergency Response Plan (CFERP) is required to ensure that workable actions for the community are incorporated. Priority should be given to the implementation of this Plan once completed, which will involve ongoing community education and awareness.

Access to the SES HQ and other emergency services at the Council depot must be available from Avoca Drive to provide flood free and safe access in the event that The Entrance Road (Central Coast Highway) is inundated. Further investigation and planning to address this issue is required.

Access from rural properties to the main centres in times of flood should be improved upon. However it is acknowledged that no measure will eliminate the risk to life. Council should evaluate the most cost effective approach that would provide the most benefit to rural residents.

6.5.3. Public Information and Raising Flood Awareness

DESCRIPTION

The success of any flood warning system and the evacuation process depends on:

- *Flood Awareness:* How aware is the community to the threat of flooding? Has it been adequately informed and educated?
- *Flood Preparedness:* How prepared is the community to react to the threat of flooding? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?
- *Flood Evacuation:* How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life during a flood? How will the evacuation be done, where will the evacuees be moved to?

DISCUSSION

A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation. On river systems which regularly flood, there is often a large, local, unofficial warning network which has developed over the years and residents know how to effectively respond to warnings by raising goods, moving cars, lifting carpets, etc. Photographs and other non-replaceable items are generally put in safe places. Often residents have developed storage facilities, buildings, etc., which are flood compatible. The level of trauma or anxiety may be reduced as people have survived previous floods and know how to handle both the immediate emergency and the post flood rehabilitation phase in a calm and efficient manner.

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors including:

- *Frequency and impact of previous floods.* A major flood causing a high degree of flood damage in relatively recent times will increase flood awareness. If no floods have occurred, or there have been a number of small floods which cause little damage or inconvenience, then the level of flood awareness may be low. As a result

of the June 2007 flood, which only caused minor damage, the community generally has a low to medium level of awareness at this time (it will decline as the time since the last flood increases).

- *History of residence*. Families who have owned properties for a long time will have established a considerable depth of knowledge regarding flooding and a high level of flood awareness. A community which consists predominantly of short lease rental homes will have a low level of flood awareness. It would appear that many of the residents have lived in the area for several years and are therefore familiar with flooding. Also it is very likely that new residents will be aware from advice at the time of their property purchase (Section 149 certificate) or from neighbours after they move in. It is very unlikely that a new resident buying a house along Erina Creek will not be aware of the potential of flooding.
- *Whether an effective public awareness program has been implemented.* Council has produced a flood awareness brochure as well as provided information on Council's web page, released media articles, held interviews on local radio / television and recently produced a DVD detailing aspects of floodplain management. No large scale awareness program has been implemented in the past for Erina Creek, although in the last few years there have been many articles in the national and local press regarding the effects of sea level rise and flooding (Brisbane River floods of January 2011).

For risk management to be effective it must become the responsibility of the whole community. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs. The perceived value of the information and level of awareness, diminishes as the time since the last flood increases.

A major hurdle is often convincing residents that major floods (larger than the June 2007 long weekend event) will occur in the future. Many residents hold the false view that once they have experienced a large flood then another will not occur for a long time thereafter. This viewpoint is incorrect as a 1% AEP event (or sometimes termed a 100 year ARI) has the same chance of occurring next year, regardless of the magnitude of the event that may have recently occurred.

It is important to also educate residents on the different mechanisms of flooding. For example, those residents afforded protection from mainstream flooding by the Barralong Road levee should be aware that they may still be affected by flooding from local drainage issues. Furthermore, an awareness campaign can be important in ensuring that those residents protected by the levee do not become complacent about their level of protection and are aware of the potential impacts if the levee was to overtop or even fail.

Some NSW Councils (Rockdale, Pittwater, Maitland) have initiated catchment-wide flood awareness strategies (for residential and commercial). Gosford City Council and the SES websites also provide excellent information on flood awareness and other flood related and climate change information.

SUMMARY

Based on feedback it would appear that the majority of residents in the Erina Creek catchment have a low to medium level of flood awareness and preparedness.

As time passes since the last significant flood, the direct experience of the community with historical floods will diminish. It is important that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program that would include Floodsafe brochures as well as advice provided on the Council's and SES's websites. These need to be updated on a regular basis. A specific fact sheet should be produced for each creek relating specifically to the local issues. Table 24 provides examples of various flood awareness methods that can be used.

Table 24: Flood Awareness Methods

Method	Comment
Letter/pamphlet from Council	These may be sent (annually or biannually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of ongoing implementation of the Risk Management Plan, changes to flood levels, climate change or any other relevant information.
Council website	Council should continue to update and expand their website to provide both technical information on flood levels as well as qualitative information on how residents can make themselves flood aware. This would provide an excellent source of knowledge on flooding throughout the LGA as well as on issues such as climate change. It is recommended that Council's website continue to be updated as and when required.
Community Working Group	Council should initiate a Community Working Group framework which will provide a valuable two way conduit between the local residents and Council.
School project or local historical society	This provides an excellent means of informing the younger generation about flooding and climate change. It may involve talks from various authorities and can be combined with topics relating to water quality, estuary management, etc.
Historical flood markers and flood depth markers	Signs or marks can be prominently displayed on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators advise of potential hazards. These are inexpensive and effective but in some flood communities not well accepted as it is considered that they affect property values.
Articles in local newspapers	Ongoing articles in the newspapers will ensure that the flood and climate change issues are not forgotten. Historical features and remembrance of the anniversary of past events are interesting for local residents.
Collection of data from future floods	Collection of data such as photographs and observed flood heights assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible (as occurred successfully after the June 2007 event).
Types of information available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the 149 Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, regarding flood information currently available, how it can be obtained and the cost. This information also needs to be provided to all visitors who may rent for a period. Some Councils have conducted briefing sessions with real estate agents and conveyancers.
Establishment of a flood affectation effects database and post flood data collection program	A database would provide information on which houses require evacuation, which public structures will be affected (eg. telephone or power cuts). This database should be reviewed after each flood event and is already being developed as part of this present study. This database should be updated following each flood with input from the community.

Method	Comment
Flood preparedness program	Providing information to the community regarding flooding helps to inform it of the problem and associated implications. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program would ensure that the community is adequately prepared. The SES would take a lead role in this.
Develop approaches to foster community ownership of the problem	Flood damages in future events can be minimised if the community is aware of the problem and takes steps to find solutions. The development of approaches that promote community ownership should therefore be encouraged. For example residents should be advised that they have a responsibility to advise Council if they see a problem such as blockage of drains or such like. This process can be linked to water quality or other water related issues including estuary management. The specific approach can only be developed in consultation with the community.

The specific flood awareness measures that are implemented will need to be developed by Council taking into account the views of the local community, funding considerations and other awareness programs within the LGA. The details of the exact measures would need to be developed in consultation with affected communities.

6.6. Flood Insurance

DESCRIPTION

Flood insurance does not reduce flood damages but transforms the random sequence of losses into a regular series of payments. It is only in the last five years or so that flood insurance has become readily available for houses, although it was always available for some very large commercial and industrial properties.

DISCUSSION

There are many issues with the premium for this type of insurance and how insurance companies evaluate the risk. For example, different insurance companies identify risk in different ways; some base it on the house floor being inundated and others the ground within the property being inundated. Possibly other methods are adopted as well. Insurance companies generally do not disclose the exact method of determining the risk as this is considered commercial in confidence. These issues are outside the scope of this present study and have been re-assessed as part of the outcomes of the Commission of Inquiry into the South East Queensland floods of January 2011 (Ref 20). Flood insurance at an individual property level is encouraged for affected land owners, but is not an appropriate risk management measure as it does not reduce flood damages.

SUMMARY

All residential insurance policies must include and specify the additional component for flood insurance. This allows householders to choose whether to take up or not this component. The cost of flood insurance will vary amongst the insurance companies which use many sources of information to determine flood risk, including Council and OEH funded Flood Studies and to a much lesser extent Floodplain Risk Management Studies and Plans.

7. AREA SPECIFIC MANAGEMENT MEASURES

This section considers each of the defined Floodplain Management Areas (Figure 3) and makes recommendations for each area. It also reviews the recommendation of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) where applicable, and assesses the effectiveness of any measures implemented.

7.1. Floodways

Floodways have been redefined as part of the 2012 Erina Creek Flood Study Review (Ref 1) and are also discussed in Sections 4.2 and 6.4.4.4 of this report which identified some areas for special consideration (also refer to Chapter 6.7 of Gosford's DCP). The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) recommended for floodway areas that land use should be carefully controlled to ensure the conveyance area of the floodway is not reduced and no buildings, hazardous uses, obstructions likely to impede the flow of floodwaters or land filling would be permitted.

The previous recommendations are supported and should be continued. However, as the floodways have been redefined as part of the updated hydraulic modelling, the policy should apply to the new floodways areas. In addition, the areas identified for special consideration should be included in Council's planning policies and controls to ensure that they are examined as necessary should a development application be submitted.

Erina Creek and all its tributaries experience on going siltation and excessive vegetative growth. Whilst these are natural phenomena they can be exacerbated by uncontrolled runoff from building sites and/or runoff from gardens or parks that are rich in nutrients. Council needs to ensure that as far as practical controls are in place and appropriate mitigation measures implemented to minimise these adverse impacts on the creek systems to ensure an ecologically sustainable creek system that will not contribute to increased flood levels.

7.2. Upstream Catchments – Upper Erina Creek (C2/A), Oak Road (C2/B), Fires Creek (C2/C) Areas

Unregulated development in the upper catchment has the potential to increase runoff and therefore flooding over time. Although impacts on peak flood levels from development of individual sites could be negligible, the cumulative effects would be unreasonable and should be mitigated. The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) suggested that for all upstream development a Flood Study should be undertaken for any development which may impede, divert or raise flood waters to ensure that major floodplains remain undeveloped, future flows are not increased, the use of "'hard" channels are avoided where possible and that use of the floodplain must be flood compatible. The recommendations are supported and, in addition, consideration should be also given to the use of water cycle management including OSD and WSUD for all new development in the catchment as a general measure.

Inundation of local roads is a significant issue for many residents but preliminary investigation indicates that there is no viable economic solution. Appendix B provides information on the location

and depth of inundation on all road crossings in these areas. One approach would be to more closely identify the worst affected areas and provide a newsletter suggesting how residents could become involved. A community based approach with input from Council, is likely to be the most successful, with Council using the level and credibility of community information to inform its maintenance priorities for drainage works. This should be accompanied by a public education program to explain the risks in crossing inundated roads.

In addition, when Council upgrades local culvert crossings or bridges are replaced, consideration should be given to increasing the capacity of each structure and/or raising the height to improve flood access.

7.3. Milina Road Area (C2/D)

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) concluded that there were no viable flood mitigation measures that could significantly reduce flood levels in the area. The plan identified several areas where filling could be permitted to allow one dwelling per lot and provide a maximum of 500 m^2 of flood free land. This may have to be slightly increased to allow for the dissipation area for on-site sewage management systems if required.

Since 1991 some filling has been undertaken on the fringe of the 1% AEP floodplain at 347 Central Coast Highway and at 7 Carlton Road to allow a building to be erected above the 1% AEP flood level. Filling has also been undertaken and a house erected on 60 Carlton Road.

The hockey field and car parking built by the Central Coast Grammar School on 1 Arundel Road is partly located on land within the 1% AEP floodplain. These type of developments are a flood compatible use of the floodplain.

As properties in this area are on the periphery of the flood extents, any new development should be subject to the standard flood planning level controls. No development should be allowed in areas defined as floodway unless it is of a flood compatible nature and environmentally acceptable.

Inundation of local roads is also a significant issue for many residents and the suggested approach indicated in Section 7.2 is recommended. An emergency access route by extending Arundel Road should also be considered under any future proposal to upgrade flood access from Wattle Tree Road to the Central Coast Highway.

7.4. Erina Valley Road Creek Area (C2/E)

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) made several recommendations for this area including progressive purchase or flood proofing of four flood liable houses and consideration of one further house. This was considered high priority due to the severity of flooding of two houses in particular.

Following completion of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) the house on 16 Nerissa Road was raised and 18, 20, 22 and 24 Nerissa Road were all voluntary purchased (also refer Section 7.5), the houses removed and the land left vacant.

Many vacant lots which were identified as being unsuitable to build a house on due to their location in the floodplain were identified as undevelopable. These lots are slowly being purchased using Council only funds and this approach should continue. The majority of this vacant land in this area has been acquired by Council. An indicative price to purchase vacant blocks in this area is $4,000.

Four houses on Chetwynd Road; nos. 92, 96, 98 and 100, are situated in the floodway and, although habitable floor levels are raised, they become isolated during flooding by hazardous water. It is recommended that these properties are offered the option of voluntary purchase. If successful the houses would be removed and the land left vacant.

As this area is subject to flooding but access to high ground is limited in places, development controls should be used to appropriately limit new development. Development should only be in those areas not designated as floodway or flood storage and subject to Council's regulations as allowable development within the floodplain.

There is potential for increased residential development in this catchment and thus possible impacts on peak flows and flood levels downstream. These will need to be addressed in a rigorous hydraulic study and it is likely that mitigation measures such as retarding basins will be required to ensure no water quantity or quality impacts downstream.

7.5. Worthing Road Creek Area (C2/F)

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) made several recommendations for this area but only on the north side (Erina Valley Road Creek (C2/E) area) except the house on 45 Kuburra Road was voluntary purchased.

As this area is subject to flooding but access to high ground is limited in places, development controls should be used to appropriately limit new development. Development should only be in those areas not designated as floodway or flood storage and subject to Council's regulations as allowable development within the floodplain.

There is potential for increased residential development in this catchment and thus possible impacts on peak flows and flood levels downstream. These will need to be addressed in a rigorous hydraulic study and it is likely that mitigation measures such as retarding basins will be required to ensure no water quantity or quality impacts downstream.

No specific management measures are proposed for this area within this management study and plan.

Council should undertake discussions with the owners of Erina Fair with a view to encouraging the owners to construct a detention basin to limit flooding downstream that may be caused by the extensive increase in impervious areas of the shopping complex.

The western embankment of the Tarragal Glen retirement village retarding basin is immediately upstream of some of the units. It is recommended that this part of the embankment be raised by

approximately 0.5m over a distance of 50m in order to provide greater protection from overtopping and floodwaters entering the units. A detailed benefit/cost ratio has not been evaluated for this measure but is likely to be low (less than 0.2) as the units will only be inundated in large rare events which overtop the embankment. One of the main reasons for this measure is that overtopping increases the likelihood of embankment failure and raising will reduce this risk, though it can never be eliminated.

Many vacant lots which were identified as being unsuitable to build a house on due to their location in the floodplain were identified as undevelopable. These lots are slowly being purchased using Council only funds and this approach should continue. The majority of the vacant land in this area has been acquired by Council.

Council should liaise with the RMS regarding modifications to the crash barriers on the Central Coast Highway crossing of Worthing Road Creek to reduce their impact on flood levels in events which overtop the road (> 0.2% AEP).

7.6. Barralong Road Area (C2/G)

7.6.1. Industrial Area south of Barralong Road within Levee

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) noted that Council proposed to construct a bridge over Erina Creek to link Barralong Road with Clarence Road. This bridge, Yerrin Bridge, was opened in December 1998. The plan recommended that a levee would be the only viable measure to protect this area and subsequently the Barralong Road levee was constructed. This area is now afforded protection from mainstream flooding from Erina Creek to the 1% AEP event when the levee overtops in the north. Although the levee was designed at the time to the 1% AEP event, advances in hydraulic modelling and revision of flood levels means that its design standard is now just below the 1% AEP event.

Although the levee prevents mainstream flooding until it is overtopped in the 1% AEP event, flooding does still occur in smaller events due to local drainage from the Karalta Road area and flows exceeding the Nunns Creek channel. This generally does not affect properties above floor level until the 5% AEP event and depths above floor are shallow. Therefore it is recommended that local drainage and the capacity of the outfall from Nunns Creek be investigated and upgraded where necessary to reduce surface flows travelling down the Central Coast Highway and entering the industrial area at Bonnal Road. It is also recommended that any opportunities for providing retarding basins upstream should be investigated as part of any drainage upgrade.

Although properties are protected by the levee this must not allow occupants of the area to become complacent in terms of flood protection. All new developments should still have floor levels set to the 1% AEP flood level outside of the levee area plus 0.5 m plus sea level rise.

The 2012 Erina Creek Flood Study Review (Ref 1) identified that local drainage issues arise, particularly along Bonnal Road near the Woodport Inn (refer Section 4.4.1). At present local drainage causes only minor inconvenience as the surrounding buildings are on higher land. Re-development in this area must consider the potential for inundation from local drainage and any

changes to the drainage system must ensure that the system is improved and the problem not exacerbated.

7.6.2. Residential Area north of Barralong Road within Levee

The Barralong Road levee was constructed as a recommendation of the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) to protect residential development in this area. As part of the levee scheme properties outside the levee were purchased by Council and the land was designated as floodway. The 1991 Plan also recommended that future development within the levee will require floor levels to be at least 0.5 m above the 1% AEP flood level. This is still supported and all new development from now on should have floor levels based on the revised flood levels from the 2012 Erina Creek Flood Study Review (Ref 1) or any subsequent studies.

Occupants protected by the levee should not become complacent with regards to the level of protection afforded by the levee and Council should ensure that there is always a level of flood awareness in the levee protected area.

The long term strategy for this area would be to fill it to the 1% AEP level (outside of the levee) + 0.5m plus sea level rise. This would reduce the potential risk to life in overtopping events, the risk of levee failure and improve the aesthetics of the area as residents would not look out onto a levee (Photo 10). Filling within this area should be permitted unless it introduces local drainage or other non flood related issues. This could be achieved through each land owner (less than 20) filling their own land as development occurs, however it would be more cost effective and efficient if this was undertaken at the one time. This could be achieved if the land was re zoned to a higher use and purchased as a single entity.

Further development within the Barralong Road leveed area should be controlled to ensure that the flood related development controls are compatible with the flood hazard and should include the possibility of levee overtopping.

The levee bank where it now overtops in the 1% AEP flood event should be raised and the structural integrity and remaining crest of the levee should be investigated to ensure it complies to current industry standards and best practices. Council may also investigate upgrading the stormwater drainage in this area to limit overflow in damaging flood events.

7.6.3. Caravan Park and Residential Estate south of Karalta Road

A caravan park and residential estate have been formed to the south of Karalta Road (Photo 22). It is part in Barralong Road (C2/G) and part in Nunns Creek (C2/H). Whilst the main creek is well defined it is likely that the general flat relief of the area will mean that shallow depth floodwaters will cross the site as a result of intense short durations storms. It is unlikely that this will result in inundation of building floors but may cause external damage and certainly disruption and inconvenience. There are no simple means of controlling these flows apart from constructing kerb and gutters (where this has not been undertaken) and ensuring flow paths are not blocked by fencing or minor structures/storage of goods. This would require ongoing awareness by the local residents and park staff so objects do not obstruct these flow paths.

The management of the drainage issues require input from the estate manager.



Photo 22: Caravan and Residential Estate off Karalta Road (1% AEP Flood Extent and contours)

7.6.4. Old Erina Estate on West side of Erina Creek (1991 Floodplain Management Area EC6)

This area is within land designated as floodway. The revised floodways are little different to those previously identified and therefore this area should continue to be treated as such. The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) noted that Council has a policy of considering vacant blocks for purchase when offered for sale. In 1991 Council owned approximately 70% of the lots. An indicative price to purchase vacant blocks in this area in 2015 is $5,000.

The area lies to the east of the residential developments between Karwin and Lakala Avenues and within the Barralong Road catchment (Figure 3). The area was subdivided in 1886 as a proposed residential estate but no houses were constructed. The boundary between the existing

developments to the west and the undeveloped land to the east is defined by a ridge line a few metres high which clearly defines the floodplain. Photo 23 indicates that there is little lateral increase in the flood extents between the PMF and 1% AEP while Photo 24 shows there is only a very small extent of flood fringe and low hazard land on the perimeter.

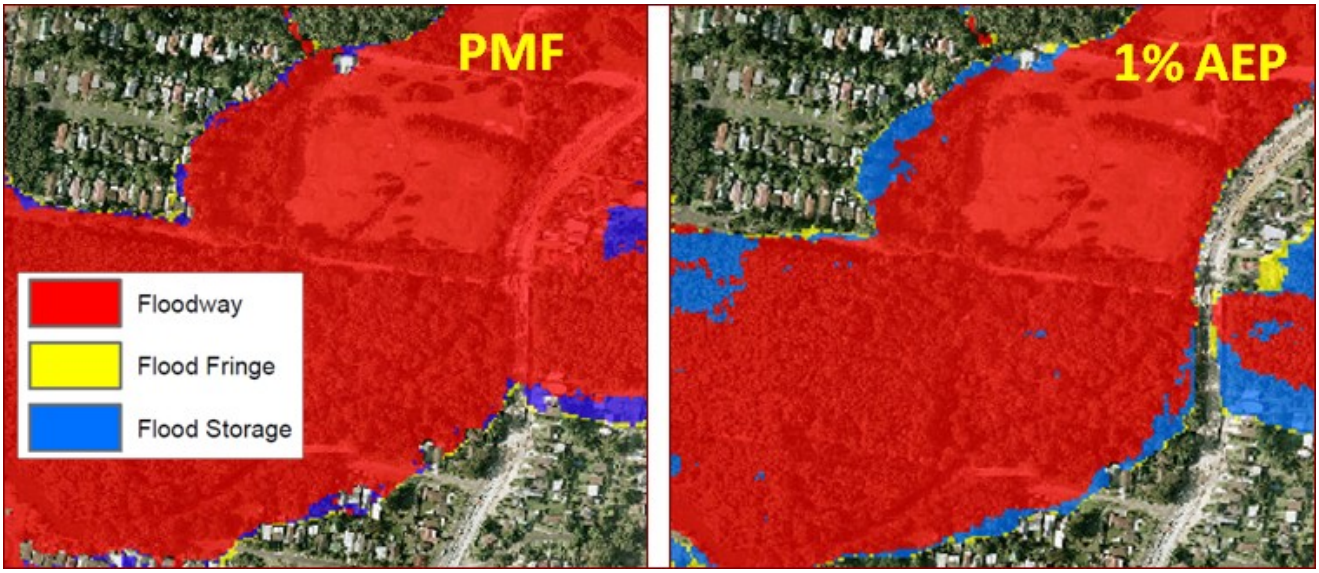


Photo 23: Hydraulic Categorisation from the 2012 Erina Creek Flood Study Review (Ref 1)

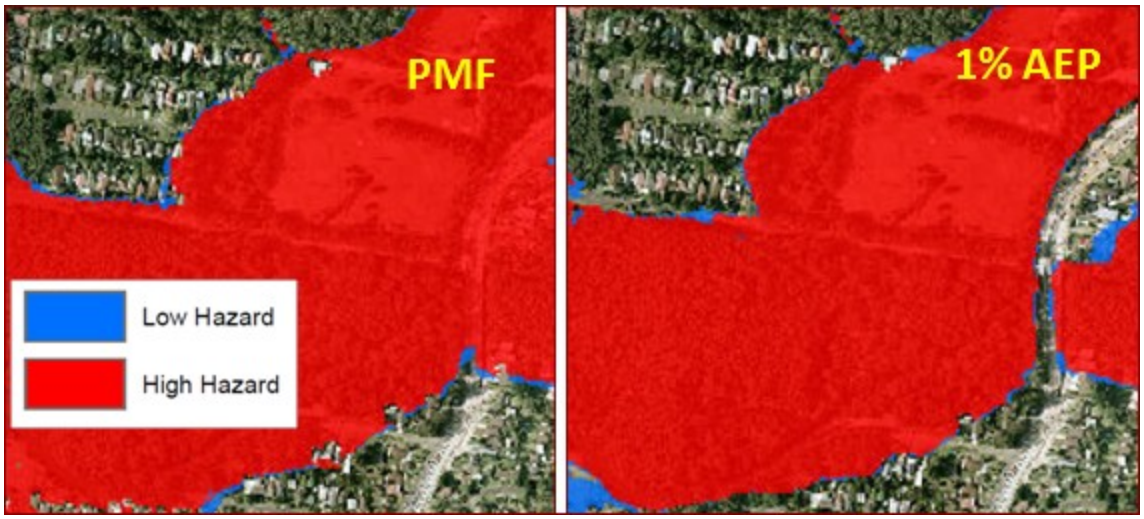


Photo 24: Hydraulic Hazard from the 2012 Erina Creek Flood Study Review (Ref 1)

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) set out management guidelines for this area as follows.

- Full development within the estate would significantly raise flood levels upstream.
- Limited minor filling will only be permitted for access to developable blocks.
- The remaining blocks will be purchased and dedicated as floodway as designated on the Plan.
- Rate relief will be initiated by Council for the non-developable blocks.

Council has provided rate relief since 1991 for the identified non-developable properties in accordance with the Plan. Council has successfully voluntarily purchased properties since 1991 and left the properties in their natural state to form part of the floodplain. As at 2014 Council owns 85 lots with approximately 76 vacant lots remaining to purchase in the floodplain (39 within the Old Erina

Estate; 16 within the Erina Valley Road/Worthing Road Creek area; 18 within the Springfield Area and 3 within the Barralong Road area). Permission has been sought to construct pole homes within the floodway/flood storage area rather than the land being purchased by Council as indicated in the 1991 Management Plan. It has been argued that the pole home and access road could be constructed in such a manner as to have a minimal impact on flood levels and flood behaviour.

In principle the pole home and access is very similar to that approved on steeply sloping coastal properties in the Gosford and other LGAs. These latter homes generally do not use the actual land beneath their building and driveway footprint. An example of the type of structure is shown on Photo 25 with the elevated driveway access to high ground on the right.



Photo 25: Example of pole home (courtesy Randle Tropical Homes)

Whilst this type of structure could satisfy the criteria of the floor and vehicle access being above the required flood planning level (1% AEP plus 0.5m freeboard) as well as meeting the required structural integrity requirements, a number of issues remain. The land is high hazard and either floodway or flood storage in the 1% AEP event. Building on such a property is generally not considered best practice according to the NSW Government's Floodplain Development Manual (Ref 5). Development of residential properties in floodways is not a suitable land use for the high flood hazard of the area.

Furthermore, there are examples of past pole homes being approved, re-sold by the owner/developer and the subsequent owner storing goods below the floor and then suffering significant below floor flood damage which may not be covered by insurance. The subsequent owner argues that such a home should not have been permitted and seeks redress from Council. The difference in arguments presented by the owner/developer for approval purposes and the subsequent owner suggesting Council was negligent in giving approval is a significant potential problem that Council must consider if approval is given. Similar situations have arisen with other flood liable properties in the Gosford LGA. The pole homes on Chetwynd Road which are within the floodway have, as part of this Study, been recommended for voluntary purchase (see Section 6.4.3).

Besides flooding, there are a number of other environmental considerations within the Erina Creek catchment area:

- *Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999*
  Relates to endangered ecological communities, threatened species and migratory species reliant on appropriate hydrological regimes.

- The *Water Management Act 2000*
  Recognises that the fundamental health of our rivers and groundwater systems and associated wetlands, floodplains, estuaries has to be protected.

- *Planning for Bushfire Protection 2006* under the *Rural Fires Act 1997* and *AS3959 -Construction in Bushfire Prone Areas*
  Includes provisions for a combination of bushfire protection measures such as increased construction standards and clearing of vegetation for the creation of asset protection zones. The latter may impact on the hydrology and soil stability within an area, particularly where the development is proposed on steep terrain or close to a watercourse or riparian area.

- *Gosford Bush Fire Risk Management Plan 2011*
  Council has prepared a Bushfire Management Policy to guide bushfire management within the local government area.

In recent years the Land and Environment Court upheld a Council determination that a new house should not be constructed on a similar flood liable property in the area. One of the key reasons given was that Council had completed the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) The Plan had controlled development on the land since 1991 in accordance with the adopted conditions and which had been prepared in accordance with the relevant State Government floodplain management guidelines.

Based on the above information, the recommendations of the 1991 Erina Creek Floodplain Management Plan for this area should be continued.

The feeder road for this old estate area is Clarence Road via its intersection with Wells Street. However this road at the intersection of Wells Street and Clarence Road is cut-off by floodwaters in only minor flood events i.e. a 20% AEP event. As this is the only access road to the area that serves in excess of 350 homes it is critical that it be upgraded to improve flood access for evacuation and emergency services. It is estimated that it would cost in excess of $1M to upgrade and raise the intersection.

7.6.5. Erina Fair

Council should undertake discussions with the owners of Erina Fair with a view to encouraging the owners to construct a detention basin to limit flooding downstream.

7.7. Nunns Creek – Industrial Area south of Erina Creek (C2/H)

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) provided an Interim (blue)

and a Final Development limit line (yellow) of filling (refer Appendix C) within the Nunns Creek area. Filling can occur to the Interim (blue) line but the 1991 Plan determined that filling could not occur to the Final Development limit until all flood affected floors upstream (in the 1% AEP event) were raised as part of re-development.

The present study has re-examined the effect of filling to the Final Development limit using the TUFLOW model. The results (refer Photo 26) using the TUFLOW model are more accurate than undertaken as part of the previous work however indicate as similar to the previous study that the effects of further filling are confined to only the immediate upstream area. Once all floors in this affected area are raised as part of re-development to be above the 1% AEP flood level then filling to the Final Development limit can be undertaken.

This assessment only investigates the effect of filling on flood impacts. Other potential environmental impacts will need to be addressed in regards to fill or vegetation as part of the development approval process.

Addendum No. 3 to the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) provided a similar Development Line for the properties to the immediate west of those shown in Photo 26 and is shown as Photo 7. No additional hydraulic modelling has been undertaken for Addendum 3.

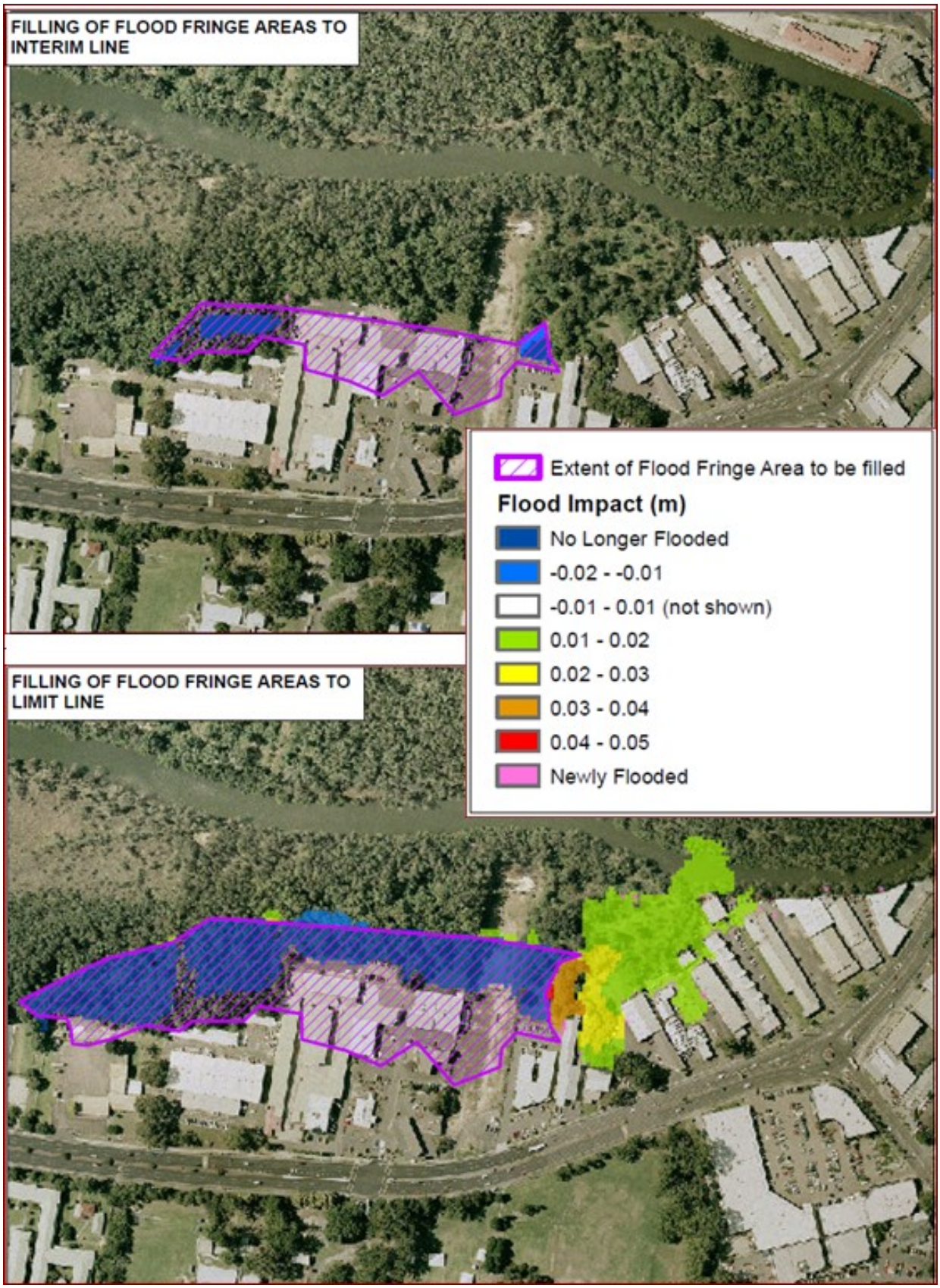


Photo 26: TUFLOW modelling of impacts of further filling for the 1% AEP event

For dimensions of development extent refer Photo 6.

Flow in Nunns Creek is restricted by the culverts under the Central Coast Highway. This issue has been discussed in Section 6.3.3 and there would be no significant benefit in upgrading the culverts. Downstream the open channel is relatively narrow and whilst widening could be undertaken the benefit must be balanced against the landtake costs and disruption to adjoining businesses. In addition these works would not prevent inundation due to high water levels in Erina Creek.

However the upgrading of the culverts and widening of the channel downstream would improve overflows across the Central Coast Highway and into the Bonnal Road area.

7.8. Springfield Area (C2/I)

7.8.1. Council Depot

In a 1% AEP event access to The Entrance Road (Central Coast Highway) becomes inundated and can be impassable to normal vehicles. This is a critical issue in that the SES headquarters and other emergency services (Rural Fire Services and Council) required during flood response, are inundated with access to the rest of the flood prone area cutoff. It is imperative that there is safe access to the site during flood times and therefore it is recommended that a dry access route to Avoca Drive is provided (see Section 6.5.2). Alternatively the SES headquarters and other essential services should be relocated out of the floodplain.

It is not viable to raise all existing buildings but temporary barriers such as flood gates (see Section 6.4.2) are recommended for existing buildings which should be implemented with a pre-prepared site Flood Plan. Any new buildings should be subject to flood proofing and floor levels above the flood planning level taking into consideration any increase in potential flooding due to sea level rise.

7.8.2. Barinya Lane

Barinya Lane (Photo 27) lies to the north of Erina Creek and immediately to the south of Wells Road within the Springfield Area. In the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) this area was referred to as the Clarence Road flood fringe area (EC8) and the Plan provided guidelines for further development. In 1991 two existing houses were located on the floodplain and subsequently four additional houses have been constructed.

The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) suggested that limited filling would not significantly increase upstream flood levels as the area is largely dominated by flood levels in Brisbane Water. The Plan made recommendation for filling to provide a maximum of 500 m^2 of land for construction of one single dwelling per block and to be at least 0.3 m above the 1% AEP flood level. Filling was not allowed to take place until the Barralong Road levee was completed. Two houses were already located in the floodplain at this location. Subsequently four additional houses have been constructed. There is the potential for one further house to be constructed and the possibility for extensions to the existing developments.

An assessment of the impacts of filling in land designated as flood fringe was undertaken with the revised hydraulic modelling (see Section 6.4.4.1). This found that even a small amount of filling in the flood fringe areas could cause an increase in flood levels elsewhere. Therefore filling is not

recommended as the cumulative effects could be adverse. Furthermore, the revised floodway definition shows that part of this area is actually classified as floodway (refer Appendix D of the 2012 Erina Creek Flood Study Review - Ref 1) and therefore, as with other areas defined floodway, there should be no obstructions to flow. Nonetheless, minor filling may have negligible impacts and therefore a hydraulic assessment, as prescribed by Council's Flood and Drainage section, undertaken for individual cases would be necessary to prove there is no flood level impact off site before any development or filling is approved. In addition to the requirement for individual property assessment, Council has stated that no more houses can be built until properties are connected to Council's sewer system as filling to provide flood free land for sewerage effluent disposal cannot be supported.

Access to high ground is the main issue for these properties. Raising of Barinya Lane (Photo 27) and the access to each house could be undertaken (depending on funding arrangements) and this would cause little adverse impact on flood levels. The amount of filling on the private access roads could be minimised if neighbours were able to "share" the access in times of flood. This would need to be negotiated between the neighbours but may not be successful in the long term as properties change ownership.

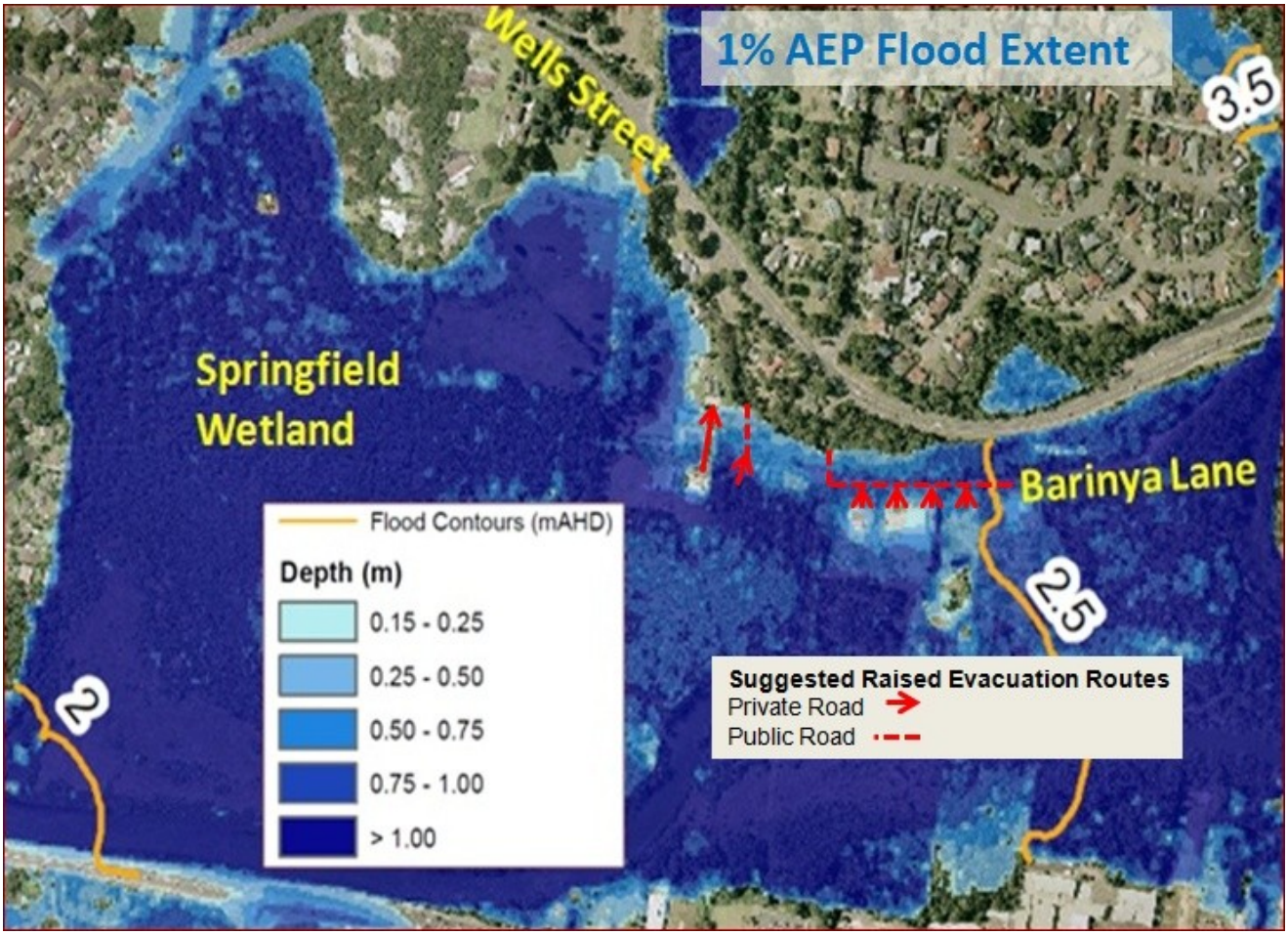


Photo 27: Barinya Lane Area (1% AEP)

A review of this area indicates the following:

- development on these properties must comply with the 1998 Environment and Health Protection Guidelines and AS 2012 – On-site Domestic Wastewater Management;

- houses are to be built as close to the road boundary as possible to reduce flood impacts;
- development not to extend south beyond the alignment of existing developments;
- flood free access in the 1% AEP is required to Meadow Road and Wells Street and consideration given to eliminating sag points in Wells Street;
- filling for a building pad or a raised access road is permitted up to a maximum of 600m^2 per property for existing development only. This includes an allowance for on-site sewage management systems and dissipation areas;
- submissions to support filling must indicate that the works do not adversely affect internal drainage of the subject or other surrounding properties;
- a number of vacant properties are identified for acquisition as part of the Coastal Open Space System and forms part of a natural reserve along Erina Creek. There are only three properties left to acquire to marry the existing western reserve to the eastern reserve; and
- a Flood Study should be undertaken for any new development to ensure no offsite impacts (refer (Photo 27).

7.8.3. Springfield Wetland Area

This (Photo 27) area was previously termed the Springfield Wetland Flood Storage Area and the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) suggested that development in this area could only have a minor impact on upstream flood levels but development may conflict with the SEPP 14 Wetland status of the land. The Plan proposed to designate the area as a wetlands flood storage area and prohibit future development. The plan also suggested that drainage of upstream stormwater which crosses Wells Street would be diverted to a channel west of the wetlands.

Wetland areas are appropriate use of flood prone land and the recommendations to prevent development are supported.

7.8.4. Wells Street Area

Wells Street in the vicinity of the Avalon Road intersection is inundated in frequent flood events (Section 6.3.2). This is a main feeder road and becomes blocked during even small floods. Council should investigate raising the road to improve access for both through and local road users. In addition it is recommended that Council investigate raising the road and enlarging the road culverts under Willow Road so as to possibly make Willow Road an alternate flood free access for Wells Street through road users.

7.9. East Gosford (C2/J)

Construction of a detention basin in the open space area adjacent to the Council Depot off Emma James Street has been investigated in previous studies. For the basin to be effective, a storage volume of the order of 10,000 m^3 would need to be provided. Potential land uses of the area have been discussed with Council and at the present time there are no proposals for the land which are inconsistent with its dual use as a detention basin. Proposals to pipe the creek downstream of the basin are favoured by many of the local residents, but given the high cost involved, are unlikely to be

viable. Further investigation of this measure, including hydraulic modelling should be undertaken.

This area has no other specific floodplain management measures except as discussed in Section 6.3.2 local drainage can be an issue in some areas. Water ponding at low points on Wells Street (Section 6.3.2) Coburg Street and Adelaide / Russell Streets (Photo 28) has been highlighted as an issue and it is recommended to upgrade drainage in this area with increased inlet and pipe capacity and consideration given to eliminating the sag point in Wells Street.

Above floor inundation occurs in several buildings (refer Figure 4).



Photo 28: Althorp Street and Adelaide / Russell Streets (1% AEP flood extent and contours)

8. RECOMMENDED FLOODPLAIN RISK MANAGEMENT STRATEGY

The Floodplain Risk Management Study has undertaken a review of the full range of management measures with the outcomes providing the basis for the Floodplain Risk Management Plan. An assessment of the relative merits of the measures has been undertaken using a matrix which considers the following criteria:

- impact on flood behaviour (reduction in flood level, hazard or hydraulic categorisation) over the range of flood events;
- number of properties benefited by measure;
- technical feasibility (design considerations, construction constraints, long-term performance);
- community acceptance and social impacts;
- economic merits (capital and recurring costs versus reduction in flood damages);
- financial feasibility to fund the measure;
- environmental and ecological benefits;
- impacts on the SES;
- political and/or administrative issues;
- long-term performance given the possible impacts of climate change and sea level rises;
- risk to life.

The scoring system for the above criteria is provided in Table 25 and largely relates to the impacts in a 1% AEP event.

Table 25: Coloured Matrix Scoring System

	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100mm increase	50 to 100mm increase	<50mm increase	no change	<50mm decrease	50 to 100mm decrease	>100mm decrease
Number of Properties Benefitted	>5 adversely affected	2-5 adversely affected	<2 adversely affected	none	<2	2 to 5	>5
Technical Feasibility	major issues	moderate issues	minor issues	neutral	moderately straight-forward	Straight-forward	no issues
Community Acceptance	majority against	most against	some against	neutral	minor	most	majority
Economic Merits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Environmental and Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on SES	major disbenefit	moderate disbenefit	minor disbenefit	neutral	minor benefit	moderate benefit	major benefit
Political / administrative Issues	major negative	moderate negative	minor negative	neutral	few	very few	none
Long Term Performance	major disbenefit	moderate disbenefit	minor disbenefit	neutral	positive	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit

The matrix presented in Table 26 has been used to rank the management options considered. The scoring system provided in Table 25 may be adjusted in the light of community consultations and local conditions.

Table 26: Matrix Scoring System – Management Options Considered

Report Ref	OPTION	COMMENT	Capital Cost to Public Authorities	Recurring Annual Cost	Impact on Flood Behaviour	Number of Properties Benefitted	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental\ Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	TOTAL SCORE	RANK
C2 GENERAL					SCORE												
5	**Limit intensification of development within the projected flood extents due to sea level rise.**	Intensification of residential development should be limited as far as possible in areas where there is a potential for permanent inundation or frequent flooding due to sea level rise. Need to investigate the potential for filling of some of these areas without causing adverse impacts on other properties.	nil	n/a	0	0	3	-1	2	0	0	1	-1	3	1	8	22
6.3.2	**Develop Overland Flow / Trunk Drainage Study for sub-catchments.**	Would more accurately define the key flood affected areas from local overland flows and allow for improved drainage to be designed and emergency response planning.	$80,000 per catchment	n/a	0	3	2	1	0	1	0	0	0	0	0	7	26
6.3.3	**Removal of build up of dense vegetation due to fallen trees and non-natural debris built up in local streams. Ensure the regular maintenance of gross pollutant traps.**	Non-natural debris and large fallen trees can be cleared from local waterbodies. Dredging and removal of sediment should not be undertaken as this will be moved by the next flood. Non-natural debris, fallen trees and sediment should be regularly cleared from gross pollutant traps to prevent an increase in flood levels.		$20,000	1	2	1	1	1	0	1	0	0	1	1	9	14
6.3.5	**Provide water cycle management on all new developments in accordance with Council's Development Control Plan.**	Will not improve current situation but can prevent it from getting worse in the future.	nil	n/a	1	3	1	2	1	0	1	0	-1	1	0	9	14
6.4.1	**House raising scheme**	Available to all flood prone properties identified within the Study.	$80,000 per house but part private and part public funding	nil	0	3	1	1	1	-2	1	1	0	1	1	8	22
6.4.2 and 6.4.8	**Flood proofing for new or existing non residential developments and requirements for electrical installation.**	Generally for non-residential development such as commercial development which may have lower floor levels. Can be enforced through Flood Planning Policies and Development Controls. Will not improve current situation but can prevent it from getting worse in the future.	nil	nil	0	3	2	1	2	1	0	0	-1	1	1	10	13
6.4.4.1 and 7.8.2	**Filling in the floodplain.**	Raising flood prone ground to above the flood level to allow for development has implications on flood behaviour. Fill is NOT RECOMMENDED unless identified in this study.	n/a	n/a	-3	0	0	0	0	0	-2	0	-1	1	1	-4	50
6.4.4.2	**Develop management strategies to adapt to the impacts of projected climate change**	For areas subject to increased flooding due to climate change (increased rainfall intensities & sea level rise) and those areas with potential to become permanently inundated in the longer term.	$30,000	nil	0	3	0	-1	1	0	1	1	-1	2	1	7	26
6.4.4.3	**Where applicable all main access roads (including the Central Coast Highway) to be upgraded to ensure accessibility in events up to the 1% AEP event or reduce regular inundation.**	Will happen overtime as part of highway upgrades. The Entrance Road is overtopped and Wells Street and Carlton Road are currently subject to regular inundation.	unknown	unknown	-1	3	-2	1	0	-1	0	2	-1	1	1	3	43

Report Ref	OPTION	COMMENT	Capital Cost to Public Authorities	Recurring Annual Cost	Impact on Flood Behaviour	Number of Properties Benefitted	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental\ Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	TOTAL SCORE	RANK
6.4.4.5	**Consideration of effects of development on flood behaviour in events greater than the 1% AEP event.**	Particularly important for large developments including those works undertaken by other authorities e.g. Roads and Maritime Services. Can be managed through planning controls and consultation with authorities.	unknown	unknown	0	0	1	1	1	0	0	1	0	1	1	6	30
6.4.4.6	**Implement controls to limit development on or near any levee.**	To ensure future works do not negatively impact on the structure and to maintain its structural integrity.	nil	nil	0	0	2	1	2	1	0	0	0	2	1	9	14
6.4.4.7	**Limit intensification of development within the 1% AEP flood extents.**	Intensification of residential development should be limited as far as possible within the 1% AEP event floodplain.	nil	nil	1	0	2	-1	1	1	1	1	0	1	1	8	22
6.4.5	**Rezoning flood prone land to open space or lower density development. Controls on development density in flood prone areas.**	Where possible, prevent increase in density in flood prone areas (see limit intensification of development within the 1% AEP flood extents). Rezoning of flood prone land to flood compatible uses.	nil	nil	0	0	0	-1	1	1	1	1	-1	2	2	6	30
6.4.7	**Review impact of increased flooding on public utilities and services.**	To be undertaken by Council and relevant authorities. Benefits in the immediate to short term are limited. Will assist in planning for the future.	$150,000	nil	0	0	1	1	1	0	0	0	-1	2	0	4	34
6.4.9	**Flood Planning Level as the 1% AEP peak flood level plus 0.5 m plus sea level rise (where applicable)**	Current controls for new residential development require this. Will not improve current situation but can prevent it from getting worse in the future.	nil	nil	0	3	3	1	3	1	0	3	2	3	2	21	1
6.4.10	**Review and update LEP and DCP**	All planning instruments and development controls across the floodplain to ensure consistency with recommendations	nil	nil	0	3	3	1	2	0	1	1	-1	2	0	12	9
6.5.1	**Review and upgrade rainfall, water level and flood warning systems throughout the catchment as required**	Install warning systems as indicated in any future flood and storm forecasting strategy. Education also needed to inform residents of actions when the alarm is raised.	>$10000	>$4000	0	3	2	1	1	1	0	3	1	1	2	15	3
6.5.2	**Ensure a Local Flood Emergency Sub-Plan for the Erina Creek catchment is regularly checked and updated by SES.**	The SES are the responsible authority for this. Information from the Flood Study, FRMS and historic flood events can be used.	$10,000	$2,000	0	3	3	2	1	1	0	3	0	1	1	15	3
6.5.2	**Review all Local Flood Emergency Evacuation Centres for the Erina Creek catchment**	To ensure evacuation centres are available during a major flood event	$10,000	$2,000	0	3	3	2	1	1	0	3	0	1	1	15	3
6.5.3	**Undertake a flood awareness program**	Council and SES to provide information to residents.	Depends on nature of program	Depends on nature of program	0	3	3	2	1	1	0	2	0	0	1	13	7
7.1	**Control land use and development in all floodplain areas**	Conveyance of the flood water should not be reduced or impeded by buildings, obstructions or filling of the land. Hazardous uses should NOT be permitted within the floodplain.	nil	nil	3	0	1	0	1	1	2	1	0	1	2	12	9
C2A UPPER ERINA CREEK																	
7.2	**Flood Studies for all significant development in the upper catchment areas and consideration for water cycle management.**	To ensure that future flows are not increased and use of the floodplain is flood compatible.	nil	nil	0	3	-1	0	0	0	0	0	-1	2	0	3	43

Report Ref	OPTION	COMMENT	Capital Cost to Public Authorities	Recurring Annual Cost	Impact on Flood Behaviour	Number of Properties Benefitted	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental\ Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	TOTAL SCORE	RANK
C2B OAK ROAD																	
7.2	**Flood Studies for all significant development in the upper catchment areas and consideration for water cycle management.**	To ensure that future flows are not increased and use of the floodplain is flood compatible.	nil	nil	0	3	-1	0	0	0	0	0	-1	2	0	3	43
C2C FIRES CREEK																	
7.2	**Flood Studies for all significant development in the upper catchment areas and consideration for water cycle management.**	To ensure that future discharge flows are not increased in the floodplain from new development.	nil	nil	0	3	-1	0	0	0	0	0	-1	2	0	3	43
C2D MILINA ROAD																	
7.2	**Flood Studies for all significant development in the upper catchment areas and consideration for water cycle management.**	To ensure that future discharge flows are not increased in the floodplain from new development.	nil	nil	0	3	-1	0	0	0	0	0	-1	2	0	3	43
7.3	**Arundel Road Extension**	Investigate emergency flood access by extending Arundel Road across the floodplain from Wattle Tree Road to the Central Coast Highway.	$1.5M		0	2	1	2	0	-1	-1	2	-1	2	1	7	26
C2E ERINA VALLEY ROAD CREEK																	
6.3.4 and 7.4	**Construction of a chain of retarding basins on Erina Valley Road Creek in conjunction with new major developments.**	Although these will not eliminate flooding, they may provide minor benefit to downstream properties during minor storm events.	n/a	n/a	1	2	-2	1	-1	-2	1	0	0	1	1	2	48
6.4.3 and 7.4	**Voluntary purchase and demolition of 92, 96, 98 and 100 Chetwynd Road.**	Removal of these properties from the high hazard floodway is the only way to reduce flood risk to the occupants.	market value	nil	1	2	2	2	2	1	0	1	2	3	3	19	2
7.4	**Council to continue purchase of undevelopable vacant lots within the floodplain.**	Council will fund this when funding is available.	$5,000 per property	nil	0	0	1	1	1	-1	0	1	-1	2	0	4	34
C2F WORTHING ROAD CREEK																	
6.4.4.5 and 7.5	**Liaise with RMS regarding modifying crash barriers at Worthing Road Creek**	Reduce impact of barriers in large floods	Unknown	nil	0	1	2	1	-2	-2	0	0	0	1	0	1	49
7.5	**Raise western embankment of Tarragal Glen basin by 0.5m over 50m**	To provide additional security to units immediately downstream	$188,000	nil	0	2	3	2	0	0	0	1	0	2	2	12	9
7.5	**Council to continue purchase of undevelopable vacant lots within the floodplain.**	Council will fund this when funding is available.	$5,000 per property	nil	0	0	1	1	1	-1	0	1	-1	2	0	4	34
C2G BARRALONG ROAD																	
6.3.1 and 7.6.2	**Review structural integrity and raise crest level of the Barralong Road levee system to provide protection to 1% AEP (including freeboard).**	Will provide security to 1% AEP	$200,000	nil	2	3	1	3	1	1	0	1	1	1	1	15	3
7.6.1	**Controls on new development for local drainage area protected by Barralong Road levee.**	To ensure local drainage is protected and new development will not cause undue damage or inconvenience.	nil	nil	1	3	1	1	1	1	0	0	0	1	0	9	14

Report Ref	OPTION	COMMENT	Capital Cost to Public Authorities	Recurring Annual Cost	Impact on Flood Behaviour	Number of Properties Benefitted	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental\ Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	TOTAL SCORE	RANK
7.6.2	**Control further development in the area protected by Barralong Road levee, and properties protected by the levee to be subject to floor level controls.**	Ensure development is appropriate for the flood hazard and to reduce risk and damages in case of levee failure or overtopping.	nil	nil	0	3	1	0	1	1	0	1	0	1	1	9	14
7.6.4	**Council to continue purchase of undevelopable vacant lots within the floodplain.**	Council will fund this when funding is available.	$5,000 per property	nil	0	0	1	1	1	-1	0	1	-1	2	0	4	34
7.6.4	**Raise intersection of Clarence Road and Wells Street and upgrade road culverts to improve flood access to Old Erina Estate area.**	Council will fund this when funding is available.	>$1 million	nil	0	2	1	2	0	-1	0	1	0	1	2	8	22
7.6.5	**Council to investigate construction of detention basin in Erina Fair**	Erina Fair will fund this	n/a	nil	0	0	1	1	1	0	0	1	-1	2	0	5	33
C2H NUNNS CREEK																	
6.3.3	**Enlarging culverts at the crossing on Nunns Creek at The Entrance Road (Central Coast Highway).**	Could reduce upstream flood levels, overtopping of the road and risk of blockage.	$2m ($1.5m works and $0.5m property acquisition and channel re-alignment)	nil	2	2	0	1	-1	-2	0	1	0	1	0	4	34
7.6.1	**Investigate overflows crossing the The Entrance Road (Central Coast Highway) and flowing into the area protected by the Barralong Road levee.**	To reduce catchment overflows causing additional pressure on stormwater system in area protected by the Barralong Road levee.	unknown	nil	1	1	1	2	1	1	0	2	0	2	1	12	9
6.4.4.1 and 7.7	**Filling on the north side of The Entrance Road (Central Coast Highway)**	Only to be undertaken once all flood affected floors upstream have been raised.	n/a	n/a	-1	3	-1	0	2	1	-1	0	-1	1	1	4	34
C2I SPRINGFIELD																	
7.8.2	**Raising Barinya Lane and property access.**	Ensure adequate access in times of flood	$1.1m	nil	-1	2	1	0	0	0	0	1	0	0	1	4	34
6.5.2 and 7.8.1	**Relocation of SES Headquarters and for other emergency services or creation of a safe access out of the Council Depot**	Ensure all services can operate during times of flood	$4.5m	unknown	0	0	1	1	2	-2	0	3	0	2	2	9	14
7.8.3	**Prevent development in the Springfield Wetland flood storage area.**	Development would conflict with the SEPP 14 Wetland status of the land.	nil	nil	0	0	2	1	0	0	3	0	0	3	0	9	14
7.8.3	**Investigate and provide alternate flood free access around Wells Street low point via Willow Road, if required.**	Ensure adequate access in times of flood	$550,000	nil	0	2	1	2	0	1	0	2	1	1	3	13	7
6.3.2 and 7.6.1 and 7.6.2	**Further detailed investigation into frequent flooding on Wells Street near Avalon Road as part of Council's local drainage works program to improve flood access.**	Frequently flooding occurs to depths of 200 mm. Lowering kerb on reserve side provides little gain and raising road will increase water levels upstream. More investigation is required to determine most appropriate treatment for improving emergency access	$50,000	nil	3	2	0	1	0	1	0	0	0	2	0	9	14
7.8.2	**Council to continue purchase of undevelopable vacant lots within the floodplain.**	Council will fund this when funding is available.	$5,000 per property	nil	0	0	1	1	1	-1	0	1	-1	2	0	4	34

Report Ref	OPTION	COMMENT	Capital Cost to Public Authorities	Recurring Annual Cost	Impact on Flood Behaviour	Number of Properties Benefitted	Technical Feasibility	Community Acceptance	Economic Merits	Financial Feasibility	Environmental\ Ecological Benefits	Impact on SES	Political / Admin Issues	Long Term Performance	Risk to Life	TOTAL SCORE	RANK
C2J EAST GOSFORD																	
6.3.2 and 7.6.4	**Investigate upgrade of drainage from Wells Street to Hylton Moore Park via Newcastle Street.**	Investigation, design and inclusion of upgrading of trunk drainage systems in Council's Forward Planning for all pipe systems in Newcastle, Maitland and Wells Streets to mitigate flooding through private properties.	$50,000	nil	1	1	-1	3	0	-1	0	0	0	3	0	6	**30**
6.3.2 and 7.9	**New or additional pipes on Coburg Street and Adelaide/Russell Streets catchments to ensure adequate drainage to Erina Creek through Hylton More Park.**	Investigation, design and inclusion into Council's Forward Planning for the upgrade of the trunk drainage system to ensure additional drainage where runoff currently collects at low points. Further investigation needed into appropriate drainage strategy	$2m ($1.5m works and $0.5m property acquisition and channel re-alignment)	nil	1	2	0	1	0	1	0	0	0	2	0	7	**26**
7.9	**Construction of detention basin in the open space area adjacent to the Council Depot off Emma James Street (Subject to further investigation).**	Not a recommendation in 1991 Plan. To ascertain any benefit with regards to local flooding, this option should be modelled in detail.	$400,000	$2,000	1	1	1	1	0	-1	0	0	0	1	0	4	**34**

9. ACKNOWLEDGMENTS

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- Gosford City Council;
- NSW Office of Environment and Heritage;
- Council's Floodplain Management Committee;
- Residents of the Erina Creek catchment.

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PART B Floodplain Risk Management Plan

FIGURES

Plan A - Upper Erina Creek
Plan B - Lower Erina Creek
Sheet 1
Sheet 2
Sheet 3
Sheet 4

1. ERINA CREEK FLOODPLAIN RISK MANAGEMENT PLAN

The Erina Creek Floodplain Risk Management Plan summarises the outcomes from the Management Study as a series of measures which will assist in reducing flooding for existing and future developments. The mix of measures has been developed following consideration of the ranking developed in the management options matrix in the study (Table 26) as well as discussions with the Floodplain Management Committee and as a result of community consultation.

The measures contained in the Plan are detailed in the following sections pertaining to each Management Area as described on Figure 3. Table i) lists the measures where there is a capital cost to undertake the measure and excludes those which can be undertaken by Council as part of amendments to its flood related planning controls and guidelines.

Further detail and insight into each measure is provided in the relevant section (as noted in Table i) of the Erina Creek Floodplain Risk Management Study.

The Priority assigned to a measure is not always compatible with the Ranking in Table 26. The Priority reflects a number of issues including availability of funds, ease of implementation, perceived benefit to residents and others. Thus voluntary purchase of the Chetwynd Road properties has a higher Priority than the public awareness program due to the frequent occurrence and risk to life at Chetwynd Road and because there is already a limited public awareness program in place.

The provision of benefit/cost ratios (i.e the benefit in terms of reduction in flood damages compared to the cost of the works) cannot be adequately provided for most floodplain management measures because the benefit is often the reduction in intangible damages (risk to life, injury etc.) which cannot be assigned a monetary value.

Table i): Priority Rating of Recommended Measures

Priority refer Plan for location	Responsibility	Area	Report Ref	OPTION	Capital Cost to Public Authorities	Recurring Annual Cost	RANK
High	Council	**C2 GENERAL**	6.4.9	**Flood Planning Level as the 1% AEP peak flood level plus 0.5 m plus sea level rise (where applicable)**	nil	nil	**1**
High A	Council & OEH	**C2E ERINA VALLEY ROAD CREEK**	6.4.3 and 7.4	**Voluntary purchase and demolition of 92, 96, 98 and 100 Chetwynd Road.**	market value	nil	**2**
High B	Council	**C2G BARRALONG ROAD**	6.3.1 and 7.6.2	**Review structural integrity and raise crest level of the Barralong Road levee system to provide protection to 1% AEP (including freeboard).**	$200,000	nil	**3**
High	Council & OEH	**C2 GENERAL**	6.5.1	**Review and upgrade rainfall, water level and flood warning systems throughout the catchment as required**	>$10000	>$4000	**3**

Priority refer Plan for location	Responsibility	Area	Report Ref	OPTION	Capital Cost to Public Authorities	Recurring Annual Cost	RANK
High	Council & SES	**C2 GENERAL**	6.5.2	**Ensure a Local Flood Emergency Sub-Plan for the Erina Creek catchment is regularly checked and updated by SES.**	$10,000	$2,000	**3**
High	Council & SES	**C2 GENERAL**	6.5.2	**Review all Local Flood Emergency Evacuation Centres for the Erina Creek catchment**	$10,000	$2,000	**3**
High	Council & SES	**C2 GENERAL**	6.5.3	**Undertake a flood awareness program**	Depends on nature of program	Depends on nature of program	**7**
High	Council	**C2 GENERAL**	6.4.10	**Review and update LEP and DCP**	nil	nil	**9**
High	Council	**C2 GENERAL**	7.1	**Control land use and development in all floodplain areas**	nil	nil	**9**
High	Council	**C2 GENERAL**	6.4.4.6	**Implement controls to limit development on or near any levee.**	nil	nil	**14**
High	Council	**C2 GENERAL**	5	**Limit intensification of development within the projected flood extents due to sea level rise.**	nil	n/a	**22**
High	Council	**C2 GENERAL**	6.4.4.7	**Limit intensification of development within the 1% AEP flood extents.**	nil	nil	**22**
Medium C	Council	**C2I SPRINGFIELD**	7.8.3	**Investigate and provide alternate flood free access around Wells Street low point via Willow Road, if required.**	$550,000	nil	**7**
Medium D	Council	**C2F WORTHING ROAD CREEK**	7.5	**Raise western embankment of Tarragal Glen basin by 0.5m over 50m**	$188,000	nil	**9**
Medium	Council	**C2H NUNNS CREEK**	7.6.1	**Investigate overflows crossing the The Entrance Road (Central Coast Highway) and flowing into the area protected by the Barralong Road levee.**	unknown	nil	**9**
Medium	Council	**C2 GENERAL**	6.4.2 and 6.4.8	**Flood proofing for new or existing non residential developments and requirements for electrical installation.**	nil	nil	**13**
Medium	Council	**C2 GENERAL**	6.3.3	**Removal of build up of dense vegetation due to fallen trees and non-natural debris built up in local streams. Ensure the regular maintenance of gross pollutant traps.**		$20,000	**14**
Medium	Council	**C2 GENERAL**	6.3.5	**Provide water cycle management on all new developments in accordance with Council's Development Control Plan.**	nil	n/a	**14**
Medium	Council	**C2G BARRALONG ROAD**	7.6.1	**Controls on new development for local drainage area protected by Barralong Road levee.**	nil	nil	**14**

Priority refer Plan for location	Responsibility	Area	Report Ref	OPTION	Capital Cost to Public Authorities	Recurring Annual Cost	RANK
Medium	Council	**C2G BARRALONG ROAD**	7.6.2	**Control further development in the area protected by Barralong Road levee, and properties protected by the levee to be subject to floor level controls.**	nil	nil	**14**
Medium	Council	**C2I SPRINGFIELD**	7.8.3	**Prevent development in the Springfield Wetland flood storage area.**	nil	nil	**14**
Medium E	Council & RMS	**C2I SPRINGFIELD**	6.5.2 and 7.8.1	**Relocation of SES Headquarters and for other emergency services or creation of a safe access out of the Council Depot**	$4.5m	unknown	**14**
Medium F	Council	**C2I SPRINGFIELD**	6.3.2 and 7.6.1 and 7.6.2	**Further detailed investigation into frequent flooding on Wells Street near Avalon Road as part of Council's local drainage works program to improve flood access.**	$50,000	nil	**14**
Medium N	Council	**C2G BARRALONG ROAD**	7.6.4	**Raise intersection of Clarence Road and Wells Street and upgrade road culverts to improve flood access to Old Erina Estate area.**	>$1 million	nil	**22**
Medium	Council	**C2 GENERAL**	6.4.4.2	**Develop management strategies to adapt to the impacts of projected climate change**	$30,000	nil	**26**
Medium G	Council & OEH	**C2 GENERAL**	6.3.2	**Develop Overland Flow / Trunk Drainage Study for sub-catchments.**	$80,000 per catchment	n/a	**26**
Medium	Council	**C2 GENERAL**	6.4.4.5	**Consideration of effects of development on flood behaviour in events greater than the 1% AEP event.**	unknown	unknown	**30**
Medium H	Council	**C2J EAST GOSFORD**	6.3.2 and 7.6.4	**Investigate upgrade of drainage from Wells Street to Hylton Moore Park via Newcastle Street.**	$50,000	nil	**30**
Medium	Council	**C2A UPPER ERINA CREEK**	7.2	**Flood Studies for all significant development in the upper catchment areas and consideration for water cycle management.**	nil	nil	**43**
Medium	Council & RMS	**C2F WORTHING ROAD CREEK**	6.4.4.5 and 7.5	**Liaise with RMS regarding modifying crash barriers at Worthing Road Creek**	Unknown	nil	**49**
Low	Council & OEH	**C2 GENERAL**	6.4.1	**House raising scheme**	$80,000 per house but part private and part public funding	nil	**22**
Low I	Council	**C2D MILINA ROAD**	7.3	**Arundel Road Extension**	$1.5M		**26**

Priority refer Plan for location	Responsibility	Area	Report Ref	OPTION	Capital Cost to Public Authorities	Recurring Annual Cost	RANK
Low J	Council	**C2J EAST GOSFORD**	6.3.2 and 7.9	**New or additional pipes on Coburg Street and Adelaide/Russell Streets catchments to ensure adequate drainage to Erina Creek through Hylton More Park.**	$2m ($1.5m works and $0.5m property acquisition and channel re-alignment)	nil	**26**
Low	Council	**C2 GENERAL**	6.4.5	**Rezoning flood prone land to open space or lower density development. Controls on development density in flood prone areas.**	nil	nil	**30**
Low	Council & Erina Fair	**C2G BARRALONG ROAD**	7.6.5	**Council to investigate construction of detention basin in Erina Fair**	n/a	nil	**33**
Low	Council	**C2 GENERAL**	6.4.7	**Review impact of increased flooding on public utilities and services.**	$150,000	nil	**34**
Low	Council	**VARIOUS**	7.4, 7.5, 7.6.3, 7.8.2	**Council to continue purchase of undevelopable vacant lots within the floodplain.**	$5,000 per property	nil	**34**
Low	Council	**C2H NUNNS CREEK**	6.4.4.1 and 7.7	**Filling on the north side of The Entrance Road (Central Coast Highway)**	n/a	n/a	**34**
Low K	Council & RMS	**C2H NUNNS CREEK**	6.3.3	**Enlarging culverts at the crossing on Nunns Creek at The Entrance Road (Central Coast Highway).**	$2m ($1.5m works and $0.5m property acquisition and channel re-alignment)	nil	**34**
Low L	Council	**C2J EAST GOSFORD**	7.9	**Construction of detention basin in the open space area adjacent to the Council Depot off Emma James Street (Subject to further investigation).**	$400,000	$2,000	**34**
Low M	Council	**C2I SPRINGFIELD**	7.8.2	**Raising Barinya Lane and property access.**	$1.1m	nil	**34**
Low	Council & RMS	**C2 GENERAL**	6.4.4.3	**Where applicable all main access roads (including the Central Coast Highway) to be upgraded to ensure accessibility in events up to the 1% AEP event or reduce regular inundation.**	unknown	unknown	**43**
Low	Council	**C2E ERINA VALLEY ROAD CREEK**	6.3.4 and 7.4	**Construction of a chain of retarding basins on Erina Valley Road Creek in conjunction with new major developments.**	n/a	n/a	**48**

Note: Rank[(1)] taken from Table 26

1.1. General Measures for all Management Areas (Table i)

- Climate change sea level rise must be considered for all developments downstream of Avoca Drive. This may mean some limit on the intensification of development.
- Overland flow studies (refer Table i) need to be undertaken for areas beyond that included in the 2012 Erina Creek Flood Study Review (Ref 1).
- Debris build up in creeks and culverts must be monitored and if necessary alleviated (refer Table i).
- Consideration should be given to the use of water cycle management and WSUD for all new developments in the catchment.
- Publicly funded house raising and or voluntary purchase will be considered on application by an owner as funding becomes available.
- Where appropriate existing and new non residential developments should incorporate flood proofing and protection of electrical installations.
- Filling or other activities within the 1% AEP floodplain that will have a greater than 0.01m increase in floodplain on adjoining properties need to supported by a rigorous hydraulic assessment which assesses the relative benefits and dis-benefits of the proposal in accordance with Council's DCP.
- Develop climate change adaptation plan.
- Inundation of local roads, particularly in the upper catchments away from Erina Creek is to be addressed with a community based approach with input from Council, using the level and credibility of community information to inform its maintenance priorities for drainage works and accompanied by a public education program to explain the risks in crossing inundated roads. Where practical the long term objective is to ensure a 1% AEP level of road access across the floodplain.
- The impacts of floods larger than the 1% AEP should be considered for all significant developments (special use, infrastructure etc.).
- The integrity of levee systems needs to be maintained and this may mean some limitations on new developments adjacent to them.
- Limit intensification of development within the 1% AEP flood extents.
- Review impact of increased flooding on public services.
- All residential buildings should be constructed with all habitable floors at or above the 1% AEP flood level + 0.5m freeboard + sea level rise component where applicable.
- Flood planning levels must include sea level rise allowance where applicable.
- Install flood warning alarms where required.
- Upgrade the rainfall and water level gauge information in the catchment.
- The SES Local Flood Plan needs to be continually updated to take account of the latest information.
- Council, SES and other authorities should continue with their flood awareness and education programs.
- No development should be allowed in areas defined as floodway unless it is of a flood compatible nature and environmentally acceptable.
- Climate change rainfall increase must be considered upon advice from Engineers Australia and/or the BoM.

- Any future flood greater than the 10% AEP needs to be investigated to assess the available flood level, rainfall and flood damage information obtained with a view to updating the design flood information (if relevant).
- All design floods levels should be based on the 2012 Erina Creek Flood Study Review (Ref 1) or any subsequent studies.
- All proposed land use activities in the floodplain need to be monitored to determine their potential impact on the flood regime.
- Isolation during floods is an issue for some rural areas in the upper catchment (termed high flood islands). These areas need to be identified based on local knowledge and the SES advised accordingly. It may be that some form of flood warning can be implemented to advise residents when bridges are cut and roads inundated.

1.2. Floodways within all Management Areas

- Floodways have been redefined as part of the 2012 Erina Creek Flood Study Review (Ref 1) and are also discussed in Sections 4.2 and 6.4.4.4 of this Erina Creek Floodplain Risk Management Study which identified some areas for special consideration.
- Recommendations from the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) that land use in floodways should be carefully controlled to ensure the conveyance area of the floodway is not reduced and no buildings, hazardous uses, obstructions likely to impede the flow of floodwaters or land filling would be permitted are supported and should be continued based on the redefined floodway extents.
- The areas identified for special consideration (refer Section 6.4.4.4 and Photo 17) should be included in Council's planning policies and controls to ensure that they are examined as necessary should a development application be submitted.
- Council needs to ensure that as far as practical controls are in place and appropriate mitigation measures implemented to minimise ongoing siltation and excessive vegetative growth on the creek systems to ensure an ecologically sustainable creek system that will not contribute to increased flood levels.

1.3. Upstream Catchments – Upper Erina Creek (C2/A), Oak Road (C2/B), Fires Creek (C2/C) Areas

- A Flood Study should be undertaken for all developments to ensure that major floodplains remain undeveloped, future flows are not increased, the use of "'hard" channels are avoided where possible and that use of the floodplain must be flood compatible.

1.4. Milina Road Area (C2/D)

- A Flood Study should be undertaken for all developments to ensure that major floodplains remain undeveloped, future flows are not increased, the use of "'hard" channels are avoided where possible and that use of the floodplain must be flood compatible.
- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) concluded that there were no viable flood mitigation measures that could significantly reduce flood levels in the areas. The plan identified several areas where filling could be permitted to allow one

dwelling per lot and provide a maximum of 500 m^2 of flood free land.

- As properties in this area are on the periphery of the flood extents, any new development should be subject to the standard floor level controls. No development should be allowed in areas defined as floodway unless it is of a flood compatible nature and environmentally acceptable.
- Inundation of local roads is also a significant issue for many residents and the suggested approach indicated in Section 7.2 is recommended. An emergency access route by extending Arundel Road should also be considered and a feasibility study undertaken.
- Flood studies for all new significant development in the upper catchment to include WSUD.

1.5. Erina Valley Road Creek Area (C2/E)

- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) identified many vacant lots as being unsuitable to build a house on due to their location in the floodplain were identified as undevelopable. These lots are slowly being purchased using Council only funds and this approach should continue. The majority of this vacant land in this area has been acquired by Council. There are still approximately 20 vacant lots upstream of the Central Coast Highway that are awaiting purchase by Council. At an indicative cost of $5000 per lot this amounts to $100,000.
- Four houses on Chetwynd Road; nos. 92, 96, 98 and 100, are situated in the floodway and, although habitable floor levels are raised, they become isolated during flooding by hazardous water. It is recommended that these properties are offered the option of voluntary purchase when funds become available. Until they can be purchased a flood warning system should be selected and installed.
- As this area is subject to flooding but access to high ground is limited in places development controls should be used to appropriately limit new development. Development should only be in those areas not designated as floodway or flood storage and subject to Council's regulations on allowable development within the floodplain.
- There is potential for increased residential development in this catchment and thus possible impacts on peak flows and flood levels downstream. These will need to be addressed in a rigorous hydraulic study and it is likely that mitigation measures such as retarding basins will be required to ensure no water quantity or quality impacts downstream.

1.6. Worthing Road Creek Area (C2/F)

- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) identified many vacant lots as being unsuitable to build a house on due to their location in the floodplain were identified as undevelopable. These lots are slowly being purchased using Council only funds and this approach should continue. The majority of the vacant land in this area has been acquired by Council.
- Council to liaise with RMS regarding the replacement of the concrete bollards with more appropriate flood compatible structures
- Raise crest of retarding basin in Tarragal Glen retirement village.

1.7. Barralong Road Area (C2/G)

1.7.1. Industrial Area south of Barralong Road within Levee

- Local drainage and the capacity of the outfall from Nunns Creek should be investigated to reduce surface flows travelling down the Central Coast Highway and entering the industrial area at Bonnal Road.
- Council should undertake discussions with the owners of Erina Fair with a view to encouraging the owners to construct a detention basin immediately west of the shopping complex to limit flooding downstream. The excessive surface flows from Erina Fair may be due to extensive impermeable areas of the shopping complex.
- Further upgrading of the Central Coast Highway should consider upgrading trunk drainage to cater for the 1% AEP flood flows.
- All new development should have floor levels based on the flood levels taken from outside of the levee but also need to consider local drainage.
- Council should ensure that there is always a level of flood awareness in the levee protected area.
- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) identified many vacant lots as being unsuitable to build a house on due to their location in the floodplain were identified as undevelopable. These lots are slowly being voluntarily purchased using Council only funds and this approach should continue. The majority of the vacant land in this area has been voluntarily acquired by Council.
- The 2012 Erina Creek Flood Study Review (Ref 1) identified that local drainage issues arise, particularly along Bonnal Road near the Woodport Inn. At present local drainage causes only minor inconvenience as the surrounding buildings are on higher land. Re-development in this area must consider the potential for inundation from local drainage and any changes to the drainage system must ensure that the system is improved and the problem not exacerbated.
- Further development within the Barralong Road leveed area should be controlled to ensure that the flood related development controls are compatible with the flood hazard and should include the possibility of levee overtopping.
- This area should be filled to the 1% AEP level from outside of the levee + 0.5m + any sea level rise component. This would reduce the potential risk to life in overtopping events, the risk of levee failure and improve the aesthetics of the area. Filling within this area should be permitted unless it introduces local drainage or other non flood related issues.

1.7.2. Residential Area north of Barralong Road within Levee

- All new development should have floor levels based on the flood levels taken from outside of the levee but also need to consider local drainage.
- This area is afforded protection from mainstream flooding from Erina Creek due to construction of a levee as recommended in the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C). Advances in hydraulic modelling and revision of flood levels means that its design standard is now just below the 1% AEP event and a technical review of the levee (structural integrity and crest level) is required. An assessment of the structural integrity of the levee should be undertaken as part of the upgrading of the levee to maintain 1% AEP flood protection.

- Council should ensure that there is always a level of flood awareness in the levee protected area.
- The long term strategy for this area would be to fill it to the 1% AEP level from outside of the levee + 0.5m + any sea level rise component. This would reduce the potential risk to life in overtopping events, the risk of levee failure and improve the aesthetics of the area as residents would not look out onto a levee. Filling within this area should be permitted unless it introduces local drainage or other non flood related issues. This could be achieved through each land owner (less than 20) filling their own land as development occurs, however it would be more cost effective and efficient if this was undertaken at the one time.
- Further development within the Barralong Road leveed area should be controlled to ensure that the flood related development controls are compatible with the flood hazard and should include the possibility of levee overtopping.
- Rezoning of the land within the leveed area to permit mass filling should be favourably considered.

1.7.3. Caravan Park and Residential Estate south of Karalta Road

- A caravan park and residential estate have been formed to the south of Karalta Road in part Barralong Road (C2/G) and part Nunns Creek (C2/H). Whilst the main creek is well defined it is likely that the general flat relief of the area will mean that shallow depth floodwaters will cross the site as a result of intense short durations storms. It is unlikely that this will result in inundation of building floors but may cause external damage and certainly disruption and inconvenience. There are no simple means of controlling these flows apart from constructing kerb and gutters (where this has not been undertaken) and ensuring flow paths are not blocked by fencing or minor structures/storage of goods. This would require ongoing awareness by the local residents and park staff so objects do not obstruct these flow paths.
- The management of the drainage issues require input from the estate manager.
- Any major redevelopment of the site should involve upgrading drainage and formalisation of overland flows.

1.7.4. Old Erina Estate on west side of Erina Creek

- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) recommended that no filling or hydraulic restrictions would be permitted on the remaining land designated as floodway. This recommendation is supported and Council should continue to purchase vacant lots and prevent inappropriate development which includes housing and any filling of land.
- Raise intersection of Clarence Road and Wells Street and upgrade road culverts to improve flood access to Old Erina Estate area.

1.7.5. Erina Fair

- Council should undertake discussions with the owners of Erina Fair with a view to encouraging the owners to construct a detention basin to limit flooding downstream.

1.8. Nunns Creek – Industrial Area south of Erina Creek (C2/H)

- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) provided an Interim (blue) and a Final Development limit line (yellow) of filling (refer Appendix C) within the Nunns Creek area. Filling can occur to the Interim (blue) line but the 1991 Plan determined that filling could not occur to the Final Development limit until all flood affected floors upstream (in the 1% AEP event) were raised as part of re-development (refer Photo 6).
- The present study has re-examined the effect of filling to the Final Development limit using the TUFLOW model. The results are more accurate than undertaken as part of the previous work and indicate that the effects of further filling are confined to only the immediate upstream area. Once all floors in this affected area are raised as part of re-development to be above the 1% AEP flood level then filling to the Final Development limit can be undertaken. This assessment only investigates the effect of filling on flood impacts. Other potential environmental impacts will need to be addressed in regards to fill or vegetation as part of the development approval process.
- Addendum No. 3 to the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) provided a similar Development Line for the properties to the immediate west of those shown in Photo 6 and is shown as Photo 7. Filling can occur to this line however other potential environmental impacts will need to be addressed in regards to fill or vegetation as part of the development approval process. Filling should be undertaken from the upstream end first and proceed downstream, however limited filling on the perimeter of the floodplain may be permitted at the discretion of Council.
- Flow in Nunns Creek is restricted by the culverts under the Central Coast Highway but there would be no significant benefit in upgrading the culverts. Downstream the open channel is relatively narrow and whilst widening could be undertaken the benefit must be balanced against the landtake costs and disruption to adjoining businesses. In addition these works would not prevent inundation due to high water levels in Erina Creek.
- Local drainage and the capacity of the outfall from Nunns Creek should be upgraded to the 1% AEP to reduce surface flows travelling down the Central Coast Highway and entering the industrial area at Bonnal Road. The Central Coast Highway should also be upgraded to provide emergency flood access for severe flood events.

1.9. Springfield Area (C2/I)

1.9.1. Council Depot

- In a 1% AEP event access to The Entrance Road (Central Coast Highway) becomes inundated and can be impassable to normal vehicles. This is a critical issue in that the SES headquarters and other emergency services required during flood response are inundated with access to the rest of the flood prone area cut. It is imperative that there is safe access to the site during flood times and therefore it is recommended that a dry access route to Avoca Drive is provided. Alternatively the SES headquarters and other emergency services should be relocated out of the floodplain.
- It is not viable to raise all existing buildings but temporary barriers such as flood gates are recommended for existing buildings which should be implemented with a pre-prepared site

Flood Plan. Any new buildings should be subject to flood proofing and floor levels above the flood planning level taking into consideration any increase in potential flooding.

1.9.2. Barinya Lane

- The 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) suggested that limited filling would not significantly increase upstream flood levels as the area is largely dominated by flood levels in Brisbane Water and the Plan made recommendation for filling to provide a maximum of 500 m^2 of land for construction of one single dwelling per block and to be at least 0.3 m above the 1% AEP flood level. Filling was not allowed to take place until the Barralong Road levee was completed. Two houses were already located in the floodplain at this location. Subsequently four additional houses have been constructed.
- An assessment of the impacts of filling in land designated as flood fringe was undertaken with the revised hydraulic modelling for the 2012 Erina Creek Flood Study. This found that even a small amount of filling in the flood fringe areas could cause an increase in flood levels elsewhere. Therefore filling is not recommended as the cumulative effects could be adverse. Furthermore, the revised floodway definition shows that part of this area is classified as floodway and therefore, as with other areas defined floodway, there should be no obstructions to flow.
- Nonetheless, minor filling in this area may have negligible impacts and therefore a detailed hydraulic assessment undertaken for individual cases may be necessary to prove there is no flood level impact off site before any development or filling is approved. In addition to the requirement for individual property assessment, Council has stated that no more houses can be built until properties are connected to Council's sewer system as filling to provide flood free land for sewerage effluent disposal cannot be supported.
- Access to high ground is the main issue for these properties. Raising of Barinya Lane (Photo 27) and the access to each house could be undertaken (depending on funding arrangements and an indicative sketch is shown as) and this would cause little adverse impact on flood levels. The amount of filling on the private access roads could be minimised if neighbours were able to "share" the access in times of flood. This would need to be negotiated between the neighbours but may not be successful in the long term as properties change ownership.
- The following conditions apply to this area:
    - development on these properties must comply with the 1998 Environment and Health Protection Guidelines and AS 2012 – On-site Domestic Wastewater Management;
    - houses are to be built as close to the road boundary as possible to reduce flood impacts;
    - flood free access is required to Wells Street and undertake further investigation to eliminate the sag point in Wells Street;
    - filling for a building pad or a raised access road is permitted up to a total of 600m^2 per property which includes allowance for an onsite sewerage management system and dissipation area;
    - submissions to support filling must indicate that the works do not adversely affect internal drainage of the subject or other surrounding properties;

- improved road access should be undertaken as shown in Photo 27;
- three vacant properties are located south of the properties fronting Barinya Lane and these should be voluntarily acquired by Council; and
- a Flood Study should be undertaken for any new development to ensure no offsite impacts (refer Photo 27).

1.9.3. Springfield Wetland Area

- Wetland areas are an appropriate use of flood prone land and the previous recommendations in the 1991 Erina Creek Floodplain Management Plan (Ref 4 - Appendix C) to prevent development are supported.

1.9.4. Wells Street Area

- The main feeder road of Wells Street in the vicinity of the Avalon Road intersection is inundated in frequent flood events. Council should investigate raising the road to improve access for both through and local road users. In addition it is recommended that Council investigate enlarging the road culverts under Willow Road so as to possibly make Willow Road an alternate flood free access for Wells Street through road users.

1.10. East Gosford (C2/J)

- Construction of a detention basin in the open space area adjacent to the Council Depot off Emma James Street to be further investigated.
- No other specific floodplain management measures except local drainage can be an issue in some areas. Water ponding at low points on Wells Street, Coburg Street and Adelaide / Russell Streets has been highlighted as an issue and it is recommended to upgrade drainage in this area with increased inlet and pipe capacity and consideration given to eliminating the sag point in Wells Street. The strategies for upgrading the drainage in various areas in East Gosford are detailed in the East Gosford Catchment Study (Reference 11). A feasibility study should be undertaken for all the identified strategies.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
PLAN A
UPPER ERINA CREEK

Sheet 4.

Sheet 3.

PAROO RD

WATTLE TREE RD

FIRES CREEK
C2/C

OAK ROAD
C2/B

OAK RD

HOLGATE

UPPER ERINA CREEK
C2/A

MILINA ROAD
C2/D

COACHWOOD RD

MATCHHAM RD

MATCHAM

N

For details refer to Sheet 1-4
Catchment and Subcatchment boundary
Creeks
Upper / Lower catchment divide
1% AEP Low Hazard
1% AEP High Hazard
1% AEP Extent
PMF Extent
Eligible Vacant Parcel for VP
House for Voluntary Purchase
Gosford Council Land

0 0.25 0.5 1 1.5 2 km

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ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
PLAN B
LOWER ERINA CREEK

Sheet 1.
Sheet 2.
Sheet 3.

MILINA ROAD
C2/D

SPRINGFIELD
C2/I

ERINA VALLEY ROAD CREEK
C2/E

BARRALONG ROAD
C2/G

EAST GOSFORD
C2/J

WORTHING ROAD CREEK
C2/F

NUNNS CREEK
C2/H

UPPER ERINA CREEK
C2/A

WATTLE TREE RD
PAUL OVAL
MILINA RD
CLYDE RD
CARLTON RD
CENTRAL COAST GRAMMAR
CENTRAL COAST HWY
ERINA HEIGHTS
SPRINGFIELD RD
WILLOW RD
EMMA JAMES RESERVE
COBURG ST
ALTHORP ST
NEWCASTLE ST
SPRINGFIELD
NOORUMBA RD
WELLS ST
CLARENCE RD
BARRALONG RD
Erina Creek
Worthing Road Creek
Erina Valley Road Creek
TERRIGAL DR
KARALTA RD
AVOCA DR
ERNEST ST
ERINA HIGH SCHOOL
Nunns Creek

N

- For details refer to Sheet 1-4
- Catchment and Subcatchment boundary
- Creeks
- Upper / Lower catchment divide
- Eligible Vacant Parcel for VP
- House for Voluntary Purchase
- Gosford Council Land
- 1% AEP Low Hazard
- 1% AEP High Hazard
- 1% AEP Extent
- PMF Extent
- A-N (Refer Table i)

0 0.25 0.5 1 1.5 2 km

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ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
SHEET 1

For details refer to Sheet 1-4
Catchment and Subcatchment boundary
Creeks
Upper / Lower catchment divide
Eligible Vacant Parcel for VP
House for Voluntary Purchase
Gosford Council Land
1% AEP Low Hazard
1% AEP High Hazard
1% AEP Extent
PMF Extent
A A-N (Refer Table i)

N

Sheet 2.
Sheet 3.
BARRALONG ROAD
C2/G
C2/D
CLARENCE RD
EMMA JAMES RESERVE
L
SPRINGFIELD RD
WILLOW RD
NOORUMBA RD
C
F
G
H
J
SPRINGFIELD
SPRINGFIELD
C2/I
COBURG ST
NEWCASTLE ST
ALTHORP ST
EAST GOSFORD
C2/J
Erina Creek
CENTRAL COAST HWY
WELLS ST
N
B
BARRALONG RD
ERINA
M
E
AVOCA DR
ERNEST ST
ERINA HIGH SCHOOL
K
NUNNS CREEK
C2/K
Nunns Creek

0 0.25 0.5 1 1.5 2 km

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ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
SHEET 2

Sheet 1.
Sheet 3.
MILINA ROAD
C2/D
MILINA RD
CLYDE RD
CARLTON RD
I
CENTRAL COAST GRAMMAR
CENTRAL COAST HWY
ERINA HEIGHTS
SPRINGFIELD RD
WILLOW RD
NOORUMBA RD
CLARENCE RD
ERINA VALLEY ROAD CREEK
C2/E
Erina Valley Road Creek
Worthing Road Creek
A
BARRALONG ROAD
C2/G
Erina Creek
F
C
N
B
SPRINGFIELD
SPRINGFIELD
C2/I
WELLS ST
BARRALONG RD
ERINA
M
TERRIGAL DR
G
STLE ST
Erina Creek
Erina Creek
CENTRAL COAST HWY
D
WORTHING ROAD CREEK
C2/F
K
ERINA HIGH SCHOOL
ERNEST ST
KARALTA RD
E
Nunns Creek
NUNNS CREEK
C2/H

N

For details refer to Sheet 1-4
Catchment and Subcatchment boundary
Creeks
Upper / Lower catchment divide
Eligible Vacant Parcel for VP
House for Voluntary Purchase
Gosford Council Land
1% AEP Low Hazard
1% AEP High Hazard
1% AEP Extent
PMF Extent
A A-N (Refer Table i)

0 0.25 0.5 1 1.5 2 km

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ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
SHEET 3

For details refer to Sheet 1-4
Catchment and Subcatchment boundary
Creeks
Upper / Lower catchment divide
Eligible Vacant Parcel for VP
House for Voluntary Purchase
Gosford Council Land
1% AEP Low Hazard
1% AEP High Hazard
1% AEP Extent
PMF Extent
A-N (Refer Table i)

N

Sheet 4.

FIRES CREEK
C2/C

OAK ROAD
C2/B

OAK RD

UPPER ERINA CREEK
C2/A

WATTLE TREE RD

COACHWOOD RD

PAUL
OVAL

MILINA ROAD
C2/D

G

MILINA RD

I

Sheet 2.

CLYDE RD

CARLTON RD

CENTRAL
COAST
GRAMMAR

CENTRAL COAST HWY

ERINA HEIGHTS

SPRINGFIELD
C2/I

BARRALONG ROAD
C2/G

ERINA VALLEY ROAD CREEK
C2/E

Erina Valley Road Creek

A

WORTHING ROAD CREEK
C2/F

0 0.25 0.5 1 1.5 2 km

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ERINA CREEK FLOODPLAIN MANAGEMENT PLAN
SHEET 4

For details refer to Sheet 1-4
Catchment and Subcatchment boundary
Creeks
Upper / Lower catchment divide
Eligible Vacant Parcel for VP
House for Voluntary Purchase
Gosford Council Land
1% AEP Low Hazard
1% AEP High Hazard
1% AEP Extent
PMF Extent
A A-N (Refer Table i)

N

FIRES CREEK
C2/C

WATTLE TREE RD

PAROO RD

OAK ROAD
C2/B

OAK RD

HOLGATE

UPPER ERINA CREEK
C2/A

MILNA ROAD

0 0.25 0.5 1 1.5 2 km

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Figures

FIGURE 1A
STUDY AREA
UPPER ERINA CREEK

Fires Creek

Maddens Creek

Erina Creek

Ridgeway District

MOUNT ELLIOT

HOLGATE

MATCHAM

Milina Road

N

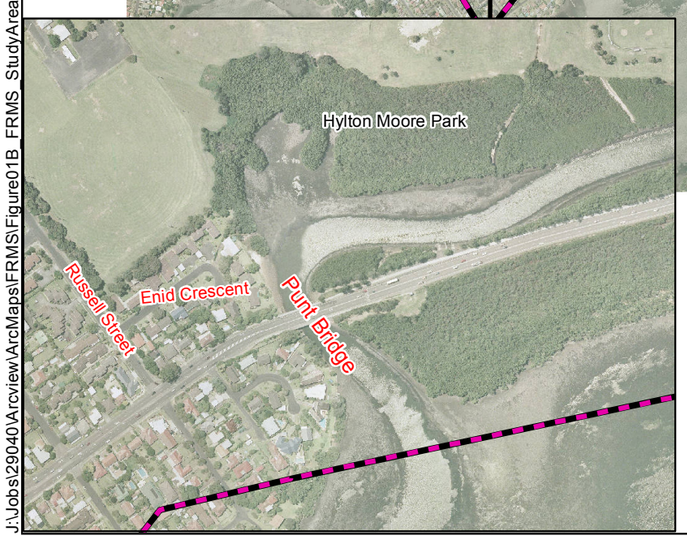
Upper / Lower catchment divide
Creeks
Catchment Boundary

0 0.5 1 1.5 2 km

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FIGURE 1B
STUDY AREA
LOWER ERINA CREEK

MATCHAM
Milina Road
Carlton Road
ERINA HEIGHTS
Central Coast Highway
Karwin Avenue
Old Erina Estate
Cheltwynd Road
Erina Valley Road Creek
Erina Creek
Barralong Road
Worthing Road Creek
SPRINGFIELD
Barinya Lane
ERINA
Tarragal Glen
Retirement Village
Hylton Moore Park
Erina Creek
Russell Street
Punt Bridge
The Entrance Road
Erina Fair
Terrigal Road
Karalta Road
Council Depot
Avoca Drive
Nunns Creek
GREEN POINT



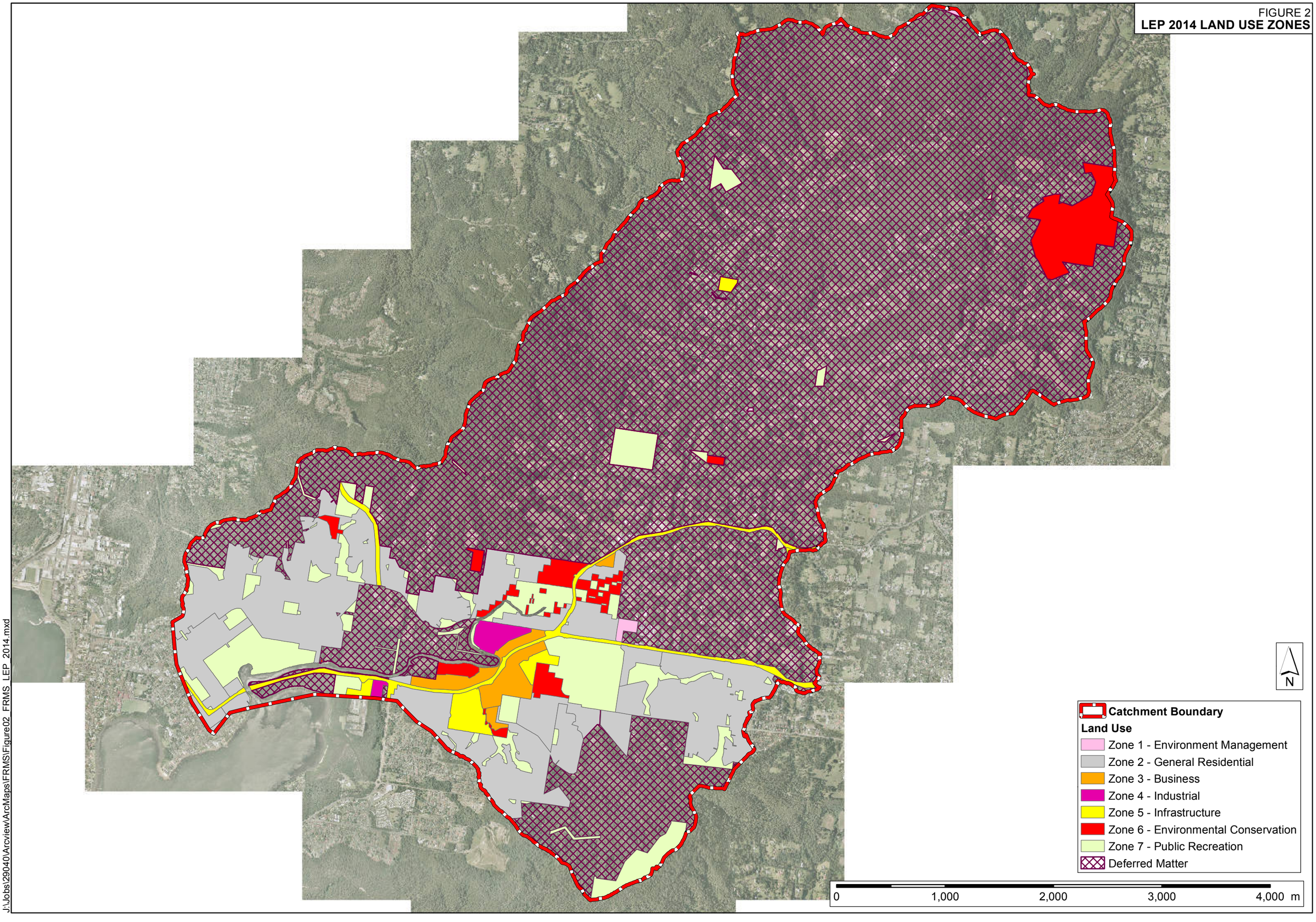
N

Upper / Lower catchment divide
Barralong Road Levee
Pipes / Culverts
Creeks
Catchment Boundary

0 0.5 1 1.5 2 km

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FIGURE 2
LEP 2014 LAND USE ZONES



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FIGURE 3
FLOODPLAIN MANAGEMENT AREAS

FIRES CREEK
C2/C

OAK ROAD
C2/B

MOUNT ELLIOT

HOLGATE

UPPER ERINA CREEK
C2/A

MATCHAM

MILINA ROAD
C2/D

ERINA HEIGHTS

SPRINGFIELD
C2/I

BARRALONG ROAD
C2/G

Erina Valley Road Creek

Worthing Road Creek

Erina Creek

ERINA VALLEY ROAD CREEK
C2/E

EAST GOSFORD
C2/J

SPRINGFIELD

ERINA

Erina Creek

Erina Creek

WORTHING ROAD CREEK
C2/F

Nunns Creek

NUNNS CREEK
C2/H

GREEN POINT

N

Creeks

Subcatchments

- C2/A, Upper Erina Creek
- C2/B, Oak Road
- C2/C, Fires Creek
- C2/D, Milina Road
- C2/E, Erina Valley Road Creek
- C2/F, Worthing Road Creek
- C2/G,Barralong Road
- C2/H, Nunns Creek
- C2/I, Springfield
- C2/J, East Gosford

0 500 1,000 2,000 3,000 4,000
m

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FIGURE 4

INUNDATION OF BUILDING FLOOR LEVELS
EVENT FIRST FLOODED

NOTE: Only those properties included in the floor level survey database are shown in this figure. Although the full cadastral lot is shown, this does not necessarily mean the entire lot is inundated.

MOUNT ELLIOT
HOLGATE
MATCHAM
ERINA HEIGHTS
ERINA
SPRINGFIELD
Milina Road
Carlton Road
Arundel Road
Central Coast Highway
Digby Road
Lakala Avenue
Meadow Road
Clarence Road
Wells Street
Barinya Lane
Erina Creek
Barralong Road
The Entrance Road
Chetwynd Road
Erina Valley Road Creek
Worthing Road Creek
Althorp Street
Russell Street
Punt Bridge
Avoca Drive
Nunns Creek
James Sea Drive
Pine Tree Avenue
Bonzewing Drive
Karalta Road
Terrigal Road

N

First Flooded Floor Level Event

- 50% AEP
- 20% AEP
- 10% AEP
- 5% AEP
- 2% AEP
- 1% AEP
- 0.5% AEP
- 0.2% AEP
- PMF
- Not Flooded Above Floor Level

0 0.3 0.6 1.2 1.8 2.4 km

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FIGURE 5

FLOOD EMERGENCY RESPONSE PLANNING AREAS

N

1% AEP Flood Extent

Flood Emergency Response Planning Area

- High Flood Island
- High Trapped Perimeter Area
- Low Flood Island
- Overland Escape Route
- Rising Road Access Area

0 0.5 1 1.5 2 km

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FIGURE 6A

LOWER ERINA CREEK
IMPACTS OF SEA LEVEL RISE
1% AEP DESIGN FLOOD

INCREASE 0.4 m SEA LEVEL RISE

INCREASE 0.9m SEA LEVEL RISE

N

Increase in peak flood level (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- Newly Flooded

0 0.25 0.5 1 1.5 2 km

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INCREASE 0.2 m SEA LEVEL RISE

INCREASE 0.74m SEA LEVEL RISE

FIGURE 6B
LOWER ERINA CREEK
IMPACTS OF SEA LEVEL RISE
1% AEP DESIGN FLOOD

N

Increase in peak flood level (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- Newly Flooded

0 0.25 0.5 1 1.5 2 km

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FIGURE 7

LOWER ERINA CREEK
IMPACT OF FILLING FLOOD FRINGE AREAS WITHIN PEAK FLOOD DEPTH OF 500mm

N

Impacts (m)

- No longer flooded
- -0.29 - -0.1
- -0.09 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5
- Newly flooded

0 200 400 600 800 1,000 m

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Appendix A

APPENDIX A: GLOSSARY OF TERMS

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Climate Change Adaption Plan (CCAP)	Management Plan prepared to establish a framework for the management of projected climate change effects
consent authority	The Council, Government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

disaster plan (EMPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information

	describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the flood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL's are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the standard flood event in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation

	to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flow paths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople

	begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.



Appendix B

APPENDIX B: INUNDATION OF ROAD CROSSINGS

The deck level of each major road crossing as well as the peak design flood levels are provided in Table B1 and Figures B1 and B2.

Table B1: Flood Levels (mAHD) at Road Crossings (refer Figure B1 and B2) for locations)

#	LOCATION	Ground Level (mAHD) at Crossing	2Y ARI	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
1	Karalta Ln	3.3				3.4	3.5	3.6	3.7	3.7	4.7
2	The Entrance Rd	1.5									2.0
3	Marana Rd	7.8		8.0	8.0	8.1	8.1	8.2	8.2	8.2	8.6
4	Springfield Rd	6.4							6.4	6.5	6.8
5	Willow Rd	1.8		2.1	2.1	2.1	2.2	2.2	2.3	2.4	3.8
6	Wells St	1.0		1.3	1.6	1.8	2.0	2.1	2.2	2.3	3.8
7	Newcastle St	1.4	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4	2.9
8	Spring Ave	1.8	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.4	2.9
9	Maitland Rd	3.3						3.5	3.5	3.5	3.7
10	Wells St	8.2			8.3	8.4	8.4	8.4	8.4	8.4	8.4
11	Althorp St	3.7	3.9	4.4	4.7	4.8	5.0	5.1	5.1	5.2	5.8
12	Waratah St	4.0	3.9	4.4	4.7	4.8	5.0	5.1	5.1	5.2	5.8
13	Coburg St	4.8	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.4	5.9
14	Wells St	6.5	6.6	6.7	6.7	6.8	6.8	6.8	6.9	6.9	7.2
15	Morella Cl	3.5									3.7
16	Wells St nr Noorumba Rd	5.3									5.8
17	Noorumba Rd	5.7									5.9
18	Wells St nr Clarence Rd	3.2									4.4
19	Clarence Rd	2.6		2.7	2.8	2.8	2.9	3.0	3.2	3.3	5.2
20	Barralong Rd	5.7	1.9	2.2	2.4	2.6	2.7	2.9	3.0	3.2	4.9
21	Bonnal Rd	1.5		1.9	2.0	2.2	2.5	2.7	2.8	3.0	4.8
22	Aston Rd	1.6			2.0	2.2	2.5	2.7	2.8	3.0	4.9
23	Marinus Pl	1.8				2.2	2.5	2.7	2.8	3.0	5.0
24	Winani Rd	1.8						2.1	2.8	3.1	5.5
25	Lingi St	1.9						2.1	2.8	3.1	5.4
26	Bonnal Rd nr Aston Rd	1.8		1.9	2.0	2.2	2.5	2.7	2.8	3.0	4.7
27	Marinus Pl	2.6							2.8	3.0	4.9
28	Barralong Rd nr Lingi St	2.4							2.8	3.1	5.4
29	The Entrance Rd nr Bonnal Rd	2.8								3.0	4.7
30	Karalta Rd	5.8	5.8	5.9	5.9	5.9	6.0	6.0	6.0	6.1	6.3
31	Karalta Rd nr Central Coast Hwy	2.9	3.1	3.2	3.2	3.3	3.3	3.3	3.3	3.3	4.6
32	Central Coast Hwy	3.1									4.6
33	Pine Tree Ave	10.6									10.9
34	Bronzewing Drive	18.2				18.3	18.3	18.4	18.4	18.4	18.4
35	Jessie Riley Ave	21.3						21.5	21.5	21.5	21.6
36	Ilya Ave	8.0									8.2
37	Legge Pl	9.7									10.0
38	Pine Tree Ave nr	12.6						12.7	12.8	12.8	13.4

#	LOCATION	Ground Level (mAHD) at Crossing	2Y ARI	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
	Lemon Tree Walk										
39	The Entrance Rd nr Worthing Road Ck	4.8									5.9
40	Terrigal Dr	6.3		6.6	6.7	6.7	6.7	6.8	6.8	6.9	7.3
41	Karalta Rd	14.7								14.8	15.3
42	Jessie Hurley Dr nr Roy Stuart Cl	16.7									16.9
43	Girrawen Ave	4.1							4.3	4.6	6.0
44	Toorak Ave	3.7					3.8	4.0	4.3	4.6	6.0
45	Kuburra Rd	2.6		3.1	3.2	3.4	3.8	4.0	4.3	4.6	6.0
46	Chetwynd Rd	4.4								4.6	6.0
47	Emma James St	11.0	11.3	11.3	11.4	11.4	11.5	11.5	11.5	11.5	11.8
48	Rumbalara Pl	11.3			11.4	11.5	11.5	11.5	11.6	11.6	11.8
49	Lakala Ave	4.5				4.6	4.7	4.7	4.7	4.7	5.7
50	Carlton Rd	4.5	4.8	5.0	5.0	5.1	5.2	5.3	5.4	5.5	7.0
51	Clyde Rd	3.9	4.3	4.4	4.5	4.5	4.6	4.7	4.8	4.9	6.7
52	Milina Rd	6.3									7.0
53	Gooriwa Rd	7.5			7.6	7.7	7.8	7.9	7.9	8.0	8.8
54	Murina Cl	7.7	8.2	8.2	8.3	8.3	8.3	8.4	8.4	8.5	9.3
55	Chetwynd Rd	3.2	3.3	3.4	3.4	3.5	3.8	4.0	4.3	4.6	6.0
56	Kirkby Rd	5.6									6.0
57	Chiltern Rd nr Kirkby Rd	5.3									6.0
58	Nerissa Rd	3.6						4.0	4.3	4.6	6.0
59	Tamara Rd	2.9		3.1	3.2	3.4	3.8	4.0	4.3	4.6	6.0
60	Wattle Tree Rd	8.2									8.6
61	Milina Rd nr Wattle Tree Rd	6.6									7.3
62	Coachwood Rd nr Milina Rd	7.5									8.7
63	Milina Rd nr Coachwood Rd	5.4	6.6	6.8	6.8	6.9	7.0	7.1	7.1	7.2	8.2
64	Arundel Rd	4.7	5.6	5.7	5.8	5.9	6.0	6.0	6.1	6.2	7.4
65	Wattle Tree Rd nr Katandra Rd	9.4									10.4
66	Oak Rd	8.0	8.2	8.3	8.4	8.5	8.6	8.8	8.9	9.1	10.7
67	Elaine Rd	16.2	16.5	16.5	16.6	16.6	16.7	16.8	16.8	16.8	17.6
68	Oak Rd nr Macs Ln	10.5	10.8	10.9	11.0	11.1	11.1	11.3	11.4	11.4	12.2
69	Macs Ln	11.1					11.2	11.3	11.4	11.5	12.3
70	Wattle Tree Rd nr Manor Hill Cl	13.1									14.2
71	Wattle Tree Rd	13.6	13.8	13.9	14.0	14.2	14.3	14.5	14.6	14.7	16.0
72	Pollard Cl	25.8	26.3	26.4	26.4	26.4	26.5	26.5	26.5	26.5	26.8
73	Matcham Rd	17.1		17.3	17.4	17.5	17.6	17.8	17.9	18.0	18.6
74	Matcham Rd	23.2			23.3	23.4	23.4	23.5	23.5	23.6	24.1

FIGURE B1
LOWER ERINA CREEK ROAD CROSSINGS

ERINA CREEK

BRISBANE WATER

ERINA FAIR

Road First Flooded In

- 2Y ARI Event
- 20% AEP Event
- 10% AEP Event
- 5% AEP Event
- 2% AEP Event
- 1% AEP Event
- 0.5% AEP Event
- 0.2% AEP Event
- PMF Event
- Creek

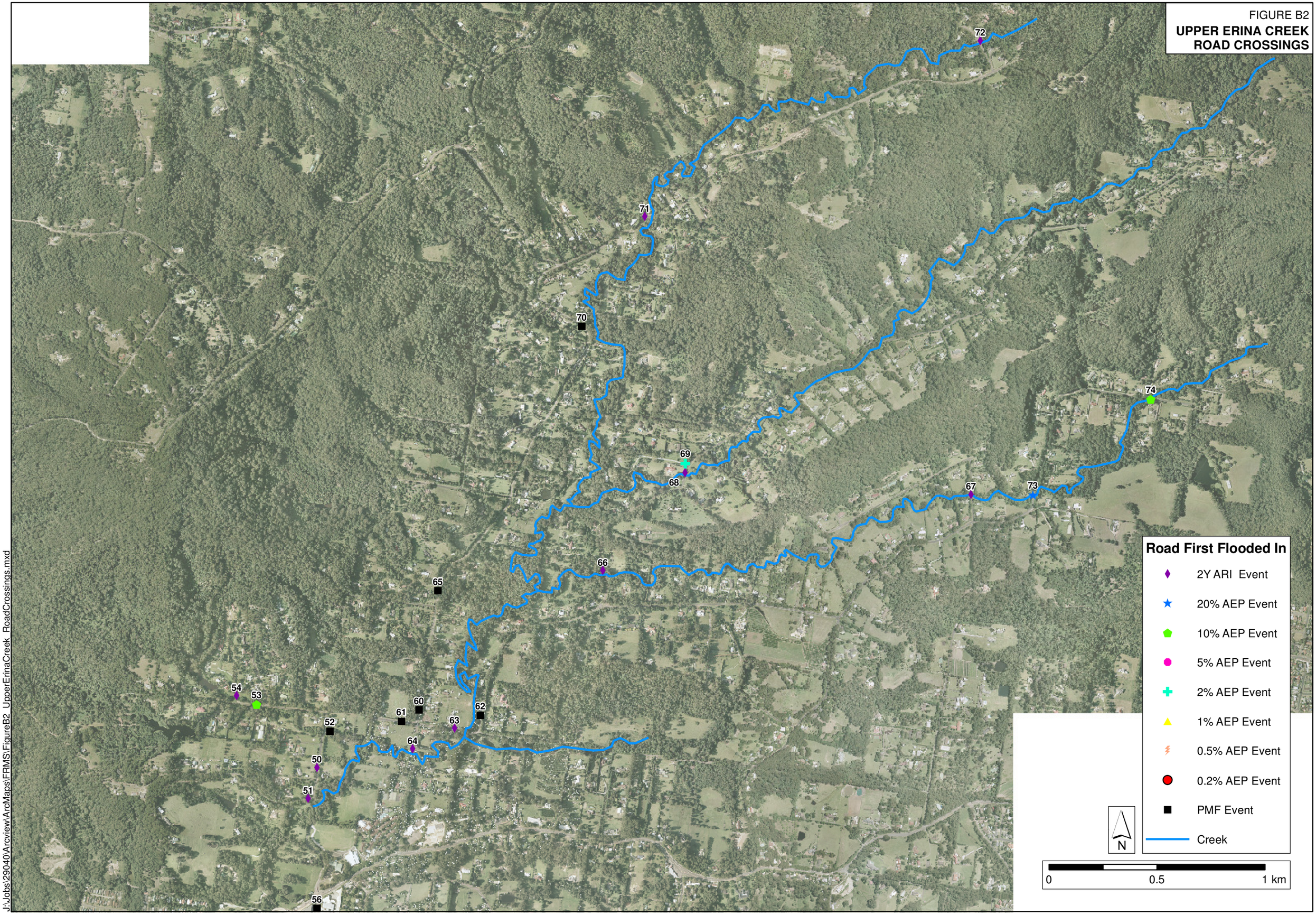
N

0 0.5 1 km

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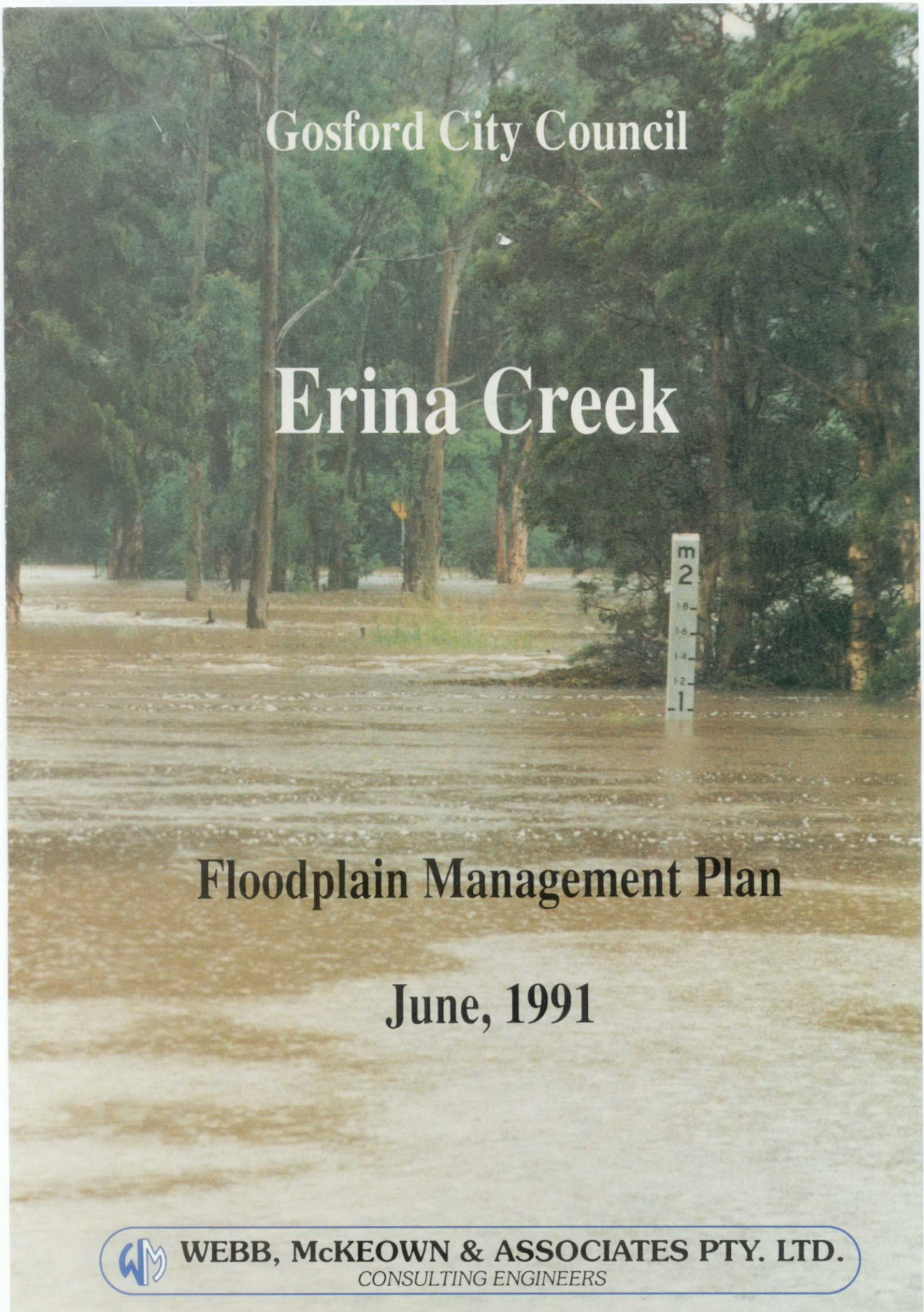
FIGURE B2

UPPER ERINA CREEK ROAD CROSSINGS



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Appendix C


Gosford City Council
Erina Creek
m
2
1.8
1.6
1.4
1.2
1
Floodplain Management Plan
June, 1991
WEBB, McKEOWN & ASSOCIATES PTY. LTD.
CONSULTING ENGINEERS

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

ADDENDUM NO 1 DATED 1 JULY 1991

Addition to Council Depot Flood Area

LOCATION: Corner of The Entrance Road and Avoca Drive (Refer to sketch plan A).

SITE: Pt 1, DP 535379 and Lot 1 DP 625529

The site is occupied by a building hardware complex and timber yard and a portion of a motor vehicle service station. It was designated in the Management Plan as an area where localised flood measures may be required.

The existing floor level of the hardware complex (which is the only building within this section of the floodplain) is 2.03m AHD and the 1% AEP design flood level in Erina Creek is 2.2m AHD. As this is a flood fringe area the velocities will be less than 0.5m/s. Proposed upstream flood mitigation measures will have negligible adverse impact at the location. The only available flood mitigation measures are local levees or flood proofing. Unless The Entrance Road was raised to act as a levee it would be difficult to construct a local levee which would not be outflanked or impose restrictions on access to the site. The preferred option in the short term is to introduce local flood proofing or damage minimisation measures. The site in the past has been flooded and the occupants have since taken precautions in protecting valuable equipment and materials.

In the long term the site should be redeveloped with a minimum floor level 500mm above the 1% flood level. In the short term the following measures should be considered:-

- Flood awareness programme.
- Relocation of stock which will suffer from inundation, electrical equipment and storage of all filing cabinets and other essential and valuable papers to above flood level.
- Flood proofing of main entrance/doors or stockpile of sand bags or other protection measures.

The area should have the following conditions applied:-

- No filling other than that required to construct a building.
- Floor levels 500mm above 1% flood level unless special conditions apply.
- Establishment of flood proofing regulations.

The conditions for this area are generally the same as for the Council Depot Flood Area and as such the area has been included as part of the Council Depot Flood Area.

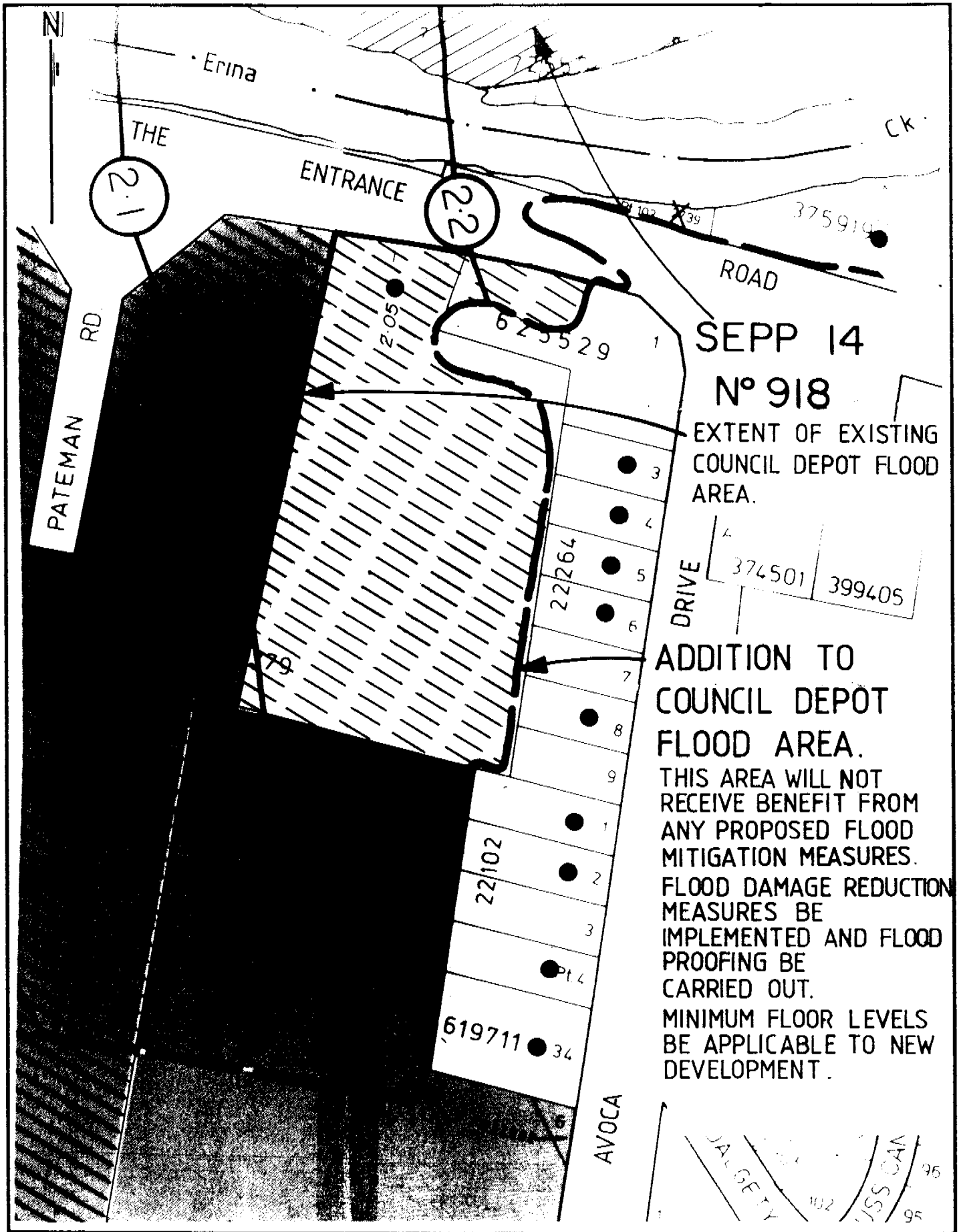
Concise Description of the Plan

Addition to Council Depot Flood Area.

- This area will not receive benefit from any proposed flood mitigation measures.
- Flood damage reduction measures be implemented and flood proofing be carried out.
- Minimum floor levels be applied for new development.

Priority of Work

The flood proofing work is of low priority due to the type of use of the area, the low flood risk and the minor flood damage costs. Flood proofing should be carried out at the owners expense.



BASE SCALE 1:200	0 2 4 6 8 m	**GOSFORD CITY COUNCIL**
DATUM	A.H.D.	EXTRACT FROM ERINA CREEK FLOODPLAIN MANAGEMENT PLAN.
SURVEYED		ADDITION TO COUNCIL DEPOT FLOOD AREA.
DRAWN	M.B. 26/07/91	
CHECKED	V.T. 26/07/91	FILE No. 920.02.01 — SKETCH PLAN 'A'

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

ADDENDUM NO 2 DATED 11 SEPTEMBER 1991

WORTHING ROAD CREEK FLOOD AREA

Review of 1% Flood Level and Minimum Floor Level

The flood level for the Worthing Road Creek Flood Area was found to be 3.4 metres AHD after the completion of the Erina Valley Road and Worthing Road Creek Trunk Drainage Studies. This level is considerably less than the original adopted flood level of 3.95 metres AHD. Adoption of the higher old flood level of 3.95 metres was favoured as:-

a Most of the area had been developed based on the higher old flood level.

b The adoption of the old level would not affect the number of properties to be acquired as determined using the new 3.4 metres level.

c The minimum floor level as determined using the higher old level contained the extreme flood event.

Council at its meeting held on 6 August 1991 resolved to adopt the higher old flood level of 3.95 metres AHD and corresponding minimum floor level of 4.45 metres AHD for this Worthing Road Creek flood area east of The Entrance Road and downstream of the 1% AEP flood profile impacts with the two upper tributaries.

Council Drawing No 2/47/A1 has now been updated to show the adopted flood line.

ADDENDUM 2.

GOSFORD CITY COUNCIL

OLD ERINA ESTATE FLOODWAY AND ACQUISITION AREA

Full development within this estate would significantly raise flood levels upstream.
Limited minor filling will only be permitted for access to developable blocks.
The remaining blocks will be purchased and dedicated as floodway as designated on the plan.
Rate relief will be initiated by Council for the non-developable blocks.

Fill may be permitted within the designated area to provide a maximum of 500 sq m of flood free land

CARLTON ROAD FLOOD FRINGE AREA

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.

Superseded

Go to the following page to view the Revised Plan

Refer Worthing Road Creek Trunk Drainage Study for information upstream of Chetwynd Road

Road Creek and Worthing Road Creek.

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

KEY TO PARISH

LEGEND

- Boundary of Classified Floodplain
- 1% (100 Year) Flood Contour in m AHD
- Approved Floor Levels (see Note)
- Existing Buildings
- Proposed Levee Bank
- Council Owned Land
- Land Subject to Geotechnical Investigation
- Wetlands Area
- Floodplain Management Areas
- Building designated for aquisition or floodproofing under the Floodplain Management Plan
- Vacant Land Identified for Acquisition X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

229D	230C	230D
244B	245A	245B
244D	245C	245D

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/47/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK
FLOODPLAIN MANAGEMENT PLAN
CLASSIFICATION OF FLOODPLAIN LANDS

ADDENDUM 2

OLD ERINA ESTATE FLOODWAY AND ACQUISITION AREA

Full development within this estate would significantly raise flood levels upstream. Limited minor filling will only be permitted for access to developable blocks.
The remaining blocks will be purchased and dedicated as floodway as designated on the plan.
Rate relief will be initiated by Council for the non-developable blocks.

Fill may be permitted within the designated area to provide a maximum of 500 sq. m of flood-free land

CARLTON ROAD FLOOD FRINGE AREA

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.
No filling or hydraulic restrictions will be permitted outside the designated areas.

Refer Erina Valley Road Trunk Drainage Study for information upstream of Tamara Avenue

WORTHING ROAD CREEK FLOOD AREA

Progressive purchase or floodproofing of the four existing flood liable houses as funds become available and consideration to one further house.
Implementation of controls for future catchment development.
Rate relief for undevelopable blocks.
Progressive purchase of undevelopable blocks.
Two further studies are being completed for Erina Valley Road Creek and Worthing Road Creek.

Refer Worthing Road Creek Trunk Drainage Study for information upstream of Chetwynd Road

See Sheet 245 A (2) For Flood Contours On Upper Tributaries Of Worthing Creek.

FLOODWAYS (for notes see Sheet 230D) (M.R. N°336)

(ADOPTED 1% AEP FLOOD LEVEL RL 3.95 AHD)

3/3000 x 3000 RCBC

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

SCHEDULE OF COMPLETED WORKS

N°	DATE	LOCATION	WORKS
4	2ND JULY 2009	THE ENTRANCE RD - WYRAMA / LAKE ST LEVEE	CONSTRUCTION
3	DECEMBER 1991	LOT 11 SEC 20 DP 2163 NERISSA ROAD ERINA	ACQUISITION
2	SEPTEMBER 1991	LOT 14 SEC 20 DP 2163 NERISSA ROAD ERINA	ACQUISITION
1	AUGUST 1991	LOT 9 SEC 24 D.P 2163 KUBURRA ROAD - ERINA	ACQUISITION

GOSFORD CITY COUNCIL

COUNTY OF NORTHUMBERLAND

KINCUMBER

KEY TO PARISH

LEGEND

- Boundary of Classified Floodplain
- 1% (100 Year) Flood Contour in 'm' AHD (3.8)
- Approved Floor Levels (see Note) 2.75
- Existing Buildings
- Existing Rd Levee Bank Constructed 1998/99
- Council Owned Land
- Land Subject to Geotechnical Investigation
- Wetlands Area
- Floodplain Management Areas
- Unconstructed Sections of Road Reserve
- Vacant Land Identified for Acquisition X
- Building Designated for Acquisition
- Building Identified for house raising subject to Councils resolution dated 26-5-92. Minute no. 503/92.

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

229D	230C	230D
244B	245A	245B
244D	245C	245D

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/47/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

CLASSIFICATION OF FLOODPLAIN LANDS

Plans adopted by G.C.C. 14-5-91

ORIGINAL

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

245A

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

ADDENDUM NO 3 DATED 14 OCTOBER 1991

The Entrance Road and Avoca Drive Flood Fringe Area

LOCATION: Council Drawing 2/46/A1. Land north of the Entrance Road, opposite Avoca Drive and west of the Electricity Sub-station.

SITE: Part Lot A of DP 375919, Lots 102, 104, 105, 106A, 106B, 107 and 108 DP 2739 The Entrance Road.

The subject land (Figure 1) consists of eight lots located on the northern side of the Entrance Road, opposite the Avoca Drive intersection. The land is generally flat at 1.6m to 1.8m AHD and rises relatively steeply to high ground along the Entrance Road. In a 1% flood the land is inundated by up to 0.7m (1% flood level - 2.3m AHD). The following two buildings are at the 1% flood level.

Location	Floor Level	Building Type
Lot A of DP 375919	2.17 - 2.26m	Non-brick residential building.
Lot 106B, DP 375026	2.25 - 2.32m	Brick commercial premises.

The remainder of the lots are generally vacant or used for a commercial nursery or have buildings whose floor levels are above the 1% floor level.

During a flood, water flowing through the site is restricted by the building on Lot 106B and the presence of vegetation and other obstructions. It is a flood fringe area and the peak velocities will be less than 0.5m/s.

Within the Erina Industrial Flood Fringe Area, located immediately upstream, filling of the floodplain will be permitted subject to future re-development upstream. These works together with proposed upstream flood mitigation measures as proposed under the Erina Creek Floodplain Management Plan will have negligible adverse impact at this location.

It is proposed that filling of the flood liable land south of the Limit Line (Figure 1) be undertaken in order to maximise its usage. The hydraulic effect of filling to above the 1% flood level was analysed using the computer model. It was concluded that the increase in the 1% flood level upstream would be less than 10mm and is therefore considered to be negligible.

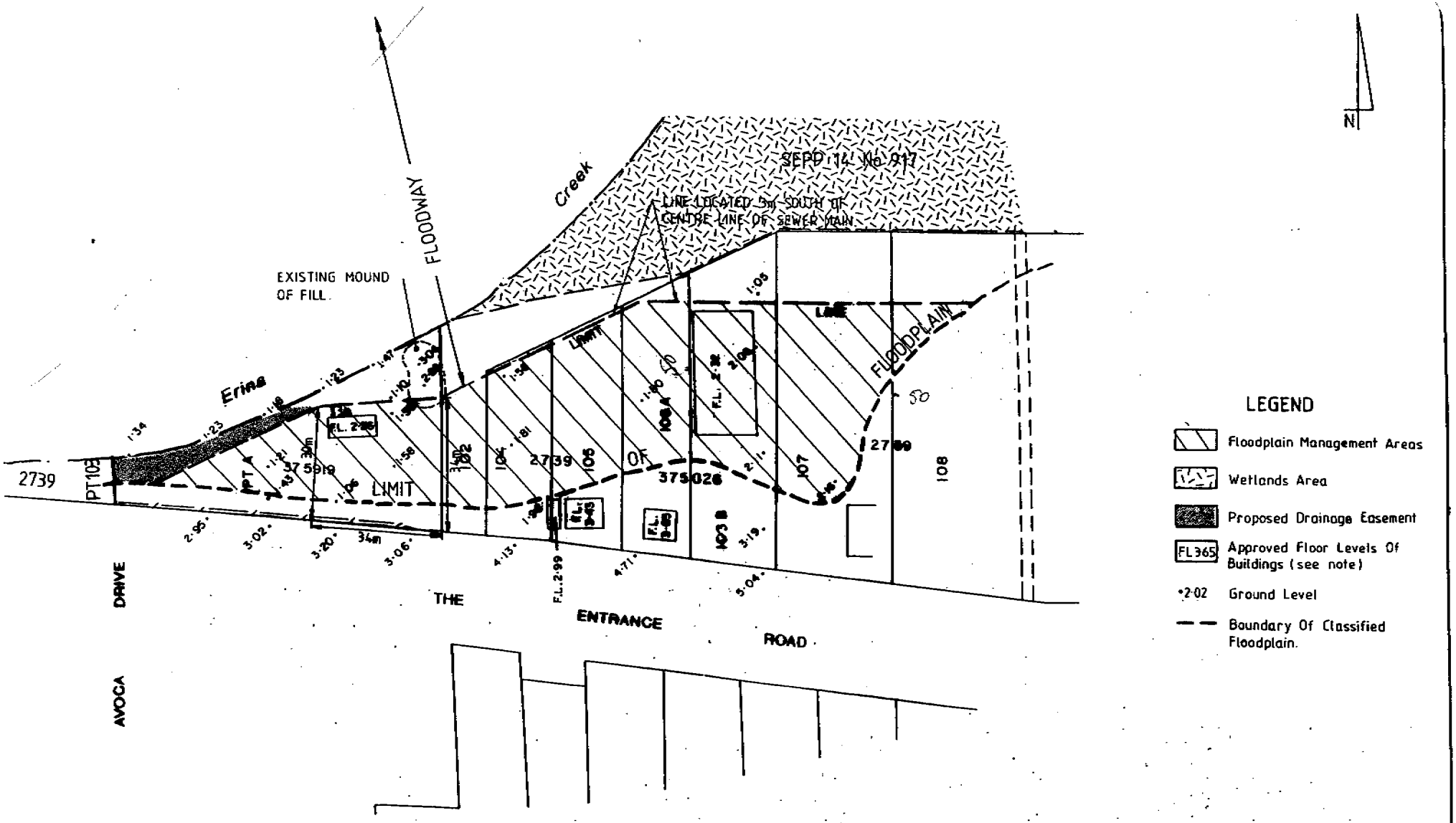
Development can therefore be undertaken subject to the following conditions:-

- All new buildings to comply to a minimum floor level.
- Filling is only permitted within the designated area.
- Filling must be a minimum of 300mm and floor levels to a minimum of 500mm above the 1% flood level.
- The remaining flood liable land outside the designated area will be dedicated to Council for drainage purposes in accordance with the Management Plan and at the owner's expense.
- Filling will be undertaken at the owner's expense.
- Filling should be undertaken from the upstream end first and proceed downstream, however limited filling on the perimeter of the floodplain may be permitted at the discretion of Council.

As the works are at the owner's expense and have no impact elsewhere they can be undertaken immediately if required.

NB **This study addresses only flooding constraints on this area of land. Town Planning issues, such as building setbacks, use of the land, access, etc, will be investigated at a later stage.**

13/5/92
E19\Misc\Erina.smd



DATUM		SURVEYED		
		DRAWN	S Mill.	2/12/91
FIELD BOOKS	LEVEL BOOKS	CHECKED	[illegible]	4/12/91
		DESIGN ENGINEER		

BASE SCALE 1:1000

BAR SCALE 0 10 20 30 40 50

GOSFORD CITY COUNCIL

FIGURE 1 - LOCALITY PLAN ERINA CREEK FLOODPLAIN MANAGEMENT PLAN ADDENDUM No. 3. THE ENTRANCE ROAD AND AVOCA DRIVE FLOOD FRINGE AREA.

FILE No. 920·02·01

DRAWING No. 2 / 49 / A3

GOSFORD CITY COUNCIL

ERINA CREEK

FLOODPLAIN MANAGEMENT PLAN

JUNE, 1991

Webb, McKeown & Associates Pty Ltd
117 York Street, Sydney
Telephone (02) 264 1544
Facsimile (02) 267 7038
ErinaFS:Rep 2

FOREWORD

The State Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following four sequential stages:

1. *Flood Study*
   - determines the nature and extent of the flood problem.
2. *Floodplain Management Study*
   - evaluates management options for the floodplain in respect of both existing and proposed development.
3. *Floodplain Management Plan*
   - involves formal adoption by Council of a plan of management for the floodplain.
4. *Implementation of the Plan*
   - construction of flood mitigation works to protect existing development.
   - use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Erina Creek Floodplain Management Plan constitutes the third stage of the management process. It has been prepared by Gosford City Council and provides the basis for the future management of flood liable lands along Erina Creek.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

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1. FLOODPLAIN MANAGEMENT AREAS

2. FLOODPLAIN MANAGEMENT PLANS
(Council Drawings 2/43/A1 to 2/48/A1)

Note: Plans may be updated from time to time. Information on the Plans should be confirmed with the Council prior to using the information for any purposes.

SUMMARY

Erina Creek is one of the larger creeks lying within the boundaries of Gosford City Council, with a total catchment area of approximately 32 square kilometres. A large portion of the floodplain downstream of Carlton Road has already been developed and experiences damages in major floods. Major flooding occurred in January 1978 and February 1990.

Gosford City Council sought to examine the range of flood mitigation options which could be employed firstly to protect the existing development as far as possible and secondly to ensure that any new development would be flood free or reasonably protected above Council's designated flood as far as possible. In accordance with the 1986 Floodplain Development Manual, Council approached the Public Works Department for assistance in preparation of a Floodplain Management Study and Plan. Council established a Floodplain Management Committee consisting of Aldermen, Council Officers, Public Works Department, Department of Planning and community representatives, to review the Study. Council had previously adopted the 1% event as the designated flood.

In 1989 Webb, McKeown & Associates, Consulting Engineers, were engaged to undertake the Erina Creek Floodplain Management Study. As part of the Study, they were required to update the earlier Erina Creek Flood Study (PWD, 1985) in the light of subsequent historical floods and revised design rainfall data in the 1987 edition of Australian Rainfall & Runoff. Computer based hydrologic and hydraulic models were established to simulate flooding within the catchment.

The models were calibrated and tested on the historical flood data prior to being used for estimation of the 1%, 2%, 5% and extreme floods. The results are presented in the "Erina Creek Flood Study Review 1990". These models were then available to assess the hydraulic impacts of various flood mitigation and development options. Currently 31 industrial premises, 14 residential buildings and 94 properties (including those of elevated houses) are inundated in a 1% flood. The average annual flood damages is estimated to be $71 000.

The Committee recommended that a series of flood mitigation/development scenarios should be examined in the Erina Creek Floodplain Management Study, in order to provide a basis for the formulation of the Erina Creek Floodplain Management Plan. The scenarios were:

- preliminary assessment of general flood mitigation strategies,
- levee alternatives in the vicinity of Barralong Road,
- construction of Barralong Road Bridge and downstream floodway channel,
- future catchment development,
- assessment of the possible consequences of the Greenhouse Effect and severe flooding.

These scenarios were refined where necessary by the Floodplain Management Committee. Three floodplain management options were considered in detail.

For each of the options the following matters were considered where applicable:

- alternative alignments or designs,
- environmental impacts,
- social impacts,
- adverse hydraulic impacts (or benefits) for the range of design floods,
- engineering issues and impacts,
- approximate fill quantities,
- indicative costings,
- indicative benefit/cost analyses.

It was concluded that the recommended approach for the future development of the Erina Creek floodplain should be a combination of controls on future development, protection to existing properties at risk and limited filling on the floodplain. This generally was determined after detailed consideration of the social, environmental, economic and hydraulic factors. Retarding basins were not recommended for reducing flood levels along the main stream of Erina Creek but were recommended for minimising the effects of future upstream development. Provision of a flood channel downstream of Barralong Road, stream clearing, dredging and additional culverts under the Entrance Road, were not found to be cost effective.

The Erina Creek Floodplain Management Plan was subsequently prepared by Council. The floodplain was subdivided into 11 areas and a description of each area is provided herein. The areas are shown on the enclosed figure and are defined as:

EC0	Floodways
EC1	Council Depot Flood Area
EC2	Erina Industrial Flood Fringe Area
EC3	Erina Industrial Flood Protection Area
EC4	Worthing Road Creek Flood Area
EC5	Carlton and Milina Roads Flood Fringe Areas
EC6	Old Erina Estate - Floodway and Acquisition Area
EC7	Barralong Road, Winani Road and Lingi Street Levee and Acquisition Area
EC8	Clarence Road Flood Fringe Area
EC9	Springfield Wetland Flood Storage Area
EC10	Upstream Catchment

The key features of the Plan are:

- ultimately no buildings will be flooded above habitable floor level by the designated flood (1% flood). This is to be accomplished through construction of a levee and voluntary purchase of existing properties,
- provision for limited development upon flood fringe land subject to strict controls,
- lands within the floodway will be maintained in perpetuity for the passage of floodwaters and acquired by Council where appropriate,
- a timetable of works,
- rate relief for non-developable blocks,
- controls for future development of the upstream catchment,
- definition of the 1% AEP flood extent.

The Plan is shown on Council Drawings 2/43/A1 to 2/48/A1, and reduced copies of these drawings are appended hereto.

A Draft of the Study and Plan were placed on public exhibition for a 10 week period. A public meeting was also held to obtain public opinion. Following the exhibition period, Council received 14 submissions which were thoroughly considered by the Consultants and Council. The majority of the submissions were supportive of the management proposals although several requested further clarification on specific details.

However a few raised new issues, and where appropriate, these were analysed using the models. A detailed response to all the submissions is included in the Floodplain Management Study.

An indicative cost to Council for implementation of the Erina Creek Floodplain Management Plan is provided below. It should be noted that several of the proposals will be undertaken at the owners' expense and these have therefore not been detailed herein. The cost estimates are in $1989.

	$'000
Construction of a Levee around the Industrial Estate (Levee 4)	200
Construction of a Levee along Winani Road/Lingi Street (Levees 1 and 2)	130
Voluntary Purchase of vacant land in Winani Road (8 blocks @ $45 000)	360
Voluntary Purchase of house and land in Winani Road (4 blocks @ $120 000)	480
Partial resumption of vacant land in Barralong Road (0.5 block @ $40 000)	20
Voluntary Purchase of house and land in Barralong Road (2 blocks @ $105 000)	210
Voluntary Purchase of house and land in Worthing Road Creek (4 blocks @ $115 000)	460
	1 860

The net present worth of the reduced flood damages (assuming an 8% interest rate) is $690 000 which provides a Benefit/Cost ratio of 0.37. These benefits only include the reduction in tangible flood damages. Intangible flood damages (such as anxiety, flood hazard) will also be reduced, and would therefore increase the Benefit/Cost ratio if quantified.

The above costs do not include the purchase of non-developable blocks. However rate relief will be initiated for these blocks and where possible these blocks will be purchased by Council.

FLOODPLAIN MANAGEMENT AREAS

ERINA CREEK
FLOODPLAIN MANAGEMENT AREAS

EC10 UPSTREAM CATCHMENT

- RETAIN FLOODPLAINS UNDEVELOPED
- NO INCREASE IN FUTURE FLOWS
- AVOID HARD CHANNELS
- STUDY OF THE EFFECT OF ALL SIGNIFICANT DEVELOPMENT PROPOSALS
- FLOODPLAIN USE TO BE FLOOD COMPATIBLE

EC5 CARLTON AND MILINA ROADS FLOOD FRINGE AREAS

EC6 OLD ERINA ESTATE FLOODWAY AND ACQUISITION AREA

EC7 BARRALONG ROAD WINANI ROAD AND LINGI STREET LEVEE AND ACQUISITION AREA

EC9 SPRINGFIELD WETLAND FLOOD STORAGE AREA

EC8 CLARENCE ROAD FLOOD FRINGE AREA

EC4 WORTHING ROAD CREEK FLOOD AREA

EC3 ERINA INDUSTRIAL FLOOD PROTECTION AREA

EC1 COUNCIL DEPOT FLOOD AREA

EC2 ERINA INDUSTRIAL FLOOD FRINGE AREA

EAST GOSFORD

SPRINGFIELD

ERINA

BRISBANE WATER

ROAD

MILINA

CARLTON RD

ARUNDEL RD

KARWIN AVE

DIGBY RD

LAKALA AVENUE

DULWICH RD

CHILTERN RD

Erina Valley Road Creek

WERRIS RD

WORTHING RD

TOORAK AVE

KUBURRA RD

CHETWYND RD

Worthing Road Creek

NARRAWA AVE

WINANI RD

Levee

New Bridge

BARRALONG RD

TERRIGAL DRIVE

BONMAL RD

ASTON RD

CLARENCE RD

SPRINGVALE AVE

NEWCASTLE ST

COBURG ST

ADELAIDE ST

Erina Ck

Punt Bridge

THE ENTRANCE RD

AVOCA DRIVE

Nunns Ck

KARALTA RD

FLOODWAY

N

SCALE

200 100 0 100 200 300

FLOODWAYS

EC0.1 Description of the Problem

The Floodplain Development Manual describes a Floodway as follows:

> *"FLOODWAYS are those areas where a significant volume of water flows during floods. They are often aligned with obvious naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, which may in time affect other areas. They are often, but not necessarily, the areas with deeper flow or areas where higher velocities occur."*

The major problems in mainstream flooding in Gosford have been caused by inappropriate development in the areas of the floodplain which should have been set aside and recognised as floodways. The industrial developments and residential developments which are subject to the greatest losses, social disruption and hardship, are located in areas which should have been classified as floodways.

EC0.2 Discussion

If the floodways are recognised at an early stage in the planning of development their provision is easy and the economic benefits very large.

The provision of floodways has added benefits: they allow retention of the existing stream environment; when coupled with a freeboard allowance for buildings they can accommodate floods larger than the designated flood; a clearly visible floodway constantly provides flood awareness to the local community. In the distant future the floodway may provide the opportunity for improvement of the stream conveyance if it is necessary following ongoing development.

Once defined the floodway should never be compromised. Small changes occurring progressively, will in time cause a significant change to the flow capacity.

EC0.3 Description of the Proposal

Land use in floodways must be carefully controlled to ensure that the conveyance of the floodway is not reduced. Buildings will not be permitted, hazardous uses will not be permitted, obstructions or operations likely to impede floodwaters will not be permitted in floodways. Only land use that is flood compatible or likely to enhance floodway capacity will be allowed.

Some areas of the floodplain outside the floodway areas are able to be filled without significantly affecting flood levels. These areas, if assessed to have no other detrimental effects, may be filled to a predetermined alignment beyond which a significant effect occurs. These areas are defined in the following sections. If filling is allowed to the floodway alignment the landowner will be required to set aside the remaining land as floodway.

Floodways will need to be crossed by major service installations that are of importance to the region. For example, Highways, arterial roads, bridges, railways, trunk water, sewer, power and gas mains. These should be permitted in the floodway provided that they are investigated adequately, and designed in a manner which does not significantly affect flood flow capacity or flood levels. They should also be designed in a manner to reduce damage potential to the services to the absolute minimum.

EC0.4 Economic Analysis

No economic analysis was undertaken as no mitigation works are proposed.

EC0.5 Conditions

Future development within the floodplain will only be permitted within the areas designated on the plans. Outside these areas only flood compatible uses will be permitted.

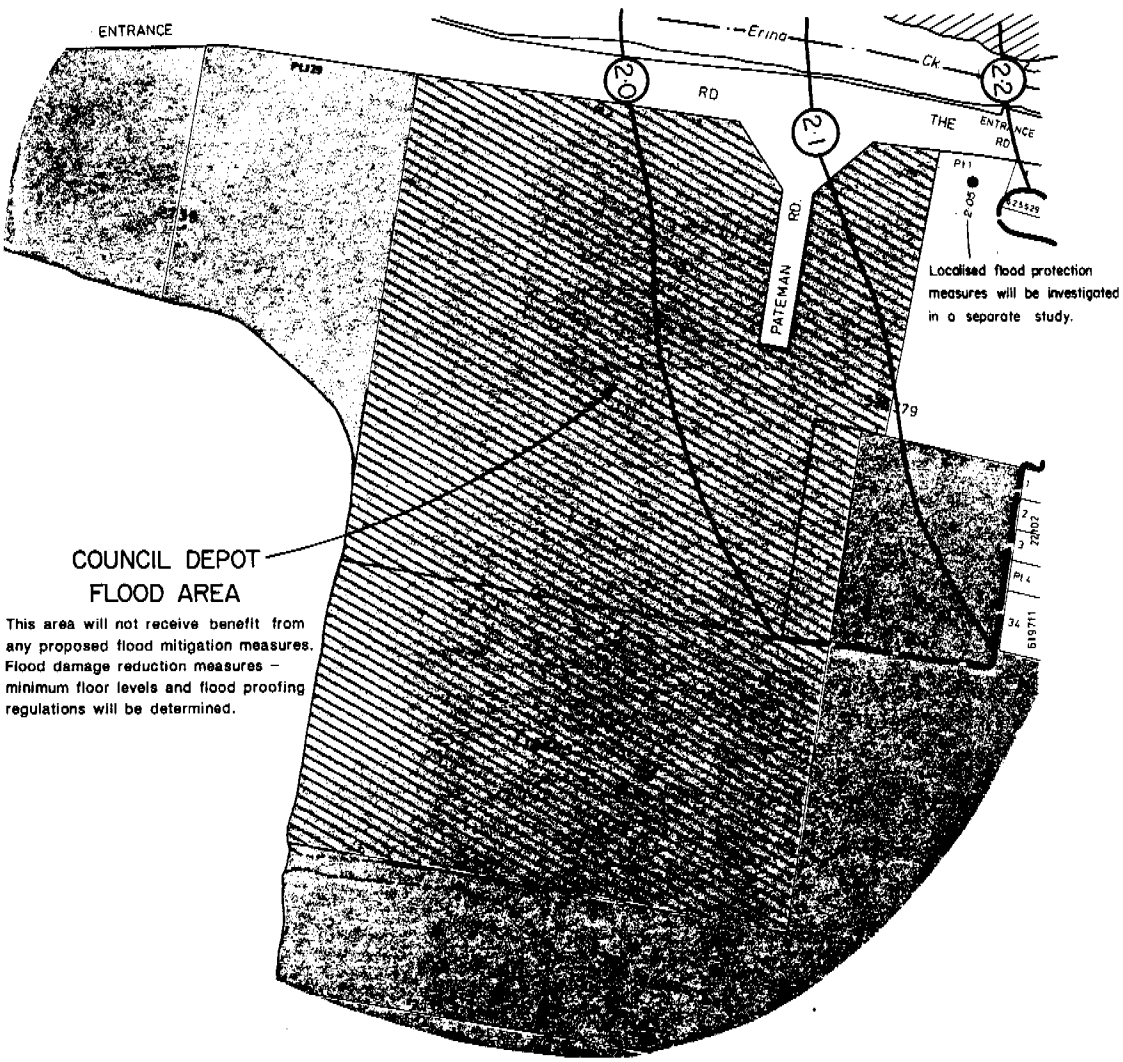
EC0.6 Concise Description of the Plan

FLOODWAYS
(Refer Drawing Nos. 2/43/A1 to 2/48/A1)

- Floodways are to be maintained in perpetuity for the passage of floodwater.
- No work is permitted in a floodway which would impede the passage of floodwater.
- No buildings are to be constructed in a floodway.
- Filling is prohibited.
- Fences likely to collect debris and/or impede floodwaters are not permitted.
- All land uses are to be flood compatible.
- Proposals to cross a floodway with services of major importance to the region (for example Highways or arterial roads, bridges, railways, major water and sewer mains) will be permitted provided that the proposals are adequately investigated and designed in a manner which does not significantly affect flood flow capacity and flood levels.

EC0.7 Priority of Work

The work is considered to be of high priority as it can be readily implemented and would be at no cost to Council.


ENTRANCE
Erina
Ck
RD
THE ENTRANCE RD
PATEMAN RD
20
21
22
79
Pt1
2.05
Localised flood protection measures will be investigated in a separate study.
COUNCIL DEPOT FLOOD AREA
This area will not receive benefit from any proposed flood mitigation measures. Flood damage reduction measures – minimum floor levels and flood proofing regulations will be determined.

COUNCIL DEPOT FLOOD AREA

EC1.1 Description of the Problem

The Council Depot was relocated to Erina in 1973 and comprises the State Emergency Services, the Fire Control Centre, Council's mechanical workshop, stores and Works Supervision section. The ground levels are at approximately 1.5m AHD and this area is zoned as 5 and 6(b). In a 1% design Brisbane Water Level (2.0m AHD) access to the Depot from The Entrance Road would be cut except for trucks and four wheel drive vehicles. Flooding of the site, as a result of flow from Erina Creek in the absence of a raised Brisbane Water Level, would only occur in floods higher than the 1% event. This area is not in a floodway. Access was partially restricted in the 7 February 1990 flood due to local runoff ponding on The Entrance Road.

EC1.2 Discussion

Raising or relocation of the buildings is not a practical solution given the use of the area. However, it is imperative that access to the site be available during floods for essential services. There are no viable mitigation measures which can reduce flood levels at the Depot.

EC1.3 Description of the Proposal

It is proposed that access to the site be evaluated and if necessary upgraded by raising the road. All new buildings should be built with floor levels 500mm above the 1% flood level unless special conditions apply. A review of the existing buildings should be undertaken and regulations produced to minimise the extent of possible flood damages. It may be possible to floodproof any essential service buildings such as the Emergency Services control centre.

EC1.4 Economic Analysis

No economic analysis has been undertaken.

EC1.5 Conditions

- Floor levels 500mm above 1% flood level unless special conditions apply.
- Establishment of flood proofing regulations.

EC1.6 Concise Description of the Plan

COUNCIL DEPOT FLOOD AREA
(Refer Drawing No. 2/45/A1)

- This area will not receive benefit from any proposed flood mitigation measures.
- Flood damage reduction measures - minimum floor levels and flood proofing regulations, will be determined.

EC1.7 Priority of Work

The flood proofing work is of low priority due to the type of use of the area, the low flood risk and the minor flood damage costs.

ERINA INDUSTRIAL FLOOD FRINGE AREA

EC2.1 Description of the Problem

This area comprises the northern parts of the lots adjoining The Entrance Road. This area is zoned as 1(d), 3(b), 4(a) and 9(a). SEPP 14 Wetlands Area No. 917 has been identified adjacent to the creek. The southern parts of most lots have been filled and all the buildings, except three which are at the junction of The Entrance Road and Avoca Drive, are above the 1% flood level. There has been pressure from developers to fill the northern parts of the blocks adjoining the creek. The ground level adjoining the creek is at approximately 1m to 1.5m AHD. The area immediately south of the creek is a flood flow zone. Towards The Entrance Road, the land is flood-fringe rather than a flow area.

EC2.2 Discussion

This land is flood liable and there are no viable flood mitigation measures which could be used to reduce flood levels within this area. Limited development of the land is considered appropriate to ensure that maximum use of the available land space within the City is achieved. However this should not increase the flood level at the existing three flooded buildings. It is also preferable that the maximum future extent of filling be established and the remaining land dedicated to Council as floodway. Detailed analyses were undertaken to determine what areas could be filled with minimal impact upstream. Council Plan 3/87 showed that landowners west of Nunns Creek could fill to an interim line without further approval. This advice was based on the available data, including flood levels, current at the time. Subsequently there has been a revision of the design flood levels.

EC2.3 Description of the Proposal

The proposed maximum extent of development will be to the floodway limit (approximately 180m from The Entrance Road and skirting the wetland area). Land south of this line will be permitted to be filled, and if undertaken, must be filled to 300mm above the 1% flood level. Where the fill will act as a levee for flood liable buildings, the land must be filled to 500mm above the 1% flood level. Development to the maximum extent will not be permitted unless the filling is undertaken, although consideration will be given in special circumstances. The remainder of the lots, from the floodway limit to the southern bank of the creek, will be given to the Council at no cost for dedication as a floodway. Filling of the area to the floodway limit will raise flood levels upstream by a maximum of 30mm.

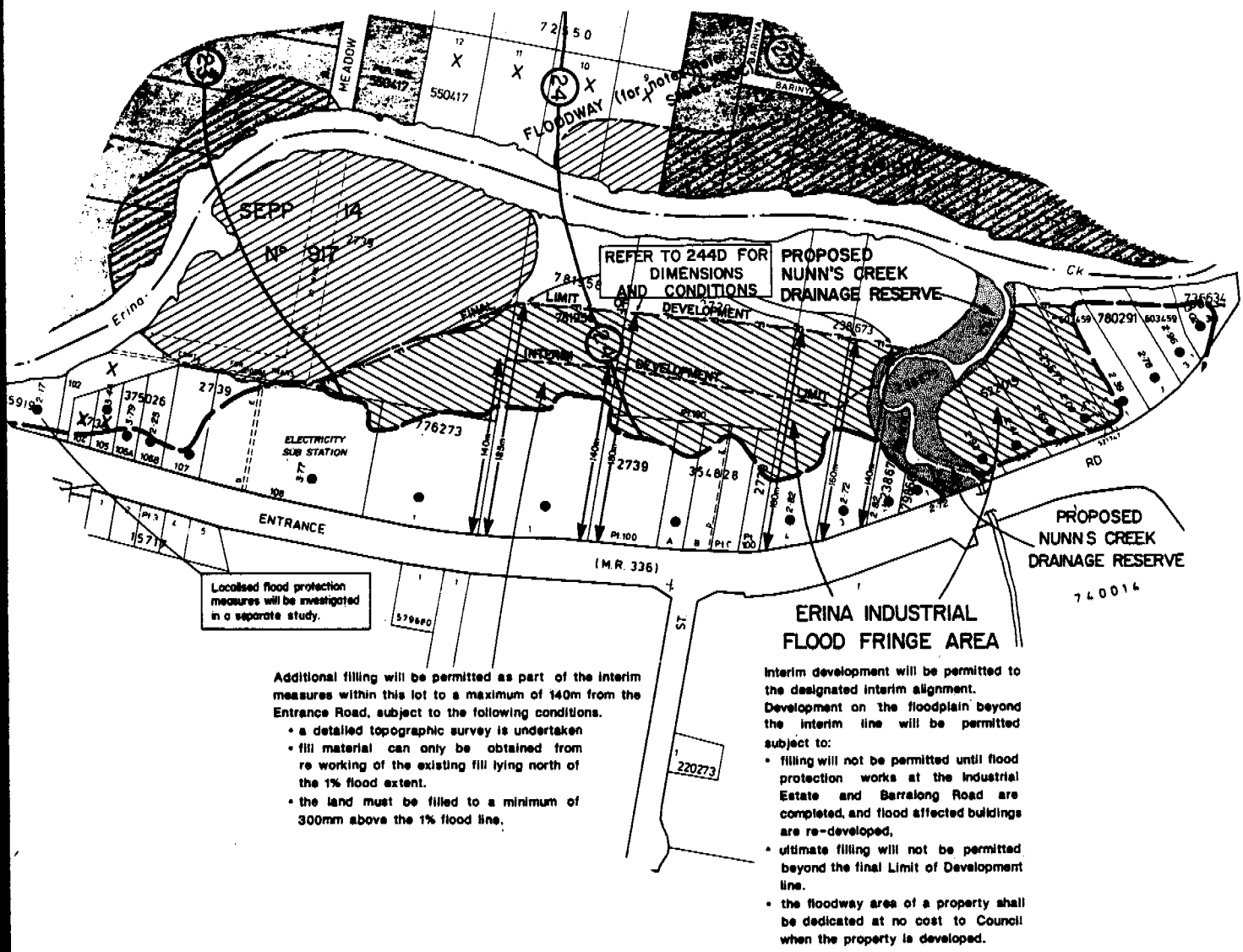
Some properties between Nunns Creek and Bonnal Road will be affected by the raised flood levels. Therefore an interim filling alignment has been determined which has no significant affect on upstream flood levels. Filling beyond the interim line will not be permitted until the upstream properties have been raised above the 1% flood level, or adequately protected. Filling to the interim filling alignment will raise the 1% flood level upstream by less than 10mm.

The interim alignment is identical to that shown on Council Plan 3/87, with the exception that it has been re-aligned parallel to the creek in order to maximise the use of the available land and minor re-working of the existing fill will be permitted.

As the three flood prone properties near Avoca Road are only marginally flooded in a 1% flood, it is recommended that local flood proofing measures be implemented at the owners' expense to provide protection.

EC2.4 Economic Analysis

The costs of filling the site will be borne by the landowners and the benefits will accrue to them also. Council will benefit from dedication of the floodway at no cost. These works will require the height of the proposed levee around the Industrial area (EC3) to be raised, due to the afflux caused by filling. The additional cost will be included as part of the flood mitigation measures for Erina Creek.



EC2.5 Conditions

- Approval to fill to the maximum extent will only be granted once approval is reached with all affected landowners, and flood protection works at the Industrial Estate and Barralong Road are completed, and flood affected buildings are re-developed.
- Filling outside the floodway limit will be required to at least 300mm (or 500mm if acting as a levee) above the 1% flood level.
- The floor levels of all new buildings are required to be at least 500mm above the 1% flood level.

EC2.6 Concise Description of the Plan

ERINA INDUSTRIAL FLOOD FRINGE AREA
(Refer Drawing No. 2/46/A1)

- Interim development will be permitted to the designated interim alignment.
- Development on the floodplain beyond the interim line will be permitted subject to:
  - filling will not be permitted until flood protection works at the Industrial Estate and Barralong Road are completed, and flood affected buildings are re-developed,
  - ultimate filling will not be permitted beyond the final Limit of Development line,
  - the floodway area of a property shall be dedicated at no cost to Council when the property is developed.

EC2.7 Priority of Work

The work is considered to be of medium priority as it is a development rather than a mitigation measure. However, except for interim work, it can only be undertaken after construction of the levee at the Industrial area (EC3) and re-development of upstream buildings to ensure that the adverse effects do not impact upon upstream development.

ERINA INDUSTRIAL FLOOD PROTECTION AREA

EC3.1 Description of the Problem

The Industrial area (Zoning 4(a)) was constructed on low-lying land which was filled in 1971 to approximately 2m AHD. The land is up to 1m higher than the acquisition area of Barralong Road and Winani Road (EC7). The area is fully developed as a light industrial/commercial estate. Four buildings adjacent to the creek at the southern end of the estate are not on filled land. During floods greater than a 10% event, floodwaters cross Barralong Road and flow down Bonnal and Aston Roads. In the 7 February 1990 flood (10% to 7% flood) the four low-lying buildings were inundated by up to 800mm of water. In addition, two premises at the corner of Aston and Barralong Road were inundated by up to 100mm of water. Up to five other premises had water just below their floor level. Access was severely restricted in this flood. The estimated flood damages were up to $100 000 for the February 1990 floods and up to $1 million for the January 1978 flood.

In a 1% flood, 27 industrial/commercial buildings are flooded, with the average depth of flooding being approximately 300mm. Council proposes to construct a bridge over Erina Creek to link Clarence Road and Barralong Road. This will prevent floodwaters crossing Barralong Road and will act as a partial levee.

EC3.2 Discussion

Flood levels could be reduced within the area by up to 250mm by construction of a flood bypass channel across the peninsula immediately downstream. This would reduce flood damages, but 22 buildings would still be flooded in a 1% event and access restricted. This option could have significant environmental impact and would cost up to $300 000 although the excavated material could be used elsewhere.

Raising the buildings is not a viable option as they are all of slab-on-ground construction. Flood proofing of the buildings may be possible, but is not seen as a practical solution.

Protection of this area is desirable and construction of a levee is the only viable measure. In addition, this measure will ensure that the adverse impact of filling of the Industrial Flood Fringe area (EC2) does not impact upon this area.

EC3.3 Description of the Proposal

It is proposed to provide flood protection for the Industrial area up to the 1% flood by construction of a levee. Raising of the Barralong Road approach to the bridge will form part of the levee. The remainder of the levee will be an earthen mound on the banks of the creek or concrete walls connecting adjoining buildings. Along the southern boundary the low lying land will be filled. Internal drainage will be reviewed to ensure that flooding from local runoff within the levee does not occur.

Construction of the levee and associated works will raise flood levels in the Winani Road flood liable area immediately upstream of Barralong Road, and by 25mm in a 1% flood in Worthing Road Creek catchment. However flood protection measures have been considered for these areas (EC7 and EC4).

EC3.4 Economic Analysis

An indicative cost to construct the levee from Barralong Road to The Entrance Road is approximately $200 000. The cost to provide fill to raise Barralong Road has not been included. The reduction in flood damages for this proposal has been considered in conjunction with EC7 and is referred to in Section EC7.4.

EC3.5 Conditions

- The floor levels of all future buildings should be at least 500mm above the 1% flood level.

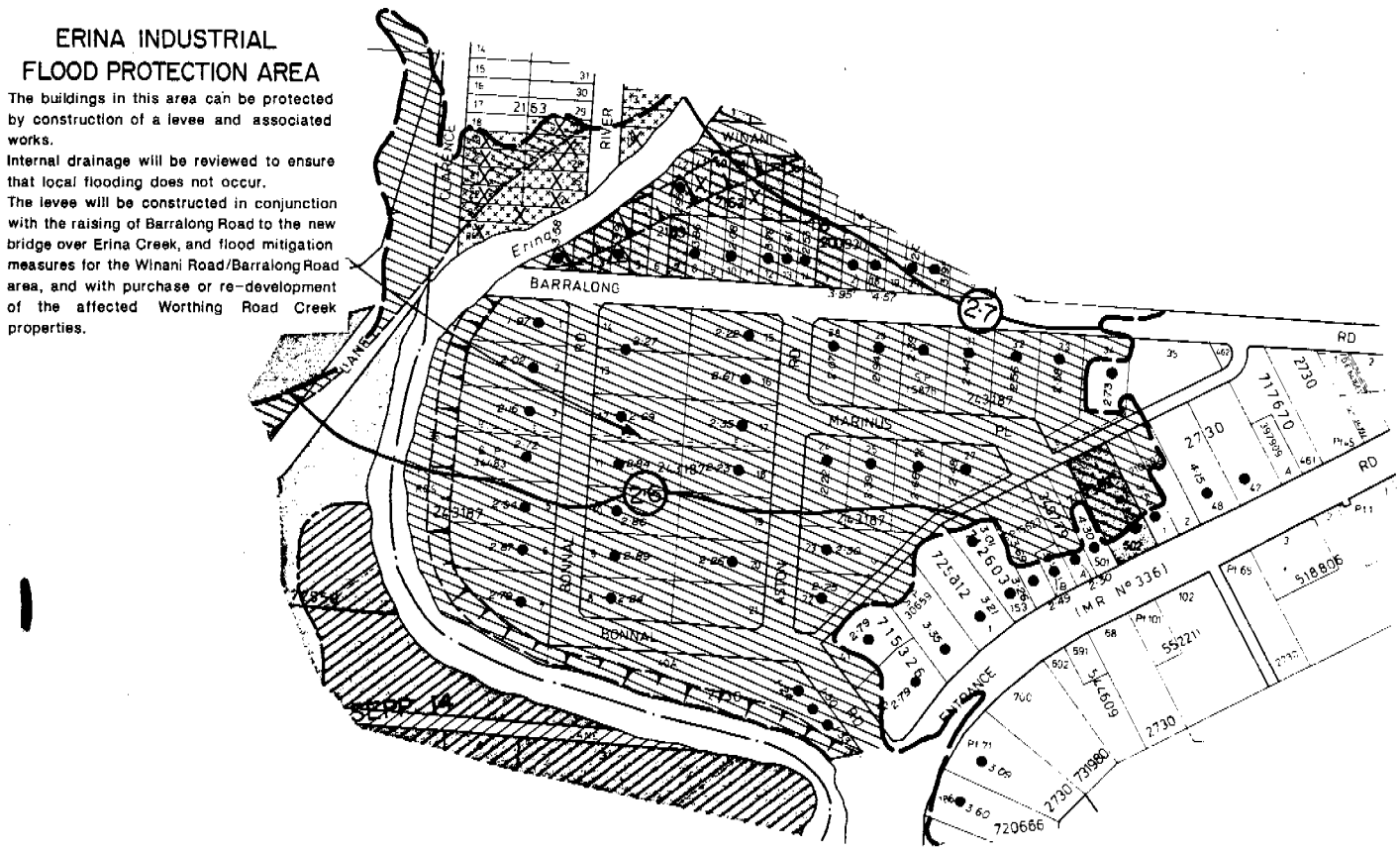
EC3.6 Concise Description of the Plan

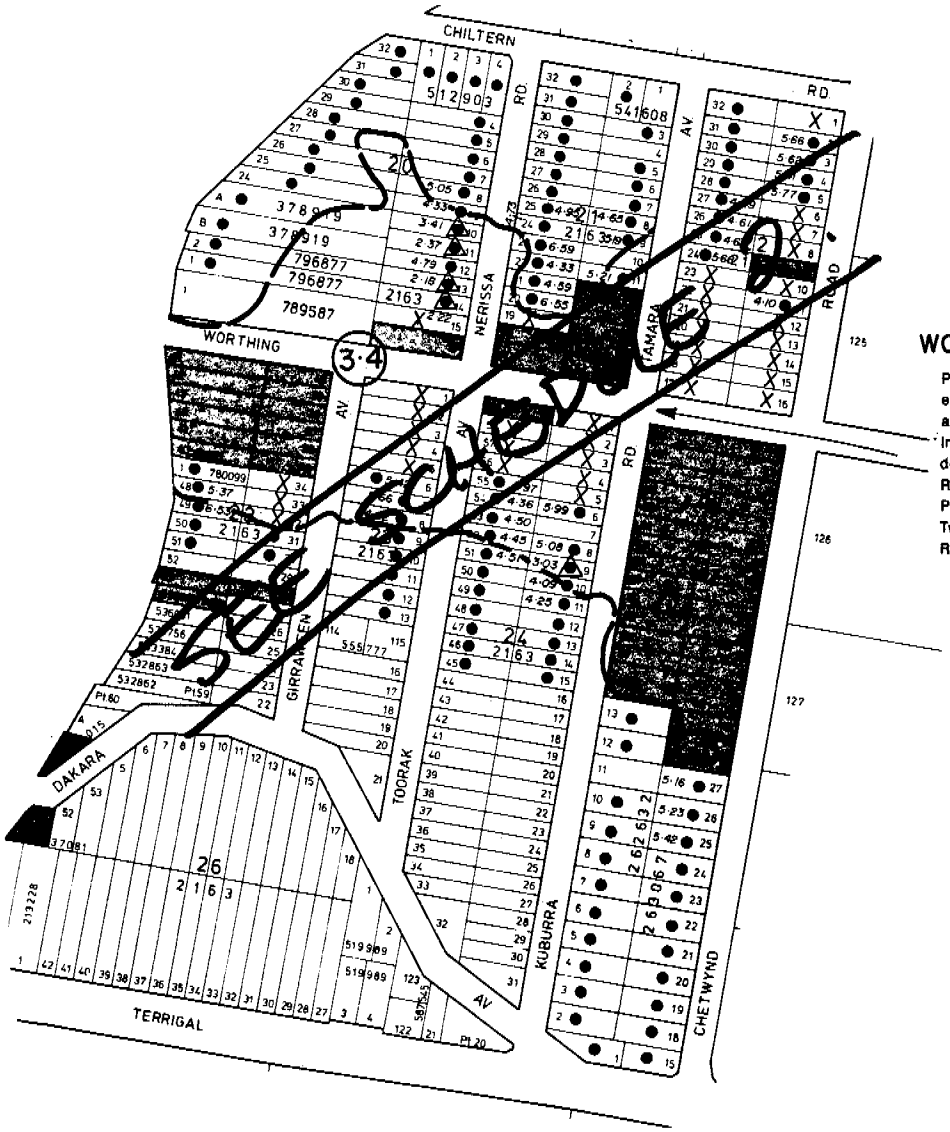
ERINA INDUSTRIAL FLOOD PROTECTION AREA
(Refer Drawing No. 2/44/A1)

- The buildings in this area can be protected by construction of a levee and associated works.
- Internal drainage will be reviewed to ensure that local flooding does not occur.
- The levee will be constructed in conjunction with the raising of Barralong Road to the new bridge over Erina Creek, and flood mitigation measures for the Winani Road/Barralong Road area, and with the purchase or re-development of the affected Worthing Road Creek properties.

EC3.7 Priority of Work

The work is considered to be of medium priority due to the need to combine the works with the upgrading of Barralong Road and construction of a new bridge over Erina Creek. The present flood risk is relatively low.





WORTHING ROAD CREEK FLOOD AREA

Progressive purchase or floodproofing of the four existing flood liable houses as funds become available and consideration to one further house.
Implementation of controls for future catchment development.
Rate relief for undevelopable blocks.
Progressive purchase of undevelopable blocks.
Two further studies are being completed for Erina Valley Road Creek and Worthing Road Creek.

WORTHING ROAD CREEK FLOOD AREA

EC4.1 Description of the Problem

The Worthing Road Creek area is subject to flooding from a combination of runoff from the catchment and backwater flooding from Erina Creek. Upstream of Chetwynd Road the backwater effect is less dominant. The area is currently zoned 9(a). The ground levels in this area are at approximately 2m AHD. There are two single-storey houses flooded (24 Nerissa Road (Lot 14) and 45 Kuburra Road (Lot 9)) and several two-storey houses flooded in a 1% flood, two of which have approved habitable ground floors (22 Nerissa Road (Lot 13) and 18 Nerissa Road (Lot 11)). As this area is predominantly a flood storage area, the risk to life is low, and access to high ground during floods is good. Re-construction of Barralong Road and associated flood protection works, will raise flood levels by up to 25mm in this area. There is ongoing pressure to develop further blocks within this area and also in the upper part of this catchment.

EC4.2 Discussion

Lowering flood levels to eliminate flooding from this area through flood mitigation measures is not viable. A levee to protect the flooded houses is also not a practical option. Raising of the single-storey dwellings is not viable due to their construction and therefore purchase of these two houses is seen as the only practical solution.

The minor afflux caused by flood protection works at Barralong Road, in addition to the existing flood problem, and the pressure for further upstream development, means that flood mitigation measures need to be considered urgently.

EC4.3 Description of the Proposal

It is proposed to purchase or floodproof the two single-storey houses and the two two-storey houses which have approved habitable ground floors. Purchase of these properties would also ensure that the afflux caused by works to protect the Industrial area (EC3) does not affect flood liable buildings. It is also proposed that consideration be given to the floodproofing or purchase of 16 Nerissa Road (Lot 10) as this house may be adversely affected. Controls will be placed on future development within the catchment to eliminate the adverse effects from upstream urbanisation and ensure that existing and future buildings are not flood liable in a 1% flood. It is proposed to purchase vacant blocks within this area which are flood liable and rate relief will be implemented for undevelopable land.

EC4.4 Economic Analysis

An indicative cost estimate to purchase the four houses is $460 000. However the land could subsequently be re-used for a flood compatible use. An alternative would be to compensate the two-storey owners for rescinding the approval for ground floor habitation, and only purchase the 2 single-storey dwellings.

EC4.5 Conditions

- Future development within the area will be restricted and all floor levels must be at least 500mm above the 1% flood level.
- Controls for upstream development (EC10) will be implemented to mitigate the adverse effects of urbanisation.

EC4.6 Concise Description of the Plan

WORTHING ROAD CREEK FLOOD AREA
(Refer Drawing No. 2/47/A1)

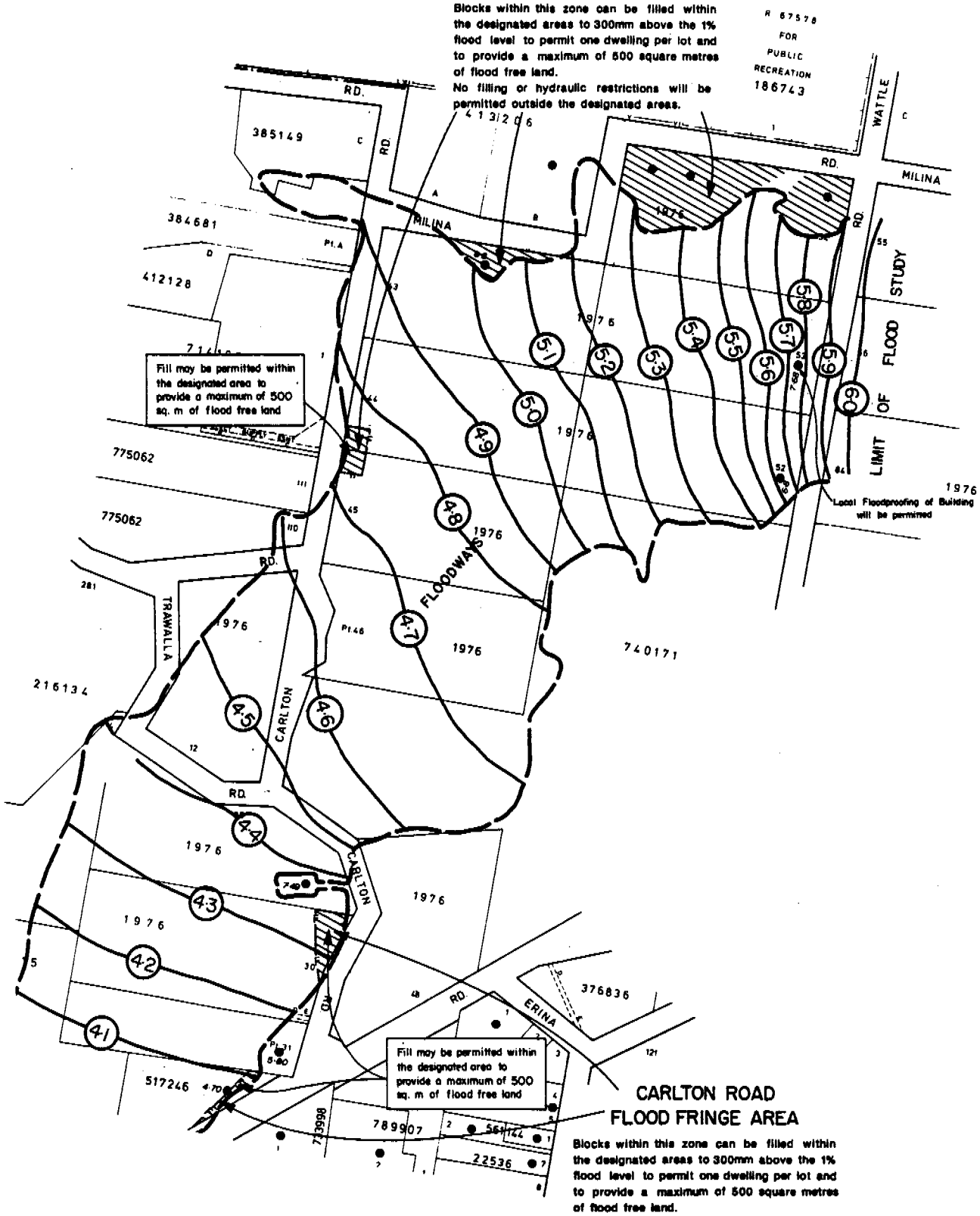
- Progressive purchase or floodproofing of the four existing flood liable houses as funds become available and consideration to one further house.
- Implementation of controls for future catchment development.
- Rate relief for undevelopable blocks.
- Progressive purchase of undevelopable blocks.
- Two further studies are being completed for Erina Valley Road Creek and Worthing Road Creek.

EC4.7 Priority of Work

The work is considered to be of high priority because of the severity of the flooding at two of the houses. Further, downstream flood mitigation measures are required to protect the Erina Industrial area (EC3) and the Winani Road area (EC7), and this will cause some minor worsening of the existing flood problem.

CARLTON AND MILINA ROADS FLOOD FRINGE AREAS

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.
No filling or hydraulic restrictions will be permitted outside the designated areas.



CARLTON ROAD FLOOD FRINGE AREA

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.
No filling or hydraulic restrictions will be permitted outside the designated areas.

CARLTON AND MILINA ROADS FLOOD FRINGE AREAS

EC5.1 Description of the Problem

Upstream of the confluence of Worthing Road Creek there has been continuing development and filling of the floodplain. Only one two-storey house on Arundel Road is currently flood liable with the remaining eight houses above the 1% flood level. The school on Arundel Road has purchased several flood liable blocks since the mid 1980's and turned them into playing fields. There are further pressures for filling the floodplain in order to enlarge existing buildings or create new building platforms and access routes. The area is currently zoned 7 (c2).

EC5.2 Discussion

There are no viable flood mitigation measures which can significantly reduce flood levels within these areas. Stream clearing or channel alignment will have only a minor impact.

Strictly limited filling of these sites to create building platforms would have no significant impact upon flood levels elsewhere and this would maximise the use of each block. The one flood liable house on Arundel Road should be flood protected at the owner's expense by construction of a partial levee and flood proofing.

EC5.3 Description of the Proposal

Filling within the designated areas will be permitted to at least 300mm above the 1% flood level, with floor levels 500mm above the 1% flood, in order to permit one dwelling per block and a maximum of 500 square metres of flood free land. Outside these limits, no filling or obstruction to flood flow would be permitted.

EC5.4 Economic Analysis

No economic analysis has been undertaken.

EC5.5 Conditions

- Filling will be permitted only within the designated areas to a minimum of 300mm above the 1% flood level.
- The placing of hydraulic restrictions upon the floodplain outside the designated areas is prohibited.
- Floor levels must be at least 500mm above the 1% flood level.

EC5.6 Concise Description of the Plan

CARLTON AND MILINA ROADS FLOOD FRINGE AREAS

(Refer Drawing Nos. 2/47/A1 and 2/48/A1)

- Blocks within these areas can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.
- No filling or hydraulic restrictions will be permitted outside the designated areas.

EC5.7 Priority of Work

This work is considered to be of medium priority as it is not dependent upon other works and will be completed at the owners' expense.

OLD ERINA ESTATE
FLOODWAY AND ACQUISITION AREA

EC6.1 Description of the Problem

This area was subdivided in 1886 and released as a proposed residential estate, but no dwellings were constructed. It is zoned 9(a) and 2(a). The ground levels within this area are at 1.5m to 2.0m AHD. It is subject to periodic flooding and is a major flow path, with inundation by up to 1.5m in a 1% flood. Council has a policy of considering purchasing vacant blocks when offered for sale. Council currently owns approximately 70% of the building blocks.

EC6.2 Discussion

There are no viable flood mitigation measures which can eliminate flooding within this area. Hydraulic analyses have shown that major filling of this area will significantly increase flood levels upstream. Limited minor filling on the fringes of this area would not significantly increase flood levels upstream. This may be permitted to allow access to flood free land. Designation of this area as a floodway will ensure that no further restrictions to flood flows will occur.

EC6.3 Description of the Proposal

No filling or hydraulic restrictions will be permitted on the remaining land. Land identified in the Plan within the floodway, will be purchased and dedicated by Council as floodway as it becomes available. Rate relief by Council will be initiated for the non-developable blocks. These may be developed in the future for flood compatible uses such as recreation areas. Prior to any future development a hydraulic assessment will be carried out. Minor filling will be permitted on the fringes to permit flood free access to blocks not identified for purchase.

EC6.4 Economic Analysis

Approximately 50 blocks will be purchased at an estimated cost of $150 000.

EC6.5 Conditions

- Limited minor filling will only be permitted for access to developable blocks.
- Floor levels must be at least 500mm above the 1% flood level.

EC6.6 Concise Description of the Plan

OLD ERINA ESTATE - FLOODWAY AND ACQUISITION AREA
(Refer Drawing Nos. 2/44/A1 and 2/47/A1)

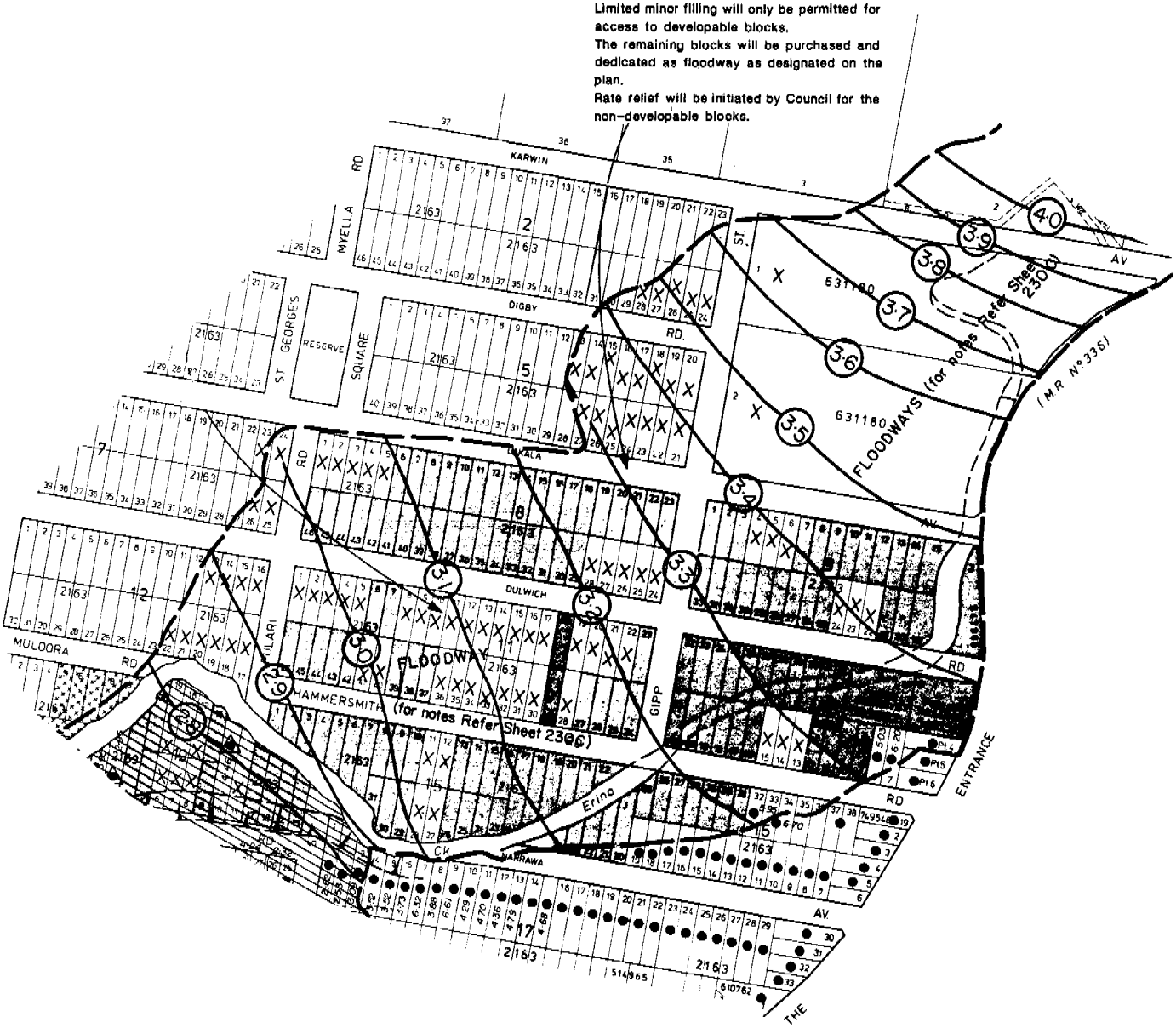
- Full development within this estate would significantly raise flood levels upstream.
- Limited minor filling will only be permitted for access to developable blocks.
- The remaining blocks will be purchased and dedicated as floodway as designated on the Plan.
- Rate relief will be initiated by Council for the non-developable blocks.

EC6.7 Priority of Work

The purchasing scheme will be initiated as medium priority, however, it is expected that it will not be finalised for several years. Filling to provide access could be a high priority item as it would be at the owners' expense.

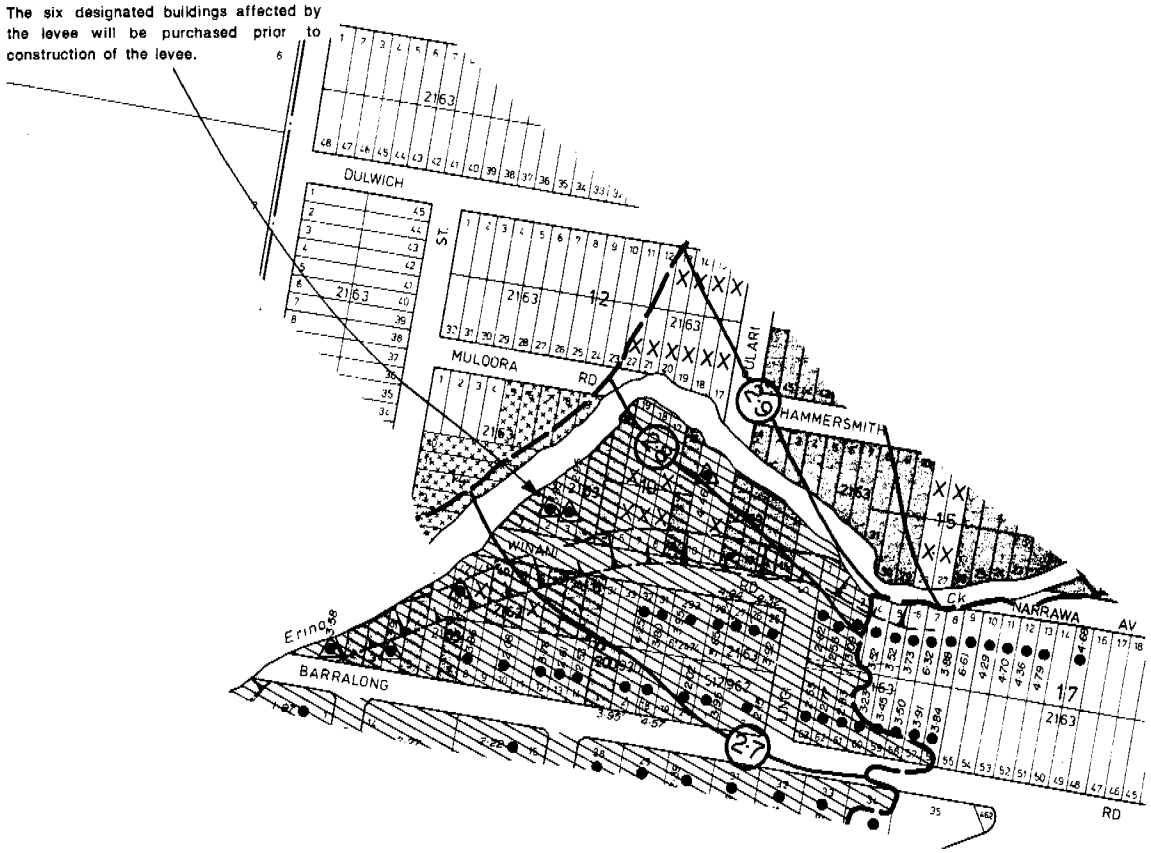
OLD ERINA ESTATE
FLOODWAY AND
ACQUISITION AREA

Full development within this estate would significantly raise flood levels upstream.
Limited minor filling will only be permitted for access to developable blocks.
The remaining blocks will be purchased and dedicated as floodway as designated on the plan.
Rate relief will be initiated by Council for the non-developable blocks.



BARRALONG ROAD WINANI ROAD AND LINGI STREET LEVEE AND ACQUISITION AREA

The majority of the buildings within this area will receive protection up to the 1% flood through construction of a levee.
Rate relief will be given to those undeveloped lots not protected by the levee.
Undevelopable land outside the levee will be purchased when funding becomes available.
The six designated buildings affected by the levee will be purchased prior to construction of the levee.



BARRALONG ROAD, WINANI ROAD AND LINGI STREET LEVEE AND ACQUISITION AREA

EC7.1 Description of the Problem

This area is currently zoned 9(a) and is occupied by 16 two-storey houses and 19 single-storey houses. Several of the houses have been raised. The ground level is at approximately 1.0 - 1.5m AHD and the area is periodically inundated by floodwaters. The 1% flood level is at approximately 2.7m AHD and all the single-storey houses (which have not been raised) are flooded, as well as all the ground floors of the two-storey houses.

Council has a proposal to construct a bridge across Erina Creek at Barralong Road. Raising the eastern approach to the proposed bridge will raise flood levels within this area by up to 50mm. Council has a policy of purchasing vacant blocks within this area and currently owns approximately 30% of the vacant blocks.

EC7.2 Discussion

Hydraulic analyses have shown that flood mitigation measures (apart from a levee) cannot eliminate flooding within this area. If the proposed bridge is to be constructed, it is essential that the flooding not be worsened. This could be accomplished by constructing a flood channel downstream, but at environmental and economic cost. A levee is the only measure which will eliminate flooding within this area. A full levee around the area is not practical.

EC7.3 Description of the Proposal

It is proposed to construct a partial levee to provide protection up to the 1% flood for 29 of the 35 houses. The alignment is shown on the Plan. Properties outside the levee would be included in a voluntary purchase scheme and the land designated as floodway. The levee would be constructed of either compacted earth embankment or reinforced concrete wall (where easement width is restricted). Internal drainage would be upgraded to ensure that local flooding within the levee does not occur. It may be appropriate in the future to amend the zoning within the levee area to allow filling and sale for industrial land in order to overcome the difficulties which could arise from further development behind the levee.

EC7.4 Economic Analysis

The preliminary cost estimate for the levee upstream of Barralong Road is $130 000. A further $15 000 would be required for internal drainage. The cost to acquire the 6 blocks with buildings and 8 vacant lots is approximately $1 million. The economic analysis was undertaken assuming that the works proposed in EC7.3 were carried out in conjunction with the bridge construction and protection of the Erina Industrial area described in EC3.3. A levee to provide protection for up to the 1% flood level, would over the life of the levee (50 years) and at an assumed 8% interest rate, provide a total saving of approximately $550 000 in flood damages. Carrying out these works would give a Benefit/Cost ratio of approximately 0.4. The B/C ratio could be improved by re-zoning and re-sale of the protected land for industrial purposes (for an approximate value of $2.3 million).

EC7.5 Conditions

- Future development within the leveed area will require floor levels to be at least 500mm above the 1% flood level.
- The land outside the leveed area will be purchased and dedicated as floodway. Only flood compatible development will be permitted within the floodway.
- Future development can only proceed once purchase of the affected properties within Worthing Road Creek Catchment (EC4) is undertaken.

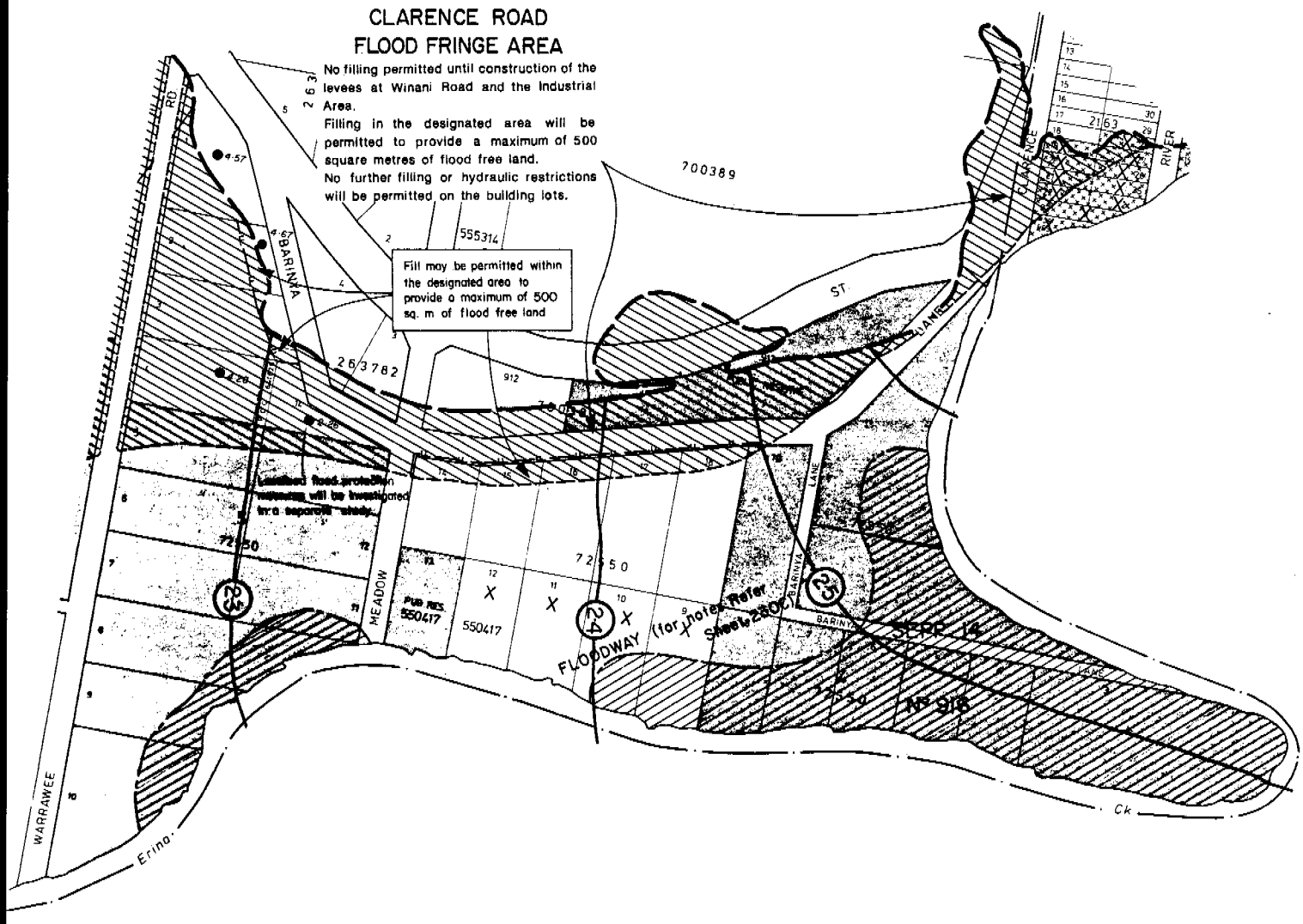
EC7.6 Concise Description of the Plan

BARRALONG ROAD, WINANI ROAD AND LINGI STREET LEVEE AND ACQUISITION AREA
(Refer Drawing No. 2/44/A1)

- The majority of the buildings within this area will receive protection up to the 1% flood through construction of a levee.
- Rate relief will be given to those undeveloped lots not protected by the levee.
- Undevelopable land outside the levee will be purchased when funding becomes available.
- The six designated buildings affected by the levee will be purchased prior to construction of the levee.

EC7.7 Priority of Work

The levee is considered to be of high priority due to the seriousness of the existing problem and number of houses which would benefit. It should be carried out prior to construction of the bridge and after purchase of flood affected buildings.


CLARENCE ROAD
FLOOD FRINGE AREA
No filling permitted until construction of the levees at Winani Road and the Industrial Area.
Filling in the designated area will be permitted to provide a maximum of 500 square metres of flood free land.
No further filling or hydraulic restrictions will be permitted on the building lots.
Fill may be permitted within the designated area to provide a maximum of 500 sq. m of flood free land
Localised flood protection measures will be investigated in a separate study.
700389
555314
263782
912
72350
PUB RES 550417
550417
FLOODWAY (for notes Refer Sheet 2 of 2)
BARINYA
MEADOW
WARRAWEE
Erina
Ck
CLARENCE
RIVER
ST
LANE
SERP 14
No 918

CLARENCE ROAD FLOOD FRINGE AREA

EC8.1 Description of the Problem

This area is largely vacant land along the northern fringe of the Erina Creek floodplain. It is zoned 7(c2). Two houses have been constructed at the western end of this area. The floor level of one house is at the 1% flood level. There are pressures from landowners to fill and construct dwellings on each road frontage block. The ground level is approximately 1.0m to 2.0m AHD and is inundated by up to 1m of water in a 1% flood. As this area is on the edge of the floodplain, it is an area of low flood hazard and not a main flow path.

EC8.2 Discussion

Flood mitigation measures cannot significantly reduce flood levels within this area as it is largely dominated by levels in Brisbane Water. Limited filling will not significantly raise flood levels upstream and will ensure that one house per designated block can be constructed.

EC8.3 Description of the Proposal

In order to optimise flood compatible use of the floodplain it is proposed to permit filling to provide a maximum of 500 square metres of flood free land within the designated area. One dwelling per lot will be permitted on fill. The minimum fill level will be 300mm above the 1% flood. No filling or hydraulic restrictions will be permitted outside the designated area. Because this land is on the fringe of the floodplain, there are no significant adverse effects from filling. The existing dwelling, which is at the 1% flood level, could be raised or flood proofed to prevent flooding in a 1% flood.

EC8.4 Economic Analysis

No economic analysis was undertaken. The additional cost of raising the proposed levee around the Erina Industrial area (EC3) to allow for the afflux caused by filling in this area, will be included as part of the flood mitigation measures for Erina Creek.

EC8.5 Conditions

- Filling will be required to at least 300mm above the 1% flood level for construction of one dwelling per block within the designated area to provide a maximum of 500 square metres of flood free land.

EC8.6 Concise Description of the Plan

CLARENCE ROAD FLOOD FRINGE AREA
(Refer Drawing No. 2/44/A1)

- No filling permitted until construction of the levees at Winani Road and the Industrial area.
- Filling in the designated area will be permitted to provide a maximum of 500 square metres of flood free land.
- No further filling or hydraulic restrictions will be permitted on the building lots.

EC8.7 Priority of Work

The work is considered to be of low to medium priority as it would be carried out at the owners' expense.

SPRINGFIELD WETLAND FLOOD STORAGE AREA

EC9.1 Description of the Problem

This area comprises a wetland area with no development within it. It is zoned 6(b), 7(c2) and 7(a). The majority of the area is designated as a SEPP14 Wetlands Area No. 918. The ground level varies from 0.5m AHD to 1.5m AHD and it is periodically flooded by a combination of Erina Creek floodwaters and backwater from Brisbane Water. Pressure for urban development could mean that the fringe areas would be encroached upon in the future without appropriate protection.

EC9.2 Discussion

There are no flood mitigation measures which can eliminate flooding within this area. Development within this area would have only a minor impact on flood levels upstream as the area is a flood storage area rather than flood flow area. However, development might conflict with the SEPP14 Wetlands status.

EC9.3 Description of the Proposal

It is proposed to designate this area as a wetlands flood storage area. Future development within this area will be prohibited. However minor filling may be permitted in limited areas outside the designated wetlands area as indicated on the Plan. Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the wetlands.

EC9.4 Economic Analysis

Designation of this area can be undertaken at no cost.

EC9.5 Conditions

- Future development will be prohibited from this area although minor filling outside the designated wetland area will be considered.

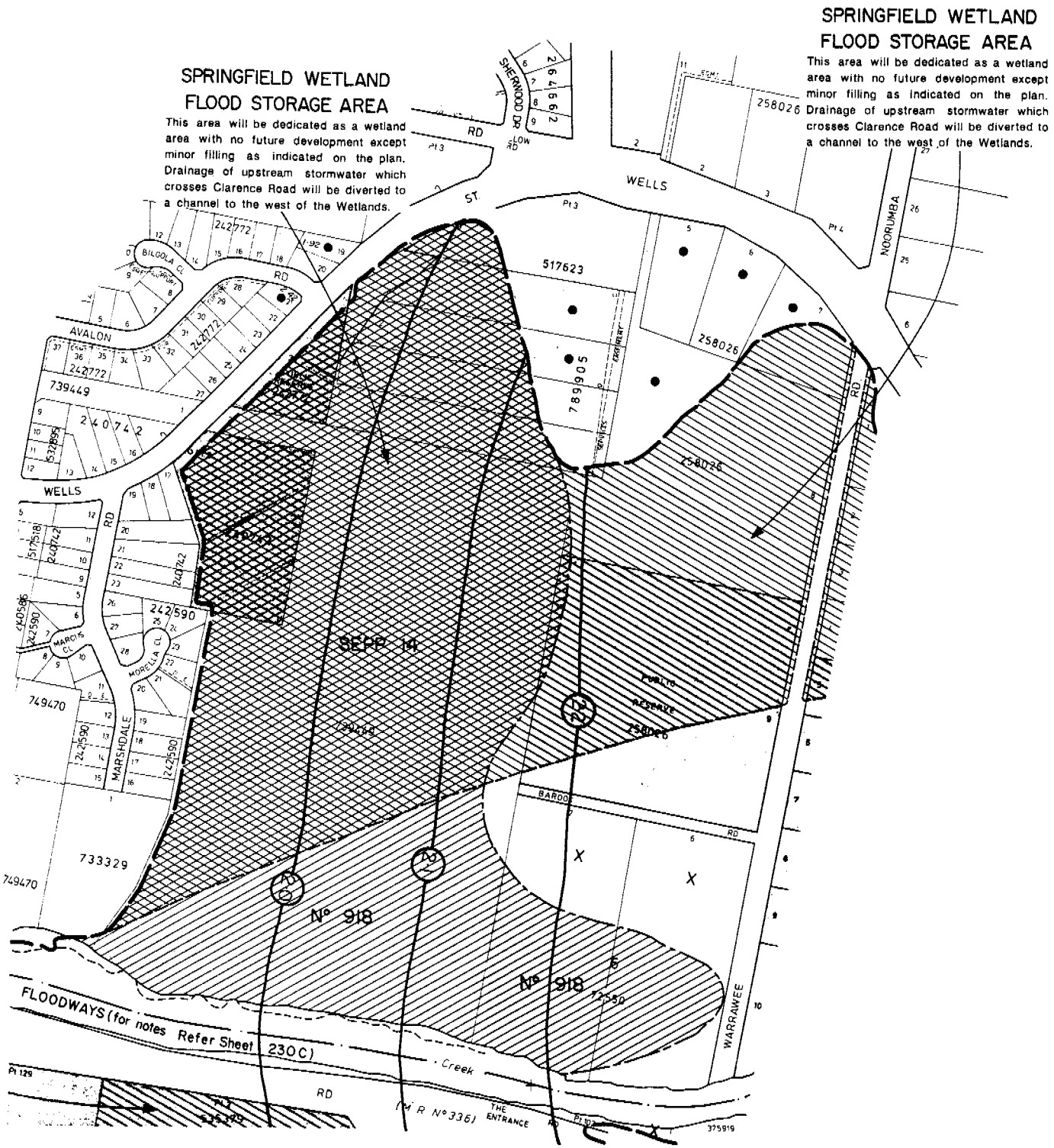
EC9.6 Concise Description of the Plan

SPRINGFIELD WETLAND FLOOD STORAGE AREA
(Refer Drawing Nos.2/43/A1 and 2/44/A1)

- This area will be dedicated as a wetland area with no future development except minor filling as indicated on the Plan.
- Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the Wetlands.

EC9.7 Priority of Work

This work is considered to be of medium priority as it can be readily undertaken.


SPRINGFIELD WETLAND
FLOOD STORAGE AREA
This area will be dedicated as a wetland area with no future development except minor filling as indicated on the plan. Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the Wetlands.
SPRINGFIELD WETLAND
FLOOD STORAGE AREA
This area will be dedicated as a wetland area with no future development except minor filling as indicated on the plan. Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the Wetlands.
SHERWOOD DR
RD
WELLS
ST
BILOOLA CL
AVALON
MARDIS CL
MORELLA CL
MARSHDALE
BARDO
RD
NOORUMBA
WARRAWEE
517623
789905
258026
242772
739449
240742
532895
517518
240582
242590
749470
733329
SEPP 14
Public Reserve
258026
N° 918
N° 918
72550
FLOODWAYS (for notes Refer Sheet 230C)
Creek
RD
(M R N°336)
THE ENTRANCE
RD
375919

UPSTREAM CATCHMENT

EC10.1 Description of the Problem

The catchment upstream of that covered by the Floodplain Management Plan is largely scattered rural holdings. There are pressures from private developers and Government bodies to develop parts of the catchment. Analyses have shown that unregulated development has the potential to increase flooding downstream. In order to permit future development of the upstream catchment, consideration must be given to the impacts upon flooding downstream.

EC10.2 Discussion

Urbanisation of the upper catchment of Erina Creek will partially alleviate the demand for housing blocks in the future. However, uncontrolled urbanisation has been shown to increase flood levels by up to 200mm downstream. It would be possible to permit upstream development through construction of water retention structures (retarding basins) and "soft" engineering works along the creek corridors. Such works will need to be environmentally sensitive, and could also incorporate water quality improvement measures.

EC10.3 Description of the Proposal

Urbanisation of the upstream catchment will only be permitted if downstream flooding is not worsened. Prior to approval, a Flood Study must be undertaken for all significant development and the following controls must be included:

- major floodplains remain undeveloped,
- future flows are not increased,
- the use of "hard" channels must be avoided where possible,
- floodplain use must be flood compatible.

EC10.4 Economic Analysis

The costs of Flood Studies and works would be borne by the developer.

EC10.5 Conditions

- Future significant development will only be permitted if a Flood Study is undertaken which shows that flooding will not be worsened elsewhere.
- Development within the defined floodway parts of the floodplain will not be permitted and all uses of the floodplain must be flood compatible.

EC10.6 Concise Description of the Plan

UPSTREAM CATCHMENT
(Refer Drawing No. 2/48/A1)

- Development will be considered in the upper catchment subject to detailed evaluation of the possible hydrologic and hydraulic effects.

EC10.7 Priority of Work

This work is considered of high priority as it can be readily implemented and would be at no cost to Council.

DRAWINGS

244A

B89975 FOR PUBLIC RECREATION & WATER SUPPLY
RUMBALARA RESERVE

SPRINGFIELD WETLAND
FLOOD STORAGE AREA

This area will be dedicated as a wetland area with no future development except minor filing as indicated on the plan. Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the Wetlands.

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

Filing of the floodplain will be permitted within this area, subject only to local restrictions.

SEPP 14
Nº 926

SEPP 14
Nº 918

FLOODWAYS (for notes Refer Sheet 230C)

COUNCIL DEPOT
FLOOD AREA
27/39

ENTRANCE

RESERVE

Erina Creek

GOSFORD CITY COUNCIL

COUNTY OF NORTHUMBERLAND

GOSFORD

KINCUMBER

KEY TO PARISH

LEGEND

- Boundary of Classified Floodplain
- 1% (100 Year) Flood Contour in 'm' AHD (3·8)
- Approved Floor Levels (see Note) 2·75
- Existing Buildings
- Proposed Levee Bank
- Council Owned Land
- Land Subject to Geotechnical Investigation
- Wetlands Area
- Floodplain Management Areas
- Building designated for acquisition or floodproofing under the Floodplain Management Plan
- Vacant Land Identified for Acquisition X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

228D	229C	229D
243B	244A	244B
243D	244C	244D

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/43/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK
FLOODPLAIN MANAGEMENT PLAN
CLASSIFICATION OF FLOODPLAIN LANDS

2448

GOSFORD CITY COUNCIL

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

SPRINGFIELD WETLAND FLOOD STORAGE AREA

This area will be dedicated as a wetland area with no future development except minor filling as indicated on the plan. Drainage of upstream stormwater which crosses Clarence Road will be diverted to a channel to the west of the Wetlands.

BARRALONG ROAD WINANI ROAD AND LINGI STREET LEVEE AND ACQUISITION AREA

The majority of the buildings within this area will receive protection up to the 1% flood through construction of a levee.
Rate relief will be given to those undeveloped lots not protected by the levee.
Undevelopable land outside the levee will be purchased when funding becomes available.
The six designated buildings affected by the levee will be purchased prior to construction of the levee.

ERINA INDUSTRIAL FLOOD PROTECTION AREA

The buildings in this area can be protected by construction of a levee and associated works.
Internal drainage will be reviewed to ensure that local flooding does not occur.
The levee will be constructed in conjunction with the raising of Barralong Road to the new bridge over Erina Creek, and flood mitigation measures for the Winani Road/Barralong Road area, and with purchase or re-development of the affected Worthing Road Creek properties.

CLARENCE ROAD FLOOD FRINGE AREA

No filling permitted until construction of the levees at Winani Road and the Industrial Area.
Filling in the designated area will be permitted to provide a maximum of 500 square metres of flood free land.
No further filling or hydraulic restrictions will be permitted on the building lots.

Fill may be permitted within the designated area to provide a maximum of 500 sq. m of flood free land.

Localised flood protection measures will be investigated in a separate study.

OLD ERINA ESTATE FLOODWAY AND ACQUISITION AREA

Full development within this estate would significantly raise flood levels upstream.
Limited minor filling will only be permitted for access to developable blocks.
The remaining blocks will be purchased and dedicated as floodway as designated on the Plan.
Rate relief will be initiated by Council for the non-developable blocks.

FLOODWAY (for notes Refer Sheet 230C)

FLOODWAY (for notes Refer Sheets 230C)

REFER TO 244D FOR DIMENSIONS AND CONDITIONS OF DEVELOPMENT

PROPOSED NUNN'S CREEK DRAINAGE RESERVE

ERINA INDUSTRIAL FLOOD FRINGE AREA

INTERIM DEVELOPMENT LIMIT

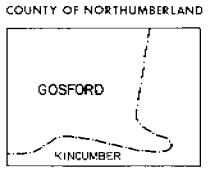
FINAL DEVELOPMENT LIMIT

SEPP 14 Nº 916

SEPP 14 Nº 917

Nº 918

COUNTY OF NORTHUMBERLAND



KEY TO PARISH

LEGEND

Boundary of Classified Floodplain	
1% (100 Year) Flood Contour in 'm' AHD	3·8
Approved Floor Levels (see Note)	2·75
Existing Buildings	
Proposed Levee Bank	
Council Owned Land	
Land Subject to Geotechnical Investigation	
Wetlands Area	
Floodplain Management Areas	
Building designated for aquisition or floodproofing under the Floodplain Management Plan	
Vacant Land Identified for Acquisition	X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

229C	229D	230C
244A	244B	245A
244C	244D	245C

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

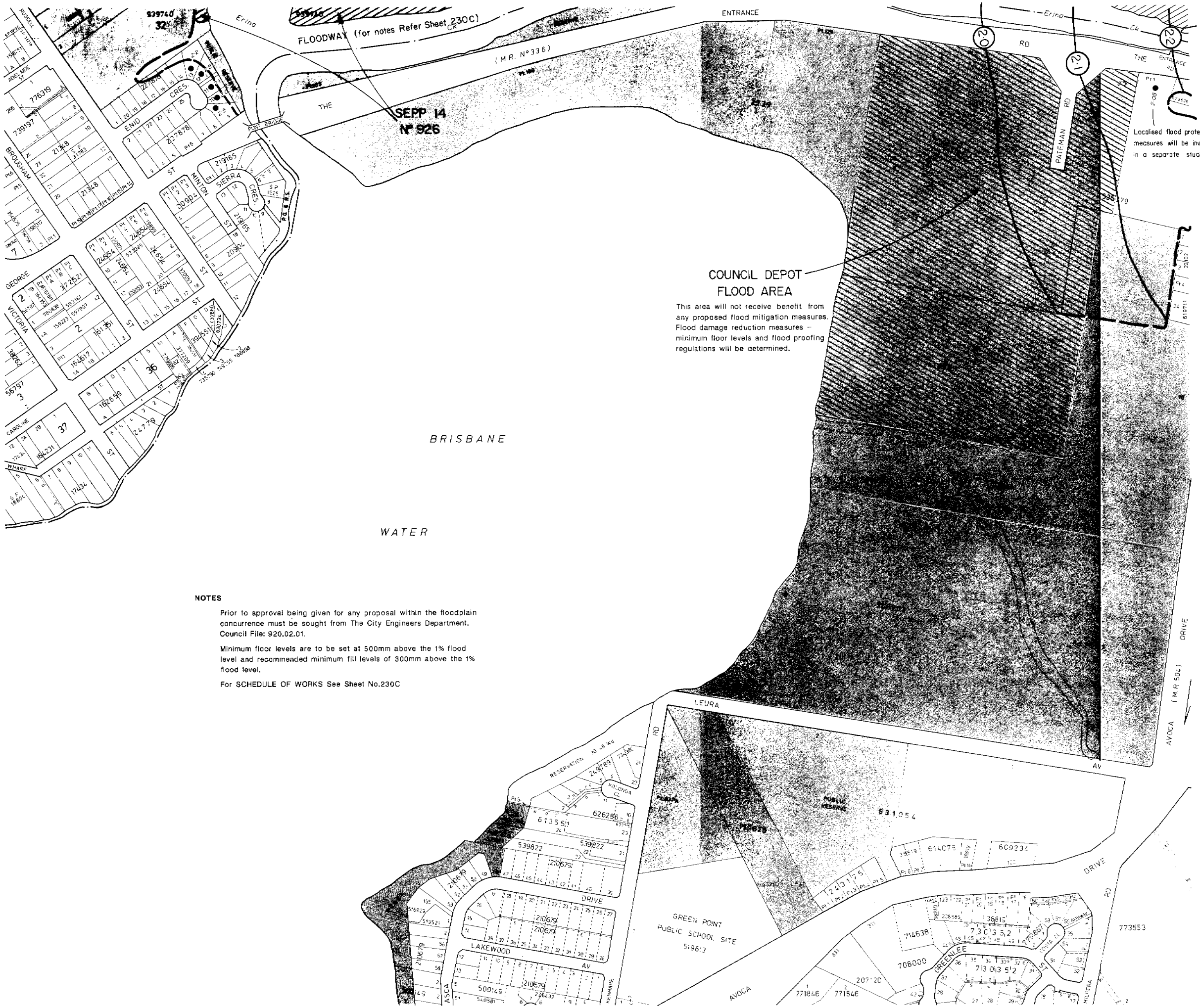
COUNCIL DRWG No. 2/44/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

CLASSIFICATION OF FLOODPLAIN LANDS

244C


Erina
FLOODWAY (for notes Refer Sheet 230C)
(M.R. N°336)
ENTRANCE
THE
SEPP 14
N° 926
ROAD RESERVE
ENID
CRES
ST
BROUGHAM
MINTON
SIERRA
CRES
ST
GEORGE
VICTORIA
ST
CAROLINE
ST
WYNDOC
RD
939740
32
776319
739197
21348
217878
219165
30982
209841
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246542
246543
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244D

SEPP 14 No 917 FINAL LIMIT OF DEVELOPMENT

INTERIM LIMIT OF DEVELOPMENT

FLOODWAY (for notes Refer Sheet 230C)

SEPP 14 No 918

ELECTRICITY SUB STATION

ENTRANCE (M.R. 336)

Localised flood protection measures will be investigated in a separate study.

COUNCIL DEPOT FLOOD AREA

This area will not receive benefit from any proposed flood mitigation measures. Flood damage reduction measures – minimum floor levels and flood proofing regulations will be determined.

Additional filling will be permitted as part of the interim measures within this lot to a maximum of 140m from the Entrance Road, subject to the following conditions.

- a detailed topographic survey is undertaken
- fill material can only be obtained from re working of the existing fill lying north of the 1% flood extent.
- the land must be filled to a minimum of 300mm above the 1% flood line.

ERINA INDUSTRIAL FLOOD FRINGE AREA

Interim development will be permitted to the designated interim alignment. Development on the floodplain beyond the interim line will be permitted subject to:

- filling will not be permitted until flood protection works at the Industrial Estate and Barralong Road are completed, and flood affected buildings are re-developed,
- ultimate filling will not be permitted beyond the final Limit of Development line.
- the floodway area of a property shall be dedicated at no cost to Council when the property is developed.

PROPOSED NUNNS CREEK DRAINAGE RESERVE 740014

Refer Nunns Creek Drainage Study for information upstream of The Entrance Rd.

R. 84725 FOR PUBLIC RECREATION ERINA PARK 707134

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

GOSFORD CITY COUNCIL

COUNTY OF NORTHUMBERLAND

KINCUMBER

KEY TO PARISH

LEGEND

Boundary of Classified Floodplain	
1% (100 Year) Flood Contour in 'm' AHD	3.8
Approved Floor Levels (see Note)	2.75
Existing Buildings	
Proposed Levee Bank	
Council Owned Land	
Land Subject to Geotechnical Investigation	
Wetlands Area	
Floodplain Management Areas	
Building designated for aquisition or floodproofing under the Floodplain Management Plan	
Vacant Land Identified for Acquisition	X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

244A	244B	245A
244C	244D	245C
257A	257B	258A

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/46/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

CLASSIFICATION OF FLOODPLAIN LANDS

245A

OLD ERINA ESTATE FLOODWAY AND ACQUISITION AREA

Full development within this estate would significantly raise flood levels upstream.
Limited minor filling will only be permitted for access to developable blocks.
The remaining blocks will be purchased and dedicated as floodway as designated on the plan.
Rate relief will be initiated by Council for the non-developable blocks.

Fill may be permitted within the designated area to provide a maximum of 500 sq. m of flood free land

CARLTON ROAD FLOOD FRINGE AREA

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.
No filling or hydraulic restrictions will be permitted outside the designated areas.

Refer Erina Valley Road Trunk Drainage Study for information upstream of Tamara Avenue.

WORTHING ROAD CREEK FLOOD AREA

Progressive purchase or floodproofing of the four existing flood liable houses as funds become available and consideration to one further house.
Implementation of controls for future catchment development.
Rate relief for undevelopable blocks.
Progressive purchase of undevelopable blocks.
Two further studies are being completed for Erina Valley Road Creek and Worthing Road Creek.

Refer Worthing Road Creek Trunk Drainage Study for information upstream of Chetwynd Road

SEE ADDENDUM 2

FLOODWAYS (for notes Refer Sheet 230C)

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

For SCHEDULE OF WORKS See Sheet No.230C

GOSFORD CITY COUNCIL

COUNTY OF NORTHUMBERLAND

KINCUMBER

KEY TO PARISH

LEGEND

- Boundary of Classified Floodplain
- 1% (100 Year) Flood Contour in 'm' AHD (3.8)
- Approved Floor Levels (see Note) 2.75
- Existing Buildings
- Proposed Levee Bank
- Council Owned Land
- Land Subject to Geotechnical Investigation
- Wetlands Area
- Floodplain Management Areas
- Building designated for aquisition or floodproofing under the Floodplain Management Plan
- Vacant Land Identified for Acquisition X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

229D	230C	230D
244B	245A	245B
244D	245C	245D

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/47/A1

Floodplain Management Plan overlay produced for Gosford City Council - July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

CLASSIFICATION OF FLOODPLAIN LANDS

230C

GOSFORD CITY COUNCIL

NOTES

Prior to approval being given for any proposal within the floodplain concurrence must be sought from The City Engineers Department. Council File: 920.02.01.

Minimum floor levels are to be set at 500mm above the 1% flood level and recommended minimum fill levels of 300mm above the 1% flood level.

SCHEDULE OF WORKS

Purchase of vacant floodprone lands, interim works at the Erina Industrial Flood Fringe and upgrading of the Council Depot and 'approved' filling of the Floodplain upstream of Karwin Avenue are low priority objectives. However all may proceed, subject to Council approval and availability of funds, outside the schedule of works listed below.

The recommended order of works is as follows:

1) Acquisition or floodproofing of designated buildings in the Worthing Road Creek area and outside the Winani Road levee.
2) Acquisition of land for Winani Road levee construction.
3) Construction of Winani Road levee.
4) Construction of the Industrial Estate levee. Construction of Barralong Road Bridge may then proceed and consideration given to refilling of land behind the Winani Road levee so long as there are no detrimental effects.
5) Filling of properties adjoining Clarence Road, subject to Council approval.
6) Filling of the Erina Industrial Flood Fringe area. Protection must also be provided to ensure that no buildings along The Entrance Road from Nunns Creek to Bonnal Road are adversely affected.

CARLTON AND MILINA ROADS FLOOD FRINGE AREAS

Blocks within this zone can be filled within the designated areas to 300mm above the 1% flood level to permit one dwelling per lot and to provide a maximum of 500 square metres of flood free land.

No filling or hydraulic restrictions will be permitted outside the designated areas.

Fill may be permitted within the designated area to provide a maximum of 500 sq. m of flood free land

FLOODWAYS

Floodways are to be maintained in perpetuity for the passage of floodwater.
No work is permitted in a floodway which would impede the passage of floodwater.
No buildings are to be constructed in a floodway.
Filling is prohibited.
Fences likely to collect debris and/or impede floodwaters are not permitted.
All land uses are to be flood compatible.
The extent of the floodway is shown on Drawing Numbers 2/43/A1 to 2/48/A1.
Proposals to cross a floodway with services of major importance to the region (for example Highways or arterial roads, bridges, railways, major water and sewer mains) will be permitted provided that the proposals are adequately investigated and designed in a manner which does not significantly affect flood flow capacity and flood levels.

UPSTREAM CATCHMENT

Development will be considered in the upper catchment subject to detailed evaluation of the possible hydrologic and hydraulic effects.

Local Floodproofing of Building will be permitted

FLOOD STUDY LIMIT

COUNTY OF NORTHUMBERLAND

GOSFORD / KINCUMBER

KEY TO PARISH

LEGEND

- Boundary of Classified Floodplain
- 1% (100 Year) Flood Contour in 'm' AHD (3·8)
- Approved Floor Levels (see Note) 2·75
- Existing Buildings
- Proposed Levee Bank
- Council Owned Land
- Land Subject to Geotechnical Investigation
- Wetlands Area
- Floodplain Management Areas
- Building designated for aquisition or floodproofing under the Floodplain Management Plan
- Vacant Land Identified for Acquisition X

NOTE

The position of the Flood Contour relative to property boundaries is approximate only and should be verified by Field Survey. Building floorlevels are indicative only. Dimensions provided overide scaled dimensions.

229B	230A	230B
229D	230C	230D
244B	245A	245B

KEY TO ADJOINING SHEETS

DATUM: AHD

METRES 40 20 0 40 80 120 160 200

CADASTRAL BASE PREPARED BY: CENTRAL MAPPING AUTHORITY

COUNCIL DRWG No. 2/48/A1

Floodplain Management Plan overlay produced for Gosford City Council – July 1990
Consulting Engineers; Webb McKeown & Associates Pty Ltd.
Consulting Surveyors; Peter Bolan & Associates Pty Ltd.

ERINA CREEK FLOODPLAIN MANAGEMENT PLAN

CLASSIFICATION OF FLOODPLAIN LANDS

End of Report

