TURO CREEK, PRETTY BEACH, FLOODPLAIN RISK MANAGEMENT PLAN

GOSFORD CITY COUNCIL

August 2007

.

CLIENT:		**GOSFORD CITY COUNCIL**
DOCUMENT NAME:		**TURO CREEK, PRETTY BEACH, FLOODPLAIN RISK MANAGEMENT PLAN**
STATUS:		**FINAL**
Prepared:	Author	Emma Maratea
Signature:		
Date		14 August, 2007
Reviewed:	Reviewer	Habib Rehman
Signature:		
Date		14 August, 2007
Approved:		Neil Lawson
Signature:		
Date		14 August, 2007

REPORT COPY NUMBER: .....

Revision Schedule

Rev	Version	Date	Description of Revision	Prepared	Reviewed	Approved
-	1	January 2006	Internal Draft	ERM	HUR	-
1	2	July 2006	Draft	ERM	HUR	NVL
2	3	October 2006	Final Draft	ERM/JJR	HUR	NVL
3	4	October 2006	Final Draft	ERM/JJR	HUR	NVL
4	5	January 2007	Final	ERM/JJR	HUR	NVL
5	6	July 2007	Final	ERM/JJR	HUR	NVL

It is the responsibility of the reader to verify the currency of the version number of this report. All subsequent releases will be made directly to the Client.

[ ] **Controlled Document No (…….)**
[x] **Uncontrolled Document**

FOREWORD

The State Government's Flood Policy is directed towards providing solutions to existing flood problems in developed areas and 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 is the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing flooding 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 State Government through the following sequential stages:

1. Formation of a Committee	Established by Council and includes community group representatives and State agency specialists.
2. Data Collection	Past data such as flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the floodplain.
4. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
6. Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Environmental Planning Instruments to ensure new development is compatible with the flood hazard.

The Gosford City Council has established a Floodplain Risk Management Committee that includes Council Staff and representatives from other stakeholders including the Pretty Beach community. Data Collection and the Flood Study for Turo Creek, Pretty Beach was completed in 2003 (PBP, 2003). The Floodplain Risk Management Study, which has been undertaken in concurrence with this study, updated the Flood Study and forms the fourth stage of the management process for the Turo Creek Floodplain. Preparation of Floodplain Risk Management Plan is the fifth stage of the process, which will be followed by implementation of the Plan.

This report has been prepared for Gosford City Council by Cardno Lawson Treloar to examine floodplain risk management options recommended by the Floodplain Risk Management Study and formulate a Floodplain Risk Management Plan.

EXECUTIVE SUMMARY

Gosford City Council commissioned Cardno Lawson Treloar to undertake a *Floodplain Risk Management Study* and prepare a *Floodplain Risk Management Plan* for the Turo Creek floodplain at Pretty Beach. This draft Plan has been prepared for public exhibition.

The Catchment

The Turo Creek catchment has an area of 44 hectares and is made up of forested and urban areas with the urban areas closer to the beach at the lower end of the catchment. Turo Creek flows between Como Parade and Venice/High View Road to the outlet into Brisbane Water at Pretty Beach. The creek traverses through private properties adjoining Venice Road and has a number of pedestrian bridges which cross the creek and act as controls during major storm events. These bridges also have a tendency to block during storm events.

The catchment is very steep with the escarpment to the south having slopes of around 30 to 50%. Flash flooding occurs as a result of the steep upper parts of the catchment. During storm events, waterfalls develop over the steep cliffs in the middle section of the catchment.

Escarpment (courtesy of Gwen Perrie)

Escarpment with Waterfalls (courtesy of Gwen Perrie)

Pretty Beach Road Culverts

Turo Creek near Como Parade

The Issue of Flooding

In the past, flooding within the catchment has caused property damage and posed a high hazard to the residents living in close proximity to the creek.

The major area of concern is the flood prone area that lies within the Probable Maximum Flood (PMF) extent. This area is subject to flooding from catchment flows and includes properties along Venice Road, Pretty Beach Road and Como Parade.

A number of hydraulic features within the floodplain control flood behaviour. These features include:

- Pretty Beach Road culverts
- Limited capacity of Turo Creek to carry floodwaters
- Blockage of private pedestrian bridges across Turo Creek.

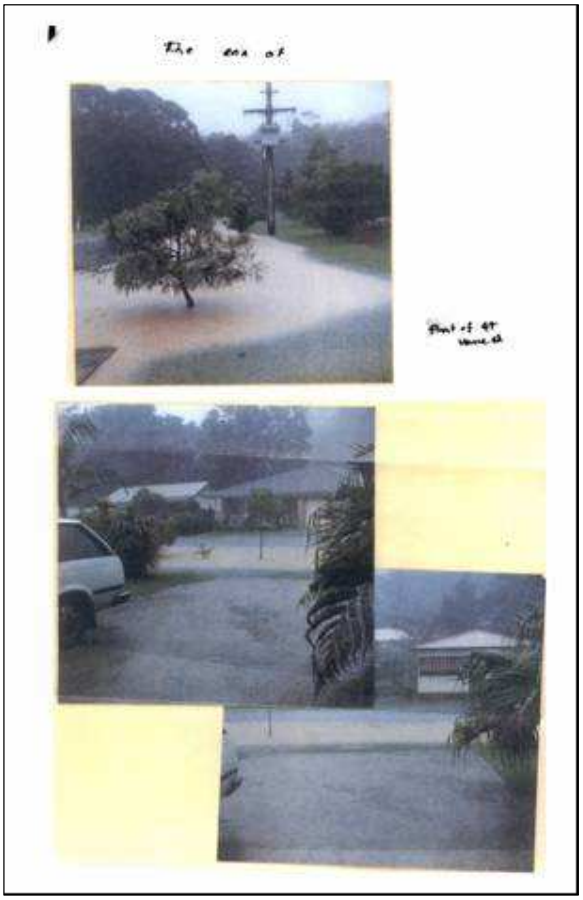
Additionally, the pipe drainage system in the catchment has a limited capacity and overland flow occurs once the capacity of the pipe drainage system is exceeded. A separate study was undertaken to assess the existing capacity of the system and suggest measures for improvement (*Pretty Beach Drainage Study* (PBP, 2003)).

Flood Behaviour - Existing Conditions

Intense rainfall periods, which are often short in duration, or occurs as a burst within a longer wet weather period are the primary factors that contribute to flood characteristics in the catchment. For example, the 100 year average recurrence interval (ARI) storm event for a 1 hour storm duration has an intensity of approximately 86 mm/hr. For an extreme event, such as the Probable Maximum Flood, the intensity of a similar duration event is substantially greater at 367 mm/hr.

Design flows for the catchment were calculated using the RAFTS hydrological model whereas design flood levels and velocities were estimated from the MIKE11 hydraulic model. This model was calibrated to available historical flood information.

Design flood events considered included the 5, 20, 50, 100, 200 year ARI and the Probable Maximum Flood (PMF) in accordance with current practice.



Historic Flooding in Turo Creek

The findings of the study indicate that significant flooding commences with the 20 year ARI event with a progressive increase in the number of flood affected properties up to the PMF.

Study Objectives

The *Floodplain Risk Management Study* has investigated the measures that can be undertaken to minimise the impact of flooding in the catchment. The *Floodplain Risk Management Plan* recommends a strategy for implementation of these measures.

The objectives of the Floodplain Risk Management Plan are 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
- reduce private and public losses due to flooding
- protect and where possible enhance the creek and floodplain environment
- be consistent with the objectives of relevant state policies
- ensure that the floodplain management plan is fully integrated with Council's existing corporate, business and strategic plans, meets Councils obligations under relevant Acts and has the support of the local community
- ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms
- ensure that the floodplain management plan is fully integrated with the flood response procedure and other relevant catchment management plans
- establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints and monitoring.

Impacts and Costs of Flooding

The table below summarises the number of properties that would be flooded in different design flood events together with the flood damage that is likely to occur.

Impacts and Costs of Flooding - Total Number of Properties with Above Floor Flooding

Flood (ARI)	Properties with above floor flooding	Flood Damage ($)
5 yr	3	$192,429
20 yr	5	$276,857
50 yr	6	$293,135
100 yr	7	$314,041
200 yr	8	$320,726
PMF	15	$720,008

Options to Manage Flooding

Using the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (2005) and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- flood modification measures,
- property modification measures, and
- emergency response modification measures.

Options Assessment

Options were assessed against a range of criteria (technical, economic, environmental and social).

Hydraulic modelling of flood modification option was undertaken along with an assessment of the economic, social, environmental, land use, heritage and planning issues with each factor given a score ranging from -2 to +2.

The finding of the assessment resulted in the recommendation of the following Flood Modification Measures:

- Removal/Modification of unapproved private access bridges.
- Improvement of Drainage Infrastructure, including Improved Overland Flowpath along Venice Road.
- Improvement/Preservation of Natural Overland Flowpaths in the Upper Catchment.
- Implementation of a Bypass Culvert.

Property Modification Measures recommended for the floodplain include:

- Strengthening of Planning and Development Controls.
- House Raising Program.
- Voluntary Purchase of House only on Eastern Portion of 38 Venice Rd.
- Data Collection Strategies
- Local Community to Prepare a Catchment Action Plan for Turo Creek and the Catchment

Emergency Response Modification Measures proposed for the floodplain include:

- Revision of DISPLAN.
- Information transfer to SES.
- Public Awareness and Education – Locality Based Floodsafe Brochure.
- Public Awareness and Education – Schools Package
- Depth markers at major road crossings

The Plan, in tabular form, is shown in Section 3 of this report.

The Next Step

The next step is the implementation of the Floodplain Risk Management Plan.

GLOSSARY

Annual Exceedence Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. e.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
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 overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.

Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the “Standard flood event” of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Integrated survey grid (ISG)	ISG is a global co-ordinate system based on a Transverse Mercator Projection. The globe is divided into a number of zones, with the true origin at the intersection of the Central Meridian and the Equator.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.

Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by the Institution of Engineers, Australia.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedence Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, 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 changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

LIST OF ABBREVIATIONS

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
DCP	Development Control Plan
DEC	Department of Environment and Conservation
DHI	Danish Hydraulics Institute
DNR	Department of Natural Resources
EPI	Environmental Planning Instrument
ESD	Ecologically Sustainable Development
FPL	Flood Planning Level
FRMC	Floodplain Risk Management Committee
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
GPSO	Gosford Planning Scheme Ordinance
GSDM	Generalised Short Duration Method
ha	hectare
HAT	Highest Astronomical Tide
IEAust	Institution of Engineers, Australia (now referred to as Engineers Australia)
IFD	Intensity Frequency Duration
km	kilometres
km^2	Square kilometres
LAT	Lowest Astronomical Tide
LEP	Local Environment Plan

LGA	Local Government Area
LIC	Land Information Centre
m	metre
m^2	Square metres
m^3	Cubic metres
m AHD	Metres to Australian Height Datum
MHWL	Mean High Water Level
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MIKE11	MIKE11 proprietary software package
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
mm	millimetre
m/s	metres per second
MSL	Mean Sea Level
NPWS	National Parks and Wildlife Service (within the Department of Environment and Conservation)
NSW	New South Wales
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
REP	Regional Environmental Plan
RTA	Roads and Traffic Authority
SEPP	State Environmental Planning Policy
SES	State Emergency Service

CONTENTS

Page

APPENDICES:

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Gosford City Council, through the Floodplain Risk Management Committee, is developing a Floodplain Risk Management Plan for the Turo Creek Floodplain in accordance with the New South Wales Government's Flood Prone Land Policy. Cardno Lawson Treloar was commissioned to prepare the Plan in accordance with the NSW Floodplain Development Manual (2005).

The area of interest is shown in a Locality Plan in Figure 1.1. The outline of the study area can be found in Figure 1.2.

1.1 STUDY CONTEXT

The preparation of this plan follows on from the Flood Study (Patterson Britton and Partners, 2003) and Floodplain Risk Management Study (Cardno Lawson Treloar, 2005) and forms the fifth stage of the Floodplain Risk Management Process, which includes:

- Formation of a Committee
- Data Collection
- Flood Study (updated from a previous study)
- Floodplain Risk Management Study
- **Floodplain Risk Management Plan**
- Implementation of Floodplain Risk Management Plan.

The study was jointly funded by Council and the Department of Natural Resources. The Department also assisted in the provision of specialist advice on flooding and related matters.

1.2 STUDY OBJECTIVES

The objectives of the *Floodplain Risk Management Plan* are to identify actions for implementation 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
- Reduce private and public losses due to flooding
- Protect and where possible enhance the creek and floodplain environment
- Be consistent with the objectives of relevant state policies
- Ensure that the floodplain management plan is fully integrated with Council's existing corporate, business and strategic plans, meets Councils obligations under relevant Acts and has the support of the local community
- Ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms
- Ensure that the floodplain management plan is fully integrated with the flood response procedure and is flexible to accommodate provisions from other relevant catchment management plans
- Establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints and monitoring.

1.3 COMMUNITY CONSULTATION

This Floodplain Risk Management Study and Plan was placed on public exhibition. Community members and stakeholders were invited during this period to make submissions on the results presented in the Study and Plan. These submissions were reviewed and then used to refine the Plan to its final version.

1.4 PLAN OUTLINE

The report format follows the study methodology, which involved:

- Overview of the Floodplain Risk Management Study (Section 2).
  - Description of flood behaviour and impacts.
  - Objectives of the FRMS.
  - Option Assessment Methodology.
  - Potential Floodplain Risk Management Options.
  - Recommended Options not included in the Plan.

- Adoption of beneficial options in the Floodplain Risk Management Plan (Section 3)
  - Implementation Action Plan
  - Summary of flood management actions for implementation.

- Data collection and further investigations for implementation (Section 4)

2 OVERVIEW OF FLOODPLAIN RISK MANAGEMENT STUDY

2.1 THE FLOOD PROBLEM IN TURO CREEK

In the past, flooding within the Turo Creek Catchment has caused property damage and posed a high hazard to the residents living in close proximity to the creek.

The major area of concern is the flood prone area that lies within the Probable Maximum Flood (PMF) extent. This area is subject to flooding from catchment flows and includes properties along Venice Road, Pretty Beach Road and Como Parade.

There are a number of hydraulic features within the floodplain that control flood behaviour. These include:

- Pretty Beach Road culverts
- Limited capacity of Turo Creek to carry floodwaters
- Blockage of private pedestrian bridges across Turo Creek.

The Floodplain Risk Management Study found that the Pretty Beach Road culverts were a major hydraulic control within Turo Creek. The limited culvert capacity restricts the flow of floodwaters to Brisbane Water.

Additionally, the pipe drainage system in the catchment has a limited capacity and overland flow occurs once the capacity of the pipe drainage system is exceeded. A separate study was undertaken to prepare the Pretty Beach *Drainage Management Plan* (PBP, 2003).

Another factor which contributes to the flood risk within the Turo Creek floodplain is that a number of houses have been built below the current flood planning level (100 Year ARI + 0.5m).

2.2 OBJECTIVES OF THE FLOODPLAIN RISK MANAGEMENT STUDY

The objectives of the Floodplain Risk Management Study were to:

- Review and modify the flood model (Patterson Britton & Partners, 2003) to include changes in the catchment since the completion of the modelling, prepare various flood interpretation graphs and tables as required for a flood study
- Review Councils existing environmental planning policies and instruments including Councils long-term planning strategies for the study area
- Identify works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events
- Assess the effectiveness of these works and measures for reducing the effects of flooding on the community and development, both existing and future
- Consider whether the proposed works and measures might produce adverse effects (environmental, social, economic or worsened flooding) in the floodplain and whether they can be minimised
- Examine the present flood warning system, community flood awareness and emergency response measures in the context of the NSW State Emergency Service's development and disaster planning requirements
- Examine ways in which the creek and floodplain environment may be enhanced by exploring the possibility of a strategy for vegetation planning that may create a valuable corridor of vegetation without having a detrimental effect on flooding, and
- Identify modifications that are required to current policies in light of the investigations.

2.3 OPTIONS IDENTIFICATION AND ASSESSMENT METHODOLOGY

A number of options were identified for the management of Turo Creek floodplain. These options included those identified by the community.

Options have been assessed in either of the following two ways:

- hydraulic modelling and detailed economic assessment (detailed economic assessment was carried out for selected flood modification options only),
- multi-criteria matrix assessment (all options)

For the selected flood modification options, hydraulic modelling results were used to calculate reduction in Average Annual Damage (AAD).

In the multi-criteria matrix assessment the results of the hydraulic modelling and detailed economic analysis were utilised where available. Qualitative methods were used for the other options. This method has been used to inform the selection of options for the Floodplain Risk Management Plan (Cardno Lawson Treloar, 2006).

The findings of this assessment were then subject to review by Committee and Council members and other relevant agencies. The review enabled a final list of floodplain management options to be compiled for public exhibition. Following the public exhibition period, public submissions were incorporated into the selection process.

2.4 FLOODPLAIN MANAGEMENT OPTIONS

Measures available for the management of flood risk can be categorised according to the approach adopted to manage the risk. Risk can be defined as being existing, future or residual risk. As a result, there are three types of measures for the management of flooding:

- Flood Modification Measures (for the existing risk)
- Property Modification Measures (for the future risk)
- Emergency Response Modification Measures (for the residual risk).

A full list of the potential options identified for the Turo Creek Floodplain is presented in Table 2.1. Table 2.1 also shows the scores and ranks of each option obtained in the multi-criteria matrix assessment.

2.5 OPTIONS NOT INCLUDED IN THE PLAN

The criteria used in the matrix assessment were not weighted to give any single criteria more importance than another. As such, the review by the consultant, the Committee and other relevant authorities, provided a number of recommendations for inclusion or exclusion of floodplain management options. These recommendations in conjunction with the results of the hydraulic analysis and benefit cost analysis have provided the necessary information to select options for implementation in the plan.

In general, options that were identified to have limited viability, excessive cost or social and environmental impact were excluded from the plan. The following options have not been included in the Plan for the reasons provided below.

2.5.1 Options FM1a and 1b – Pretty Beach Road Culvert Enhancement

The Culvert at Pretty Beach Road currently consists of a 2 cell culvert. These options would enhance the culverts at Pretty Beach Road by two additional cells (Option FM1a) or four additional cells (Options FM1b).

Hydraulic modelling of these options shows that these options have some benefit in reducing flood levels. The maximum reduction in flood levels in the 100 year ARI event is only 8cm for Option FM1a but a reduction of up to 24cm results from Option FM1b. The reduction in flood level as a result of the implementation of these options would benefit the houses located on Pretty Beach Road.

The economic assessment showed that both Option FM1a and FM1b could have a positive economic benefit, with both cost-benefit ratios greater than 1 (1.79 and 1.47 respectively).

The Mulit-criteria Matrix assessment established a score of 6 for Option FM1b and 5 for Option FM1a. Options with a score of 5 or higher have been proposed for inclusion in the Floodplain Risk Management Plan (Section 3). However, another flood management option (Option FM10 – Bypass Culvert) that has been recommended, scored more highly than either Option FM1a or FM1b and as such would negate the need for implementation of either Option FM1a or FM1b.

2.5.2 Option FM3 – Creek Enhancement and Replacement of Current Access Bridges with Arched Bridges

Hydraulic analysis shows that Turo Creek has limited conveyance capacity within the channel. This option proposed to increase the channel capacity by widening the channel to 5m (between top of banks). This option assumes removal of existing bridges and provision of arch bridges at a level above the 100 year ARI flood level for access across the creek.

Hydraulic modelling of this option resulted in a slight reduction of levels along some of the Venice Road properties (maximum reduction of 12cm). However, Council currently applies a 100 percent blockage policy when undertaking hydraulic modelling of culverts and bridges. Therefore, although the arched bridges would be unlikely to become completely blocked, this option results in floodwaters building up behind the blocked bridges thereby reducing the apparent benefit of this option.

Due to the culvert blockage policy, the subsequent benefit-cost analysis showed limited economic benefit and the matrix analysis also resulted in a low score.

In addition to the above mentioned assessments which showed the limited viability of the option, advice from the Department of Primary Industries suggests that the Department would not support any works which would cause major disturbance to the Creek unless it can be shown that the option has significant benefits. As the hydraulic analysis, benefit-cost analysis and matrix assessment did not show significant benefit to proceed with this option, it was not included in the Plan.

2.5.3 Option FM4 – Creek Enhancement and Realignment with Removal of Private Access Bridges

Turo Creek currently flows through the backyards of the Venice Road properties. To allow access across the divided backyard, property owners have constructed pedestrian bridges over the creek channel. This option proposes to realign the creek towards the rear boundary of the properties.

This option would involve a large amount of disturbance to the creek. Discussions with the Department of Primary Industries and DNR suggested that the department would not support creek realignment works due to the impact this would have on existing aquatic and riparian habitats in Turo Creek. Therefore this option has not been included in the final list of actions to be implemented in the Floodplain Risk Management Plan.

2.5.4 Option FM5 – Detention Basin

Turo Creek currently runs from the upper catchment, through predominantly forested land until it passes under Como Parade. This option proposed to provide an embankment at the upstream side of Como Parade to provide detention storage of flood flows upstream of Como Parade.

Hydraulic modelling of this option shows that the area upstream of Como Parade would flood to a depth of up to approximately 3m for all design events for an extended period of time. Although, the area is predominantly undeveloped land, its proximity to the residential area with significant depth of the stored waters could potentially provide a safety hazard.

Hydraulic modelling of this option shows that there is little or no difference from the existing flood levels in the vicinity of residential development (downstream of Como Parade). As such, this option does not provide any benefit to the properties of Pretty Beach. The economic analysis showed only a marginal reduction in Average Annual Damages.

This option was not included in the plan due to negligible benefit to flooding of properties in Pretty Beach and the potential safety issues associated with the detention basin.

2.5.5 Option FM6a, FM6b and FM6c – Creek Enhancement in Lower Reaches, Removal/Replacement of Access Bridges and Enhance Pretty Beach Culverts

Option FM6 has three variations:

Option FM6a Creek Enhancement in Lower Reaches and Removal/Replacement of Access Bridges.

Option FM6b Creek Enhancement in Lower Reaches, Removal/Replacement of Access Bridges and Enhance Pretty Beach Culverts to 6 Cells.

Option FM6c Creek Enhancement in Lower Reaches, Removal/Replacement of Access Bridges and Enhance Pretty Beach Culverts to 12 Cells

None of these options resulted in a score from the Multi-criteria Matrix of 5 or more, all resulting in a negative score. This is largely due to significant disturbance to the existing creek in the lower reaches.

This option would involve a large amount of disturbance to the creek. Discussions with the Department of Primary Industries and DNR suggested that the department would not support creek realignment works due to the impact this would have on existing aquatic and riparian habitats in Turo Creek. Therefore this option has not been included in the final list of actions to be implemented in the Floodplain Risk Management Plan.

2.5.6 Option FM7 – Levee Banks

The Turo Creek floodplain does not provide any feasible locations or opportunities for the implementation of levee banks. Therefore this option has not undergone any further assessment and has not been included in the Floodplain Risk Management Plan.

2.5.7 Option PM3a and PM3b – Voluntary Purchase Options

In high hazard areas of the floodplain an alternative to the construction of flood modification options to mitigate high flood hazard to existing properties at risk is the use of voluntary purchase (VP). This option would free both residents and emergency service personnel and volunteers from the hazard of future floods. This can be achieved by the purchase of properties and the removal and demolition of buildings. Council could purchase properties at an equitable

price and only when voluntarily offered. Such areas would then need to be rezoned to a flood compatible use, such as recreation or parkland (NSW Government, 2005) or possibly redeveloped in a manner that is consistent with the flood hazard.

The recommended criteria to determine properties that are eligible for voluntary purchase are:

- property located totally in the combined high hazard/floodway area for the 100 year ARI flood.
- Property access totally inundated by 100 Year ARI high hazard and/or floodway.
- occurrence of above floor flooding in the 20 year ARI flood event, and
- economic value of damages for a particular property is comparable to the property market value.

There are no properties in the Turo Creek Floodplain that are completely affected by high hazard and/or floodway for the 100 Year ARI. All properties have a significant portion still available for flood sensitive development, as detailed in the proposed development controls in Section 3.5.1.

No properties have their access completely inundated by the 100 Year ARI High hazard and/or Floodway. However, the portion of 38 Venice Road, which lies on the eastern side of the creek, has this limitation. In a flood emergency the access to this part of the property could be extremely dangerous.

Based on economic criteria alone, it would appear that none of the properties are suitable for VP. However, it may be feasible for Council to consider purchasing the house only on the eastern portion of 38 Venice Road and then limiting development in this portion as per the development controls proposed in this Floodplain Risk Management Plan.

Whilst economically voluntary purchase of most properties does not seem feasible, it has been included for assessment against other factors such as social and environmental factors. Two options have been identified for VP. The first option (Option PM3a) is to only include, for purchase, the house on the eastern portion of 38 Venice Road. It has been assumed that the cost of purchasing this house would be $50,000. The second option (Option PM3b) is to include all high hazard and floodway affected properties in the 100 Year ARI flood event. For assessment purposes the purchase price for the properties was assumed to be $800,000.

Both of these options obtained a score greater than 5 in the multi-criteria matrix (see Table 2.1). However, only option PM3a has been recommended for inclusion in the Floodplain Risk Management Plan. The exclusion of Option PM3b was based primarily on a benefit-cost ratio analysis. Option PM3b returned a benefit-cost ration of 0.22, which was the lowest benefit-cost ratio returned by any of the economically assessed options.

Whilst Option PM3a returns a benefit-cost ratio, which does not support the financial viability of these options, Council may want to pursue this option on a long-term basis to progressively minimise the flood hazard with gradual voluntary purchase of the high hazard affected properties as funding becomes available.

Council may want to pursue the option of VP for properties in the high hazard area and use that land for creating a local park for Turo Creek catchment and neighbouring communities. The success of such a program is contingent on joint funding from the Department of Natural Resources and the meeting of the relevant subsidy criteria as applied by the Department.

An alternative to pure voluntary purchase is the consideration of a land swap program whereby Council swaps a parcel of land in a non-flood prone area (e.g. an existing park) for the flood prone land with the appropriate transfer of park facilities to the acquired site. After voluntary

purchase, Council would then arrange for demolition of the building(s) and have the land rezoned to open space. The land swap approach may result in a significant saving on the land component of the voluntary purchase costs. It is recommended that this approach be investigated first before voluntary purchase proceeds. However, it is understood that there is a limited scope for land swap in the catchment.

ID	Locality	Type of Measure	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	NPV of Reduction in AAD	Benefit - Cost Ratio	Peak Reduction in Water Levels	Likely Overall Hydraulic Improvement	Capital and Operating Costs	Reduction in Risk to Property	Reduction in Risk to Life	Reduction in Social Disruption	Water Quality and Flow	Fauna & Flora	Community Criteria	Council/ Agency/ SES/etc	Compatible with Policies and Plans	TOTAL SCORE	RANK on TOTAL SCORE
FM1a*	Pretty Beach Road and Pedestrian Crossing	Culvert Enhancement (Double Culvert Capacity)	$330,000	$5,000	$399,004	**$51,617**	$712,351	**1.79**	0.08	0	0	1	0	0	0	0	2	1	1	**5**	**14**
FM1b*	Pretty Beach Road and Pedestrian Crossing	Culvert Enhancement (Triple Culvert Capacity)	$470,000	$8,000	$580,406	**$61,789**	$852,734	**1.47**	0.24	1	-1	2	0	0	0	0	2	1	1	**6**	**11**
FM2*	Between Como Parade and Pretty Beach Rd	Removal/Modification of all unaproved private access bridges	$90,000	$1,000	$103,801	**$20,627**	$284,661	**2.74**	0.52	2	0	1	0	1	0	0	0	2	2	**8**	**4**
FM3*	Between Como Parade and Pretty Beach Rd	Creek Enhancement (creek widened to 5m) and private access bridges replaced with arched bridges.	$460,000	$5,000	$529,004	**$44,920**	$619,933	**1.17**	0.12	1	-1	1	0	1	1	-1	0	-2	-2	**-2**	**22**
FM4*	Between Como Parade and Pretty Beach Rd	Creek Enhancement (creek widened to 5m) and Realignment with private access bridges removed	$480,000	$5,000	$549,004	**$75,402**	$1,040,610	**1.90**	0.12	1	-2	2	1	1	0	-2	0	-2	-2	**-3**	**23**
FM5*	Upstream of Como Pde	Detention Basin	$60,000	$1,000	$73,801	**$743**	$10,260	**0.14**	0.00	0	1	1	0	0	0	0	1	1	-1	**3**	**19**
FM6a*	Lower reaches of Creek upstream of Pretty Beach Rd	Creek Enhancement (creek widened to 5m) and private access bridges removed and replaced with causeways.	$390,000	$10,000	$528,007	**$44,546**	$614,762	**1.16**	0.08	0	-1	1	0	0	0	-1	0	-2	-2	**-5**	**24**
FM6b*	Lower reaches of Creek upstream of Pretty Beach Rd	Creek Enhancement (creek widened to 5m) and private access bridges removed and replaced with causeways. Pretty Beach Culverts enhanced (total 6 culvert cells)	$690,000	$12,000	$855,609	**$75,313**	$1,039,380	**1.21**	0.24	1	-1	2	1	1	0	-1	0	-2	-2	**-1**	**20**
FM6c*	Lower reaches of Creek upstream of Pretty Beach Rd	Creek Enhancement (creek widened to 5m) and private access bridges removed and replaced with causeways. Pretty Beach Culverts enhanced (total 12 culvert cells)	$1,140,000	$15,000	$1,347,011	**$88,637**	$1,223,258	**0.91**	0.51	2	-2	2	1	1	0	-1	0	-2	-2	**-1**	**20**
FM7	Between Como Parade and Pretty Beach Road	Levee Banks	NOT SUITABLE																		
FM8	Catchment wide	Improvement of Drainage Infrastructure, including Improved Overland Flowpath along Venice Road	$500,000	$20,000	$776,015	-	-	-	-	0	-1	1	0	1	1	0	1	1	1	**5**	**14**
FM9	Catchment Wide	Improvement/Preservation of Natural Overland Flowpaths in the Upper Catchment	$200,000	$10,000	$338,007	-	-	-	-	0	0	1	0	0	1	0	1	1	1	**5**	**14**
FM10	Upstream of Como Pde to an outlet at the Bay	Bypass Culvert to divert flows from Turo Creek	$1,242,000	$5,000	$1,311,004	**$150,905**	$2,082,608	**1.59**	1.37	2	-1	2	1	1	0	0	1	1	1	**8**	**4**
PM1	Catchment Wide	Planning and development controls	$15,000	$1,000	$28,801	-	-	-	-	0	2	2	1	1	0	0	1	1	2	**10**	**2**
PM2	Properties with over floor flooding in the 100 Year ARI Event (4 houses)	House Raising Program - Houses Raised above the PMF	$225,000	$0	$225,000	**$49,842**	$687,851	**3.06**	-	1	0	1	1	1	0	0	0	1	1	**6**	**11**
PM3a	Floodplain	Voluntary Puchase of House on Eastern Portion of 38 Venice Rd	$50,000	$0	$50,000	**$49,978**	$689,739	**13.79**	-	0	-1	1	2	1	0	0	0	1	1	**5**	**14**
PM3b	Floodplain	Voluntary Purchase Program (of all houses with high hazard within property)	$8,800,000	$0	$8,800,000	**$141,428**	$1,951,814	**0.22**	-	1	-2	2	2	2	0	0	0	0	1	**6**	**11**
PM4	Catchment wide	Review of On Site Detention Policy	$20,000	$2,000	$47,601	-	-	-	-	0	2	0	0	0	2	1	1	1	1	**8**	**4**
PM5	-	Data Collection Strategies	$5,000	$2,000	$32,601	-	-	-	-	0	2	0	0	0	0	0	0	2	1	**5**	**14**
PM6	Catchment wide	Catchment Action Plan - Rivercare	$20,000	$2,000	$47,601	-	-	-	-	0	2	0	0	0	2	2	1	2	2	**11**	**1**
EM1	-	Revision of DISPLAN	$15,000	$2,000	$42,601	-	-	-	-	0	2	0	1	0	0	0	1	1	2	**7**	**8**
EM2	-	Information Transfer to SES	$2,000	$0	$2,000	-	-	-	-	0	2	0	1	0	0	0	1	1	2	**7**	**8**
EM3	Catchment wide	Public Awareness and Education - Locality Based Floodsafe Brochure	$10,000	$2,000	$37,601	-	-	-	-	0	2	1	1	1	0	0	1	1	2	**9**	**3**
EM4	-	Public Awareness And Education - Schools Package	$10,000	$2,000	$37,601	-	-	-	-	0	2	1	1	1	0	0	1	1	1	**8**	**4**
EM5	Pretty Beach Road and Como Parade	Depth markers at major road crossings	$6,000	$0	$6,000	-	-	-	$0	0	2	1	1	0	0	0	1	1	1	**7**	**8**

** Indicates hydraulic model and detailed economic assessment used*

3 FLOODPLAIN RISK MANAGEMENT PLAN

3.1 OVERVIEW OF AVAILABLE FLOODPLAIN RISK MANAGEMENT MEASURES

Flood risk can be defined as being existing, future or residual risk:

- Existing flood risk - the existing problem refers to existing buildings and developments on flood prone land. Such buildings and development by virtue of their presence and location, are exposed to an 'existing' risk of flooding.
- Future flood risk - the future problem refers to buildings and developments that may be built on flood prone land in the future. Such buildings and developments may be exposed to a 'future' flood risk, i.e. a risk would not materialise until the developments occur.
- Continuing risk of flooding - the continuing problem refers to the 'residual' risk associated with floods that exceed management measures already in place, i.e. unless a floodplain management measure is designed to withstand the Probable Maximum Flood, it will be exceeded by a sufficiently large flood at some time in the future.

Measures available for the management of flood risk can be categorised according to the approach adopted to manage the risk. The alternative approaches to managing risk are outlined in Table 3.1 (after SCARM, 2000):

Table 3.1: Flood Risk Management Alternatives

Preventing/Avoiding risk	i.e. setting the planning level at the Probable Maximum Flood or not allowing development to be within the floodplain
Reducing likelihood of risk	i.e. implementing structural measures to reduce risk. The potential for implementation of flood modification options is limited by economic, social and environmental constraints)
Reducing consequences of risk	i.e. using development controls - design of structures to withstand flooding, allows a floodplain to be developed in lower areas
Transferring risk	via insurance - not viable given the non-insurability of most flood-prone areas
Financing risk	through natural disaster funding
Accepting risk	regardless of the options implemented, a continuing risk will be present.

As a result, there are three types of measures for the management of flooding:

- Flood Modification Measures (for the existing risk)
- Property Modification Measures (for the future risk)
- Emergency Response Modification Measures (for the residual risk).

3.2 FLOODPLAIN RISK MANAGEMENT PLAN OPTIONS

The floodplain management options recommended in the plan are shown in Table 3.2 and where appropriate on Figure 3.1. Figure 3.1 has been presented as two Figures (Figure 3.1a and 3.1b). Figure 3.1a is the existing Floodplain Risk Management Plan. Once Options FM10 (Bypass Culvert) and the drainage upgrades (Part of Option FM8) have been undertaken, Figure 3.1b will then apply. Figure 3.1b shows a change in the flood extents, which would result from implementing the selected floodplain management options.

To assist with the interpretation of the Plan (Figures 3.1a and 3.1b) the landuse zoning is shown in Figures 3.2.

The actions recommended in the Plan are not necessarily required to be implemented in any particular order, i.e. no one action is dependant on the implementation of another. However, to assist Council and the community with the implementation and prioritisation of the Plan, the actions have been defined as either High or Medium priority. Where funding permits, High priority requires implementation in the next 1 to 3 years; Medium priority requires implementation in the next 3 to 7 years.

The priority ranking is based on the following factors:

- Impact on flood risk;
- Ease of implementation; and
- Cost of implementation.

Table 3.2 Turo Creek Pretty Beach Floodplain Risk Management Plan

ID	*Description*	*Estimated Cost*		*Funding Sources/Responsibility*	*Priority (High or Medium)*
		Capital	*Recurrent*		
Flood Modification Options					
FM2	Removal/Modification of unapproved private access bridges.	$90,000	$1,000	Council/DNR/ Landowners	Medium
FM8	Improvement of Trunk Drainage Infrastructure, including Improved Overland Flowpath along Venice Road	$500,000	$20,000	Council	Medium
FM9	Improvement/Preservation of Natural Overland Flowpaths in the Upper Catchment	$15,000	$10,000	Council	High
FM10	Implementation of a Bypass Culvert - Upstream of Como Pde to Brisbane Water.	$1,242,000	$5,000	Council/DNR	High
Emergency Modification Options					
EM1	Revision of DISPLAN by SES in liaison with Council	$15,000	$2,000	Council/SES	High
EM2	Information transfer to SES	$2,000	$0	Council/SES	High
EM3	Public Awareness and Education – Locality Based Floodsafe Brochure	$10,000	$2,000	Council/SES	High
EM4	Public Awareness and Education – Schools Package	$10,000	$2,000	Council/SES	High
EM5	Depth markers at major road crossings ($2,000 per marker)	$6,000	$0	Council	High
Property Modification Options					
PM1	Strengthening of Planning and Development Controls	$15,000	$1,000	Council	High
PM2	House Raising Program	$225,000	$0	Council/DNR/ Landowners	High
PM3a	Voluntary Purchase of House only on Eastern Portion of 38 Venice Rd	$50,000	$0	Council/DNR	High
PM5	Data Collection Strategies	$5,000	$2,000	Council/DNR	Medium
PM6	Local Community to Prepare a Catchment Action Plan for Turo Creek and the Catchment	$20,000	$2,000	Council/Community	Medium

These options are shown in diagrammatic form in Figure 3.1, where feasible.

3.3 RECOMMENDED FLOODPLAIN MODIFICATION OPTIONS

3.3.1 Option FM2 – Removal/Modification of Private Access Bridges

There are a number of private access bridges across Turo Creek in the properties located along Venice Road. The bridges generally result in an increase in flood levels, especially when blockage occurs. As such this option assessed the benefit of removing or modifying these bridges.

Hydraulic modelling of this option resulted in a significant reduction in flood levels in the upper reaches of Turo Creek (up to 0.52m). This would provide a significant benefit to properties along Venice Road and Como Parade in terms of garden damage incurred by flooding. However, there is no significant benefit to overfloor flooding for all design flood events.

As the access bridges are on public property the removal and or modification of these bridges is the responsibility of the land owners. It is recommended that rather than enforcing an immediate compulsory removal of the bridges, no maintenance works on these bridges be allowed. As such, as the bridges become dilapidated, they will require removal. Any replacement of these bridges will be subject to the DA process including hydraulic assessment.

Recommended Actions:

- Prohibiting any maintenance works on private access bridges which cross the creek.
- Removal of degraded bridges, where possible.
- Replacement of bridges with DA consent only.
- Recording of the present condition of the existing access bridges over Turo Creek for possible comparison to their future condition.

3.3.2 Option FM8 - Improvement of Drainage Infrastructure, including Improved Overland Flowpath along Venice Road

Gosford City Council commissioned Patterson Britton and Partners to undertake an investigation into the performance of the existing drainage network at Pretty Beach and to develop a conceptual Drainage Management Plan to address any identified deficiencies. Table 3.3 lists the recommendation for drainage infrastructure that were made in the Drainage Study (Patterson Britton and Partners, 2003). Table 3.3 also details the recommendations in light of the investigations carried out in the Floodplain Risk Management Plan.

Table 3.3 Drainage Infrastructure Recommendations

Drainage Study Recommendations	Floodplain Risk Management Plan Recommendations
Install formalised grass swales along all roads to convey floodwaters to drainage pits and allow a flowpath for the 1% AEP flood.	The provision of grassed swales has been given a high priority in the drainage study. It is recommended that the grass swale along the west side of Venice Road be given top priority as this swale is likely to provide benefit during a major flood event in Turo Creek where the floodwaters are likely to flow along Venice Road. Provision of a formalised swale would provide efficient discharge of these floodwaters.
Encourage residents to maintain swales.	Agree

Drainage Study Recommendations	Floodplain Risk Management Plan Recommendations
Install drainage to service the low spot at the front of No.22 and No. 23 Pretty Beach Rd.	Would prevent the ponding of water at the front of these properties.
Install new drainage network along Como Pde	Hydraulic assessment of this upgrade (in conjunction with the High View Rd and Venice Rd upgrades) showed that this will have a slight benefit on flood levels along the creek. - The upgrade should be implemented with the captured flows being discharged directly to the bay. - The network should be designed to carry the 100 Year ARI flows.
Upgrade drainage network and High View Rd to Council standards. Upgrade pipe from a 10% AEP (*10yr ARI)* to a 5% AEP (*20yr ARI*).	Hydraulic assessment of this upgrade (in conjunction with the Como Parade and Venice Rd upgrades) showed that this will have a slight benefit on flood levels along the creek. - The upgrade should be implemented with the captured flows being discharged directly to the bay. - The pipes should be designed to carry the 100 Year ARI flows.

Recommended Actions:

- Where possible, install formalised grass swales along all roads in Pretty Beach.
- Encourage residents to maintain swales.
- Install new drainage network along Como Pde with a 100 Year ARI capacity.
- Upgrade drainage network along High View Rd from a 10 Year ARI capacity to a 100 Year ARI capacity.
- All drainage upgrades should discharge directly to the Bay.
- To minimise the construction costs of the drainage upgrades, the pipe along Venice Rd (shown in Figure 3.1) could be laid in conjunction with the proposed Bypass Culvert.

3.3.3 Option FM9 - Improvement/Preservation of Overland Flowpaths

Gosford City Council commissioned Patterson Britton and Partners to undertake an investigation into the performance of the existing drainage network at Pretty Beach and to develop a conceptual Drainage Management Plan to address any identified deficiencies. Table 3.4 lists the recommendation for overland flow that were made in the Drainage Study (Patterson Britton and Partners, 2003). Table 3.4 also details the recommendations in light of the investigations carried out in the Floodplain Risk Management Plan.

Table 3.4 Overland Flowpath Recommendations

Drainage Study Recommendations	Floodplain Risk Management Plan Recommendations
Prevent flooding for 9 to 10 houses from 1% AEP flood in Turo Creek.	This action is the primary motivation for the Floodplain Risk Management Study and Plan. The implementation of the options listed for action in the plan will reduce the impact of flooding in Pretty Beach.
Create an emergency drainage easement between the common boundaries of No 44 and 46 High View Rd and No 41 and 43 Venice Rd.	Outside the extent of the Hydraulic model. But would allow a formal overland flow path between High View Rd and Venice Rd, which may reduce property flooding This option is superseded by the option of drainage system upgrade in High View Rd and Venice Rd, which is proposed to carry 100 year ARI storm events.
Set minimum floor levels at 500mm higher than 1% AEP flood levels.	Investigations in the FRMS concluded that additional benefits could be obtained by setting minimum floor levels to 500mm above the 200 Year ARI flood level. However, as Council has advised they wish to achieve consistency with development policies in other catchments: • Minimum floor levels are to be set at 500mm above the 100 Year ARI flood level.
	Other important drainage flowpaths that were not identified in the drainage study are those flowpaths that convey flow from the waterfalls. It is important that these flowpaths be identified and preserved to prevent any future drainage issues. The flowpath identification could be achieved as a part of assessment of any development on the properties in the upper Turo Creek catchment.

Recommended Action:

- Preserve overland flowpaths that convey flow from the waterfalls to prevent any future drainage issues.

3.3.4 Implementation of a Bypass Culvert - Upstream of Como Pde to Brisbane Water (Option FM10)

Hydraulic modelling of Turo Creek found that the channel, down stream of Como Parade, has limited capacity to convey design flood flows as the creek is bounded by residential development. This is the reach of Turo Creek where most if not all flood damages are incurred. It is proposed to implement a bypass culvert to partly divert flows from Turo Creek, approximately 20m upstream of Como Parade. The box culvert with dimensions of approximately 2m x 1m would run underground parallel to Venice Road, under the reserve fronting Pretty Beach Road and discharge directly to the Bay.

It is proposed that the culvert inlet be located approximately 0.5m above the creek bed. The Inlet invert would be located at approximately 2 m AHD. This level allows for two provisions. Firstly, by not placing the culvert inlet at the channel bed level, low flows are allowed to pass downstream along Turo Creek. These low flows are vital for the creek's health.

Secondly, the culvert inlet should be at a level that provides sufficient culvert slope to enable efficient conveyance of flood flows. The proposed culvert is approximately 260m long and would have an average slope of 0.8%. The proposed layout is shown on Figure 3.1a and the assumed design specifications are shown in Table 3.5.

Table 3.5 Bypass Culvert Design Specifications

	Chainage*				
	0	**22**	**102**	**162**	**257**
Invert (m AHD)	2	1.82	1.18	0.7	-0.058**

*Chainage shown in Figure 10.1 of Turo Creek Pretty Beach Floodplain Risk Management Study Report # R2182.

**derived from 0.8% slope over a length of 257m with a starting elevation of 2 m AHD. This level is within the range of surveyed levels near the beach, including the invert level of -0.29 m AHD at pretty Beach Road culverts.

Hydraulic modelling of this option resulted in a significant decrease in flood levels at most locations along Turo Creek. The bypass culvert carries approximately 5 m^3/s out of the total 11 m^3/s in Turo Creek upstream of Como Parade in a 100 year ARI event. The greatest reduction in flood levels was just upstream of the bypass culvert inlet (up to 1.37m). However, decreases in flood levels at this location do not benefit existing properties in the floodplain. Within the vicinity of the existing residential properties (downstream of Venice Road to Pretty Beach Road), the reduction in flood levels varies from 0.44m to 0.95m. There is a significant reduction in overfloor flooding and an overall reduction in Average Annual Damages of approximately $150,000. The cost for this option is approximately $1.24 million with a benefit cost ratio of 1.59.

It is noted that no blockage has been assumed for this culvert. This is due to the fact that the culvert is laid at a short acute angle to the flow direction and is not likely to provide obstruction to the passing debris. However a debris control structure would be required to prevent debris from flowing into the culvert.

Recommended Actions:

- Detailed design and implementation of the bypass culvert and associated debris control structure.

3.4 RECOMMENDED PROPERTY MODIFICATION OPTIONS

3.4.1 Planning and Development Controls (Option PM1)

Strengthening of existing Council planning and development controls and development of new plans and development controls is recommended. It is also recommended that the continued revision and updating of these documents occur on an as-needed basis. A general review should be undertaken at least every five years.

In addition to the recommendation to SES/Council's general planning instruments, a number of development controls have been recommended for the Turo Creek Catchment and Floodplain.

It may be noted that during the preparation of a new city wide Comprehensive LEP under the state government guidelines, the recommended modifications to the planning documents may not be required or would need to be considered in the framework of the new Standard LEP Template. The recommendations made in this report are based on the current documents and would need to be reassessed once the new LEP is prepared.

Recommended Review of Existing Planning and Development Controls

DISPLAN

- It is recommended that the Gosford Local Emergency Management Committee consider incorporating special provisions for the small catchments in the LGA such as the Turo Creek catchment in the *Gosford City Local Flood Plan*.
- These catchments are subjected to flash flooding where the emphasis for flood emergency management should be on post-flood emergency management.
- Similarly, there should be more emphasis on educating the community of the flood hazard and measures during and after the flood event, since the community cannot be evacuated due to flash flooding in the catchment. The community therefore need to learn/understand the skills required to manage through a flood event. Local schools and community forums can be regularly prompted by the SES/Council to hold information sessions for the local residents.

Flood Warning

- The Gosford City Local Emergency Management Officer can possibly play a role in warning the community by contacting local community groups in case of severe weather warnings issued by the BOM.

Recovery

- It needs to be recognised that the recovery operation in the Turo Creek floodplain would need to be in place in a matter of few hours after the onset of the flood event. Hence it is recommended that a nearby community building is nominated as temporary shelter, where the residents can move immediately after the event, before the Gosford Local Emergency Management Committee can mobilise further assistance.

Planning Instruments and Policy

- It is recommended that consideration be given to rezoning the flood-affected properties from 2(a) Residential to 9(a) Restricted Development (Flood prone Land).
- It is also recommended that the following amendments be made in the Zone 9(a) description to make the development controls more effective for the flood prone land.
    - Provide definition of flood prone land as per the Floodplain Development Manual
    - Provide direction to consult the Development Control Plan 115 (Building in Flood Liable Areas).
- Additionally, the following amendment is suggested for section 49B sub clause (3) in Part VI of the GPSO to ensure that the principles of the Floodplain Development Manual are applied to all developments to be consented under this section:
  " *When considering to grant consent as referred to in sub clause (1) and (2) on land within Zone No 9(a) the Council is to take into account the principles of Floodplain Development Manual (latest version) published by New South Wales Government* ".

DCP No. 115

A number of improvements are suggested to achieve better development control. The suggestions are:

- Reference to the local Floodplain Risk Management Plan for delineation of floodway, flood storage, flood fringe, high hazard and low hazard areas.
- Specific development controls for high hazard areas
- Use of the term Flood Planning Level (FPL) rather than Minimum Floor Level (MFL) and provision of FPL definition. The definition should mention the freeboard incorporated in the FPL. It should also state that the FPL might vary across catchments.
- The current DCP No 115 'Building in Flood Liable Land' does not define the flood planning level. It is recommended that the DCP No 115 be amended, providing definition of the FPL for various landuses (residential, commercial, industrial etc) in the LGA.
- Change the terminology 'Flood Liable Land' to 'Flood Prone Land', and amend its definition to include areas inundated by the PMF event, in line with the Floodplain Development Manual.
- Requirement to submit a flood study as part of the DA to ensure that the proposed development will not have an adverse impact on other properties in the catchment.

DCP No. 159

DCP 159 'Character Statements and Maps' provides details for the desired character for various areas in the Gosford LGA. A character statement for Pretty Beach is available in DCP 159. This statement provides details of the existing as well as the desired character for the area. In particular the statement recommends preservation of the distinctive ridge-top reserve by allowing very low impact developments. The statement, however, does not refer to the scenic quality of waterfalls that develop during rainfall events.

Given the significant feature of 'waterfalls'/escarpment in the Turo Creek catchment, the character statement may be modified to incorporate the significance of waterfalls and recommendation for its preservation.

Gosford Vision 2005

The vision statements do not include implementation of flood risk management plans as a goal for safe living along the coast. It is recommended that hazard (both flood and others) be included in Gosford Vision 2025 or in a supplementary document, either as a separate 'Key Focus Area' or in the 'Focus Area Vision Statement' for *Promoting Health and Safety.*

Turo Creek, Pretty Beach Development Controls

General:

- Flood Planning Level (FPL) for setting habitable floor levels to be 100 year ARI flood level + 500 mm freeboard. The minimum FPL in the entire floodplain is 2.45 m AHD, which is derived from Brisbane Water flooding. This FPL is subject to modification following completion of the ongoing Brisbane Water Foreshore Flood Study.
- No development allowed in high hazard area or floodway of 100 year ARI flood event.
- No development allowed in the 100 year floodplain that is likely to obstruct overland flow or reduce the storage area of the floodplain. Certain types of development may be permissible such as carports and in-ground swimming pools.
- Increase in dwelling density (dual occupancy, subdivision etc) not allowed for properties lying entirely within the floodplain. Properties lying partially in the floodplain may intensify dwelling density provided there is no increase in the flood risk.

- No fences to be erected where they would obstruct overland flowpath. Where allowed, acceptable fence type would be preferably post and wire strand or grid mesh with not less than 150 mm spacing.
- No development allowed to the creek side of the building setback lines.
- All electrical fixtures to be located above the PMF level or FPL whichever is the highest.
- All proposed development located in proximity of watercourses to address structural stability issues.
- All development within 40m from the top of banks of Turo Creek will require separate approval from the Department of Environment and Climate Change under the Rivers and Foreshore Improvement Act.
- No development allowed that increases flood risk eg risk to increased flood damages, risk to life both for occupants and emergency crew accessing floodplain, etc.
- Mangrove community to be maintained at current levels and water flows be maintained in the lower reaches of Turo Creek to avoid possible impact. Present mangrove extent is to be benchmarked with the help of land and aerial photos to provide a basis for creek management in the future. Future management of mangroves is to be carried out in consultation with Department of Primary Industries (*S.204-5 Fisheries Management Act*). (Based on advice received from Department of Primary Industries, presented in Appendix A).
- In addition to the controls presented here, all development to comply with DCP115 "Building in Flood Liable Areas" and other relevant Council policies/ DCP/documents.
- Council may request preparation of a localised flood study to determine the impact of the proposed development.
- All development on piers to have minimum pier spacing of 2.0 m. No enclosure or storage of equipment or materials in underfloor area permitted in flood plain. Offsets for individual piers in rows parallel to the flow shall be no more than 100 mm. Cladding below floor level, irrespective of type, is not permitted.
- All bank and bed protection work requires Council approval.
- All permissible development in the PMF floodplain not to adversely affect overland flows

Redevelopment is also subject to specific controls for specific management areas shown in Figure 3.1. Details of the proposed development controls are listed below.

Pretty Beach Road Management Area:

- Flood Planning Level (FPL) varies across the properties. Highest FPL to be adopted for any development within the property.
- No habitable development allowed in the public reserve fronting Pretty Beach Road that lies within the 100 year ARI flood extent.
- No filling or obstruction allowed in the public reserve fronting Pretty Beach Road that will divert flows or remove any part of the storage area of the 100 year ARI floodplain. Lot filling not to adversely affect adjoining properties particularly with regard to overland flooding.
- All development related to building extensions or reconstructions, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
- Filling at Pretty Beach Road frontage permitted to gain 100 year ARI flood free access to the new garages or carports only after all flood mitigation works identified under the plan have been completed and provided that the fill area is outside the defined flood storage area.
- Proposed carports, garages and vehicular access not to impede the flood flows through to Brisbane Water. If redeveloped, greater area for flow to be allowed, where practical.
- Lot filling that is allowed cannot be higher than existing Pretty Beach Road level, which acts as a weir during flood events.
- No raising of Pretty Beach Road allowed that would increase the weir level in the floodplain, resulting in adverse impact on upstream properties

Venice Road Management Area:

- Redevelopment of properties to the east of Venice Road to be encouraged to relocate building footprint closer to Venice Road frontage to improve access during flood emergency and move away from high risk areas of the floodplain. Council to consider relaxing of building setbacks from the road to the front of the houses where appropriate. Applications to be assessed on their merit.
- All development related to building extensions or reconstruction, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
- For complete redevelopment of the site, filling at Venice Road frontage is permitted to gain 100 year ARI flood free access to new garages or carports only after all building development on property has been raised on piers above FPL. This should not result in net decrease in floodplain storage ie the volume of fill should be less than or equal to the volume made available under the existing building footprint. If Venice Road is not flood free in the 100 year event at the site of the development, then habitable floor levels to be at the PMF level.
- No habitable development is permitted on the portions of properties on the eastern side of Venice Rd that lies to the east of Turo Creek due to access difficulties in a flood emergency and due to its location in high hazard area of the floodplain.
- Erosion protection and bank stabilisation of Turo creek to be addressed through Rivercare initiative of Natural Heritage Trust or similar group.

Como Parade Management Area:

- All developments to consider design that reduces flood risk eg risk to life and damage to property etc. All development to have safe 100 year flood free access out of the floodplain to Como Parade.

Upper Catchment Management Area (Generally above Highview Road and Como Parade):

- Overland flow paths to be preserved and maintained through properties. The significant local feature of Waterfall to be preserved where appropriate.
- Minimum floor level should be established at least 0.5 m above the finished ground level, making sure that any earthwork does not adversely affect the adjoining properties with regard to overland flooding.

Figures 3.7 and 3.8 provide details of some of the controls recommended for the Venice Road and Pretty Beach Road Management Areas. These figures are provided to help understand various controls and do not necessarily provide all the recommended controls in this study.

Recommended Actions

- Implement the above listed amendments after further review of Council's General Development Controls and Policies.
- Implement the above listed Development Controls specific to Turo Creek floodplain.

3.4.2 Voluntary House Raising/Flood Proofing Program (Option PM2)

House raising is a possible option to reduce the incidence of overfloor flooding in properties. Whilst house raising can reduce the occurrence of flooding, there are issues related to the practice including:

- the potential for damage to items on a property other than the raised dwelling (such as gardens, sheds and their contents, garages, cars, etc)
- unless a dwelling is raised above the level of the PMF, the potential for above floor flooding still exists (i.e. there will be a residual risk)
- evacuation may be required (e.g. medical emergency during a flood event) even if no above floor flooding occurs. This evacuation is likely to be hampered by floodwaters surrounding a property
- need to ensure the new footings and piers can withstand flood-related forces, house raising is generally only suitable for low hazard areas, however all properties have been considered as part of this assessment
- potential conflict with height restrictions imposed for a specific zone or locality within the local government area (for properties to be raised a significant level, e.g. greater than 1m).

To identify which properties would be suitable for house raising, information on the nature of the construction of each property within the floodplain was provided by the Council (Section 4.2).

The following criteria was applied to determine the properties that are eligible for house raising:

- occurrence of above floor flooding in the 100 year ARI flood event,
- foundation construction type – only structures on piers considered, cost of raising slab on ground would be prohibitive or impractical (where the footing type was unknown it was assumed at this stage to include the building in the house raising assessment).
- single storey dwellings only.

Table 3.6 presents all houses with overfloor flooding in the 100 Year ARI flood event. The foundation construction type and suitability for house raising is also shown. For those houses for which their suitability for house raising is “unknown”, they have been assumed to be included in the proposed house raising programme. It is proposed that these houses are raised above the PMF, since the differences in flood levels between more frequent events and the PMF is not significant for house raising purposes.

Table 3.6 Properties with Overfloor Flooding in 100 Year ARI Flood Event

Property	Overfloor Flooding 100 Year ARI	Foundation Construction Type	Suitable for House Raising
20 Pretty Beach Road	0.04m	Unknown	Unknown[1]
21 Pretty Beach Road	0.11m	Brick Piers	Yes
24 Pretty Beach Road	No Floor Level	Unknown	Unknown[1,2]
38 Venice Road	0.20m	Brick Piers	Yes
42 Venice Road	0.12m	Slab on Ground	No

[1] The foundation construction type should be verified before inclusion of this property in the House Raising Programme.
[2] The floor level should be obtained to verify that overfloor flooding occurs in the 100 Year ARI flood event before inclusion of this property in the House Raising Programme.

A breakdown of the numbers of identified properties and associated costs are listed in Table 3.7. An assumed cost of the order of $45,000 is considered reasonable for house raising of each property as a preliminary assessment.

Table 3.7 Breakdown of Properties for House Raising

Street	Number of Properties Identified	Likely Total Cost
Pretty Beach Road	3	$135,000
Venice Road	2	$90,000
Total	**5**	**$225,000**

Success of the house raising program is contingent on joint funding from the Department of Natural Resources and the meeting of the relevant subsidy criteria as applied by the Department.

If Option FM10 is implemented the only house for possible house raising option would be 38 Venice Road (house on western side of the creek). After the implementation of Option FM10 this house will only experience 6cm of overfloor flooding in the 100 Year ARI event.

Recommended Actions

- Assuming the implementation of Option FM10 (Bypass Culvert), only the house on the western side of the creek on 38 Venice Rd should be raised above the PMF level.

3.4.3 Voluntary Purchase Program (Option PM3)

In high hazard areas of the floodplain an alternative to the construction of flood modification options to mitigate high flood hazard to existing properties at risk is the use of voluntary purchase (VP). This option would free both residents and emergency service personnel and volunteers from the hazard of future floods. This can be achieved by the purchase of properties and the removal and demolition of buildings. Properties could be purchased by Council at an equitable price and only when voluntarily offered. Such areas would then need to be rezoned to a flood compatible use, such as recreation or parkland (NSW Government, 2005) or possibly redeveloped in a manner that is consistent with the flood hazard.

The recommended criteria to determine properties that are eligible for voluntary purchase are:

- property located totally in the combined high hazard/floodway area for the 100 year ARI flood.
- Property access totally inundated by 100 Year ARI high hazard and/or floodway.
- occurrence of above floor flooding in the 20 year ARI flood event, and
- economic value of damages for a particular property is comparable to the property market value.

The first criteria is met by a number of properties in the floodplain. However, none of the properties in the Turo Creek Floodplain are completely inundated with high hazard and/or floodway for the 100 Year ARI. All properties have a significant portion still available for flood sensitive development, as detailed in the proposed development controls in Section 3.4.1

No properties have their access completely inundated by the 100 Year ARI High hazard and/or Floodway. However, the portion of 38 Venice Rd which lies on the eastern side of the creek does. In an emergency this hazardous access could be extremely dangerous.

The economic value of damages for individual properties is in the range of $30,000 - $40,000, which is not comparable to the market value of these properties, which ranges from $600,000 -

$900,000 (Based on the search of listed property prices for the area through www.realestate.com.au as at September 2005).

Thus based on economic criteria alone, it would appear that none of the properties are suitable for VP. However, it may be feasible for Council to consider purchasing the house only on the eastern portion of 38 Venice Road and then limiting development in this portion as per the development controls proposed in Section 3.4.1.

Two options were identified for Voluntary Purchase. The first option (Option PM3a) is to only include, for purchase, the house on the eastern portion of 38 Venice Road. It has been assumed that the cost of purchasing this house would be $50,000. The second option (Option PM3b) is to include all high hazard and floodway affected properties in the 100 Year ARI flood event. These properties are listed below:

• 38 Venice Road • 40 Venice Road • 42 Venice Road • 44 Venice Road • 46 Venice Road • 48 Venice Road • 50 Venice Road • 52 Venice Road	• 22 Pretty Beach Road • 23 Pretty Beach Road • 24 Pretty Beach Road

As discussed in Section 2.5.7, the voluntary purchase of all High Hazard affected properties (Option PM3b) was not considered suitable for inclusion into the Floodplain Risk Management Plan, primarily due to the high capital cost of undertaking the purchases. However, council may want to pursue the option of VP for properties in the high hazard area and use that land for creating a local park for Turo Creek catchment and neighbouring communities. The success of such a program is contingent on joint funding from the Department of Natural Resources and the meeting of the relevant subsidy criteria as applied by the Department.

An alternative to pure voluntary purchase is the consideration of a land swap program whereby Council swaps a parcel of land in a non-flood prone area (e.g. an existing park) for the flood prone land with the appropriate transfer of park facilities to the acquired site. After voluntary purchase, Council would then arrange for demolition of the building and have the land rezoned to open space. The land swap approach may result in a significant saving on the land component of the voluntary purchase costs. It is recommended that this approach be investigated first before voluntary purchase proceeds. However, it is understood that there is a limited scope for land swap in the catchment.

The Multi-Criteria Matrix and economic assessment of the purchase of only the house on the eastern portion of 38 Venice Road (Option PM3a) was feasible for inclusion in the Floodplain Risk Management Plan.

Recommended Action:

- Voluntary purchase of the house (not the land) located on the eastern portion of 38 Venice Road.

3.4.4 Data Collection Strategies (Option PM5)

Floodplain Management is an ongoing process and involves collection of historic flood data that can be used in future review and update of the Floodplain Risk Management Plan. It is

therefore imperative that data collection strategies are put in place for this vital component of the floodplain management process. This would involve the preparation of a flood data collection form and use of this form following a flood event.

3.5 RECOMMENDED EMERGENCY REPONSE MODIFICATION OPTIONS

3.5.1 Public Awareness and Education by SES (EM3, EM4)

Flood awareness is an essential form of communication for people residing on a floodplain. The affected community must be made aware, and need to remain aware, of their role in the overall floodplain management strategy for their area. This includes the defence of their property and their own evacuation if required. Given the short duration of flooding and the hazardous nature of a number of roads within the area, residents should be encouraged to seek refuge via vertical evacuation, where possible.

Flood awareness is an ongoing issue and requires continuous effort of related organisations (e.g. Council and SES). The major factor determining the degree of awareness within the community is the frequency of moderate to large floods in the recent history of the area. The more recent and frequent the flooding, the greater the awareness.

One difficulty with flood emergency planning is to maintain an adequate level of flood awareness during the extended periods when flooding does not occur. A continuous awareness program needs to be enforced to ensure new residents are informed, the level of awareness within long-term residents is maintained, and to cater for changing circumstances of flood behaviour and new developments. An effective awareness program requires ongoing commitment.

It is recommended that the following awareness campaigns be considered for the floodplain:

- Preparation of a FloodSafe brochure by the SES (EM3). Such a brochure with a fridge magnet may prove to be a more effective means of ensuring that people retain necessary information
- Development of a Schools Package from existing materials developed by the SES and distribution to schools accordingly (EM4).

The meeting of local Community groups could be used to arrange flood awareness programs on regular intervals.

Information dissemination is recommended to be included in Council rates notices for all affected properties on a regular basis.

Once prepared, the FloodSafe brochure can then be uploaded to the SES website (www.ses.nsw.gov.au) in portable document format (PDF) where it is available under the ‘information for local communities’ section.

Recommended Actions:

- Preparation of a FloodSafe brochure by the SES which is provided as a fridge magnet.
- Development of a schools package by the SES to be distributed to local schools.
- Distribution of the FloodSafe brochure at local community group meetings.
- Flood risk awareness information to be distributed with Council rates notices for all flood affected properties on a regular basis.
- Upload the FloodSafe brochure onto the SES website in portable document format (pdf) where it should be available under the ‘information for local communities’ section.

3.5.2 Information Transfer to SES by Council (EM2)

The findings of the flood study provide an extremely useful data source for the State Emergency Service. Information could be provided from the findings of the flood study in two forms:

- Electronic information (flood extent mapping and flood hazard mapping in geographic information system format).
- Laminated plans (hard copies of flood extent and hazard mapping) in laminated plan format for use in the operations centre to assist with directing teams to the most likely affected localities. This can also help to overcome any issues associated with power loss or difficulty with accessing information in an emergency.

Recommended Action:

- Transfer the flood data (flood extents, hazard and hydraulic category mapping) from the Floodplain Risk Management Study to the SES.

3.5.3 Revision of DISPLAN by SES (EM1)

The following amendments to the existing DISPLAN are recommended:

- It is recommended that the Gosford Local Emergency Management Committee consider incorporating special provisions for small catchments in the LGA in the *Gosford City Local Flood Plan.* For example flood warning systems for small catchments like Turo Creek, where flash flooding occurs.
- Considering that the recovery operation in Turo Creek floodplain by the SES would need to be in place in a matter of few hours after the onset of a major flood event, it is recommended that a nearby community building is nominated as temporary shelter, where the residents can move immediately after the event, before the Gosford Local Emergency Management Committee can mobilise further assistance.
- Reference to the timing of flooding for small catchments like Turo Creek should be included in the plan (e.g. 15min to 30min for various design events).
- More emphasis should be placed on educating the community for small catchments like Turo Creek where evacuation is not feasible.
- Numbers of properties inundated are detailed in this report and as such DISPLAN can be updated with this information.

3.5.4 Depth Markers at Major Road Crossings by SES (EM5)

Flood depth markers provide guidance as to the depth of flooding at a specific location. Depth markers are commonly located on roads that are periodically inundated and present a traffic or pedestrian hazard.

In addition to providing guidance to drivers and pedestrians on the depth hazard, the markers can also be used by roaming crews of the SES to provide updates on the nature of the changing flood threat in an area for a relatively large duration event.

A flood depth marker is recommended to be installed at the Turo Creek crossing of Pretty Beach Road and Como Parade. It is recommended that twin-sided markers be installed at these locations. Approximate location of these depth markers is shown in Figure 3.1.

Recommended Actions:

- Installation of depth markers at Pretty Beach Road (twin sided markers) and Como Parade (single twin sided marker). Approximate location of these markers is shown in Figure 3.1.

3.6 FLOOD BENEFIT OF THE FLOODPLAIN RISK MANAGAMENT PLAN

The implementation of the Turo Creek Floodplain Risk Management Plan will result in the reduction of flood risk within the floodplain and catchment. In general, it is difficult to quantify exactly the actual flood risk benefit that would result from the implementation of the Plan. However, the major flood management options, which have been proposed as part of the plan can be hydraulically modelled to represent the likely reduction in flood levels and extents. The reduction in the floodplain (PMF Extent) is shown in Figure 3.3. The reduction in the 100 Year ARI flood extent and high hazard extent is shown in Figure 3.4. The change in hydraulic categorisation for the 100 Year ARI event is shown in Figure 3.5.

4 DATA COLLECTION AND FURTHER INVESTIGATIONS

4.1 DATA COLLECTION

The ongoing collection of data to aid the assessment of the performance of implemented actions as well as aid in future revisions of this floodplain management plan is an integral part of the Floodplain Management Process in the catchment.

Gosford Council currently has data collection strategies for the LGA. It is recommended that data collection for flood related parameters such as flow gauging and water level data be continued and where possible enhanced within the Turo Creek floodplain.

4.2 FURTHER INVESTIGATIONS

Further investigations are recommended for all options once funding is secured for that option. These investigations would provide recommendations for ongoing monitoring and maintenance specific to the detailed design of the option. For example, the creek modification options will require ongoing monitoring and maintenance through the preparation and implementation of a creek management plan for each creek system. This plan should include aspects such as a schedule of regular inspections and a means of identifying and rectifying issues. Detailed design should make reference to appropriate guidelines and manuals such as *A Rehabilitation Manual for Australian Streams* (CRC for Catchment Hydrology, 1999).

5 TURO CREEK FLOODPLAIN RISK MANAGEMENT PLAN MAINTENANCE

The floodplain risk management options presented in this plan are based on the existing topographic and hydrological conditions of the catchment. The modelled flood behaviour has been established from the current creek cross section geometry. Any change in this geometry due to the actions of the residents or natural catchment processes is likely to violate the findings presented in this plan. As an example, if the population of mangroves in the lower reaches of the catchment were to increase, it is likely that the siltation of the creek bed would also increase with consequent rise in flood levels. In addition, dense mangroves would also result in higher resistance to flow of floodwaters causing increase in flood levels. Similarly any obstruction to the flow of floodwaters through the properties is likely to increase the flood levels and may result in excessive flooding than predicted in the current study.

It is therefore important that a monitoring and maintenance plan be developed to preserve the existing creek conditions including the density of mangroves in the lower reaches of the creek. The maintenance plan should also include monitoring and cleaning of other structures such as the bypass culvert and other culverts in the floodplain.

It is also important that the residents adhere to a monitoring and maintenance plan by avoiding obstruction of floodwaters. This can be achieved by keeping the creek clean of any debris and keeping the overland flow paths clear of any obstructions.

5.1 TURO CREEK CONDITION SURVEY

NSW Department of Primary Industries (DPI) has undertaken a review of the Turo Creek, Pretty Beach Floodplain Risk Management Plan and provided a written submission (Appendix A). DPI has acknowledged the importance of maintaining a balance between the mangrove growth and its flooding impacts. In this regard, DPI has recommended that a condition survey of the creek be undertaken and documented for future reference.

A photographic survey was undertaken on 2 January 2007 to document the existing condition of Turo Creek (Appendix B). This survey provides details on the existing Mangrove growth near the Pretty Beach Road. The survey also documents the existing bridges/structures on Turo Creek. Information contained in Appendix B should be used as a basis for developing and implementing a maintenance management plan for Turo Creek.

6 PUBLIC EXHIBITION OF THE PLAN

The Turo Creek Floodplain Risk Management Plan approved by the Floodplain Management Committee was placed on public exhibition from 30 October 2006 to 1 December 2006 at prominent locations in the Gosford area. A copy of the plan was also submitted to primary stakeholders for review and comment.

Only minor comments were received from the community and were incorporated in the plan. Among the stakeholders, Department of Primary Industries and Darkinjung Local Aboriginal Land Council provided written submission, which are presented in Appendix A. The comments from these submissions were also incorporated in the Plan.

7 QUALIFICATIONS

This report has been prepared by Cardno Lawson Treloar for Gosford City Council and as such should not be used by a third party without prior approval from Council.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts.

Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The results of the study are based on the following assumptions/conditions:

- Flood estimation and assessment of flood management options is based on local catchment flooding only, the impact of Brisbane Water flooding has not been accounted for in this study.
- Design flood extents, hydraulic categories and hazard categories are approximate between cross sections of the model. Where surveyed levels are not available, flood extents are based on the 2m LIC contour data provided by Council and the interpolation of model results.
- The local pit and pipe stormwater drainage system is not modelled.
- The report relies on the accuracy of the survey data provided by Council.
- Cost estimates provided for options in this report are preliminary only and more detailed cost estimates should be prepared during the detailed design phase.

Study results should not be used for purposes other than those for which they were prepared.

8 ACKNOWLEDGEMENTS

The assistance of the residents of the Pretty Beach area, Pretty Beach/Wagstaffe & District Progress Association Inc, Hardys Bay Resident's Group Inc, Gosford City Council and the Department of Natural Resources is gratefully acknowledged.

This study was funded under the State Government's Floodplain Management Program through the Department of Natural Resources on a 2:1 (State:Council) ratio.

9 REFERENCES

Bureau of Meteorology (2003), The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method

Bureau of Meteorology (2005) Averages for Gosford (Narara Research Station) AWS Climate, Australian Government.

Cardno Lawson Treloar, (2005), Brisbane Water Estuary Processes Study (In progress), for Gosford City Council.

Department of Environment and Conservation (2005) Contaminated Land Register. NSW Government.

Department of Land and Water Conservation (1997) Acid Sulfate Soil Risk Map – Edition 2 – Broken Bay. Department of Infrastructure, Planning and Natural Resources.

Department of Conservation and Land Management (1993) Soil Landscapes of the Gosford – Lake Macquarie 1:100 000 Sheet,

Department of Primary Industries (NSW Fisheries) (2005) www.fisheries.nsw.gov.au. NSW Government

Department of Public Works, NSW (1997), Brisbane Water Flood Levels May 1974.

Engineers Australia (2004) 'Guidelines for Responding to the Effects of Climate Change in Coastal and Ocean Engineering', The National Committee on Coastal and Ocean Engineering.

Gillespie, C. (2005) Determining Freeboard – Accepting Uncertainty as Inevitable, Proceedings, NSW Floodplain Management Authorities Conference, Narooma, February.

Hennessy, K., McInnes, K., Abbs, D., Jones, R., Bathols, J., Suppiah, R., Ricketts, J., Rafter, T., Collins, D. and Jones, D. (2004) Climate Change in New South Wales. Part 2: Projected changes in climate extremes, Consultancy report prepared for the NSW Greenhouse Office, November.

Kellogg Brown & Root Pty Ltd (2005) Brisbane Water Estuary Process Study – Recreational Activities and Foreshore Land Uses. Prepared for Cardno Lawson Treloar Pty Ltd.

Manly Hydraulics Laboratory (2004) DNR Brisbane Water Estuary Tidal Data Collection – Draft Report MHL1319, Department of Commerce.

New South Wales Government, (2005), Floodplain Development Manual, DNR 05 020, ISBN 0 7347 5476 0.

NSW National Parks and Wildlife Service (2004) Bouddi National Park. Department of Environment and Conservation.

NSW National Parks and Wildlife Service (2005) Atlas of NSW Wildlife. Department of Environment and Conservation.

Patterson Britton & Partners, (2003), Turo Creek, Pretty Beach Flood Study, Prepared for Gosford City Council.

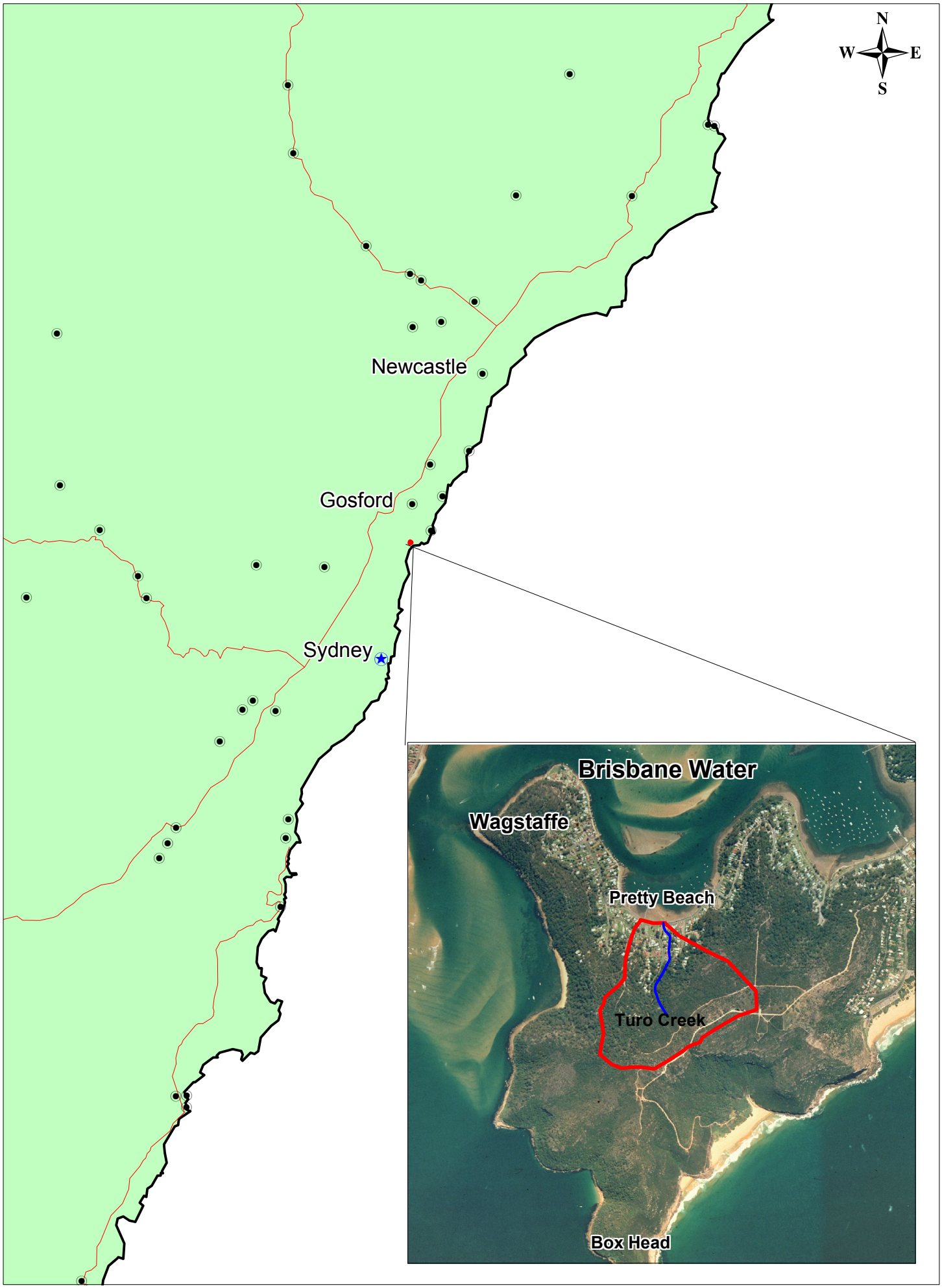
Patterson Britton & Partners, (2003), Turo Creek, Flood Study and Pretty Beach Drainage Investigation Questionnaire, Prepared for Gosford City Council

SCARM (2000) Floodplain Management in Australia - Best Management Principles and Guidelines, SCARM Report No 73, CSIRO Publishing, Victoria.

Sustainability Officer (2003) Supplementary State of the Environment Report 2003. Gosford City Council.

Thomson, Rehman, Chanan and IGhetti (February 2005) "Water Reuse Options in an Urban Catchment – Impact on Flood Behaviour", 45th Floodplain Management Conference, Narooma, NSW.

FIGURES



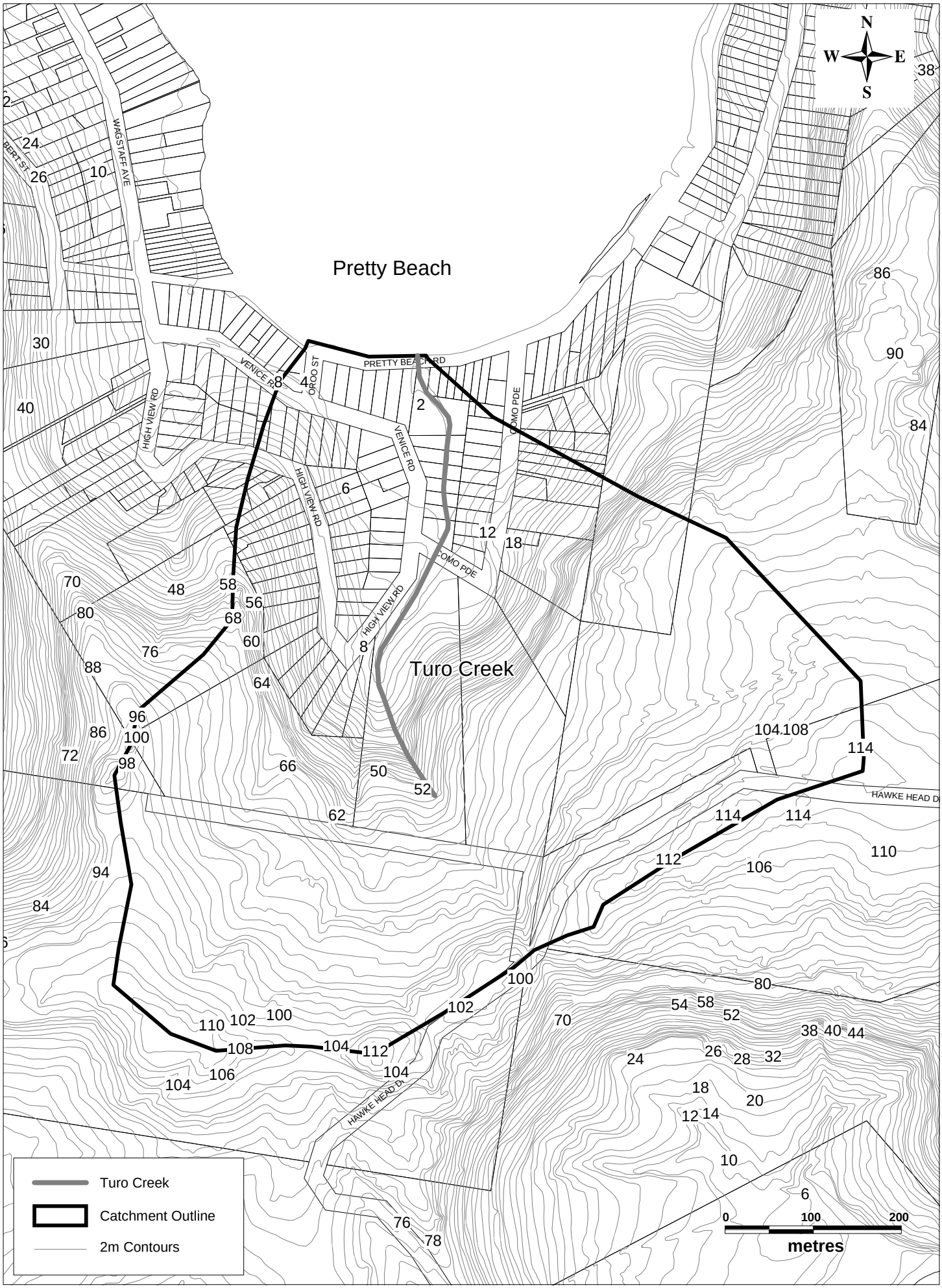
Cardno Lawson Treloar

J2313/R2241/V4
October 2006

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 1.1
LOCALITY PLAN

J2313\Figures & Appendices\R2241\V4\Figures\Figure 1.1 - Location Map.Wor



Cardno Lawson Treloar

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 1.2
STUDY AREA

J2313/R2241/V4
July 2007

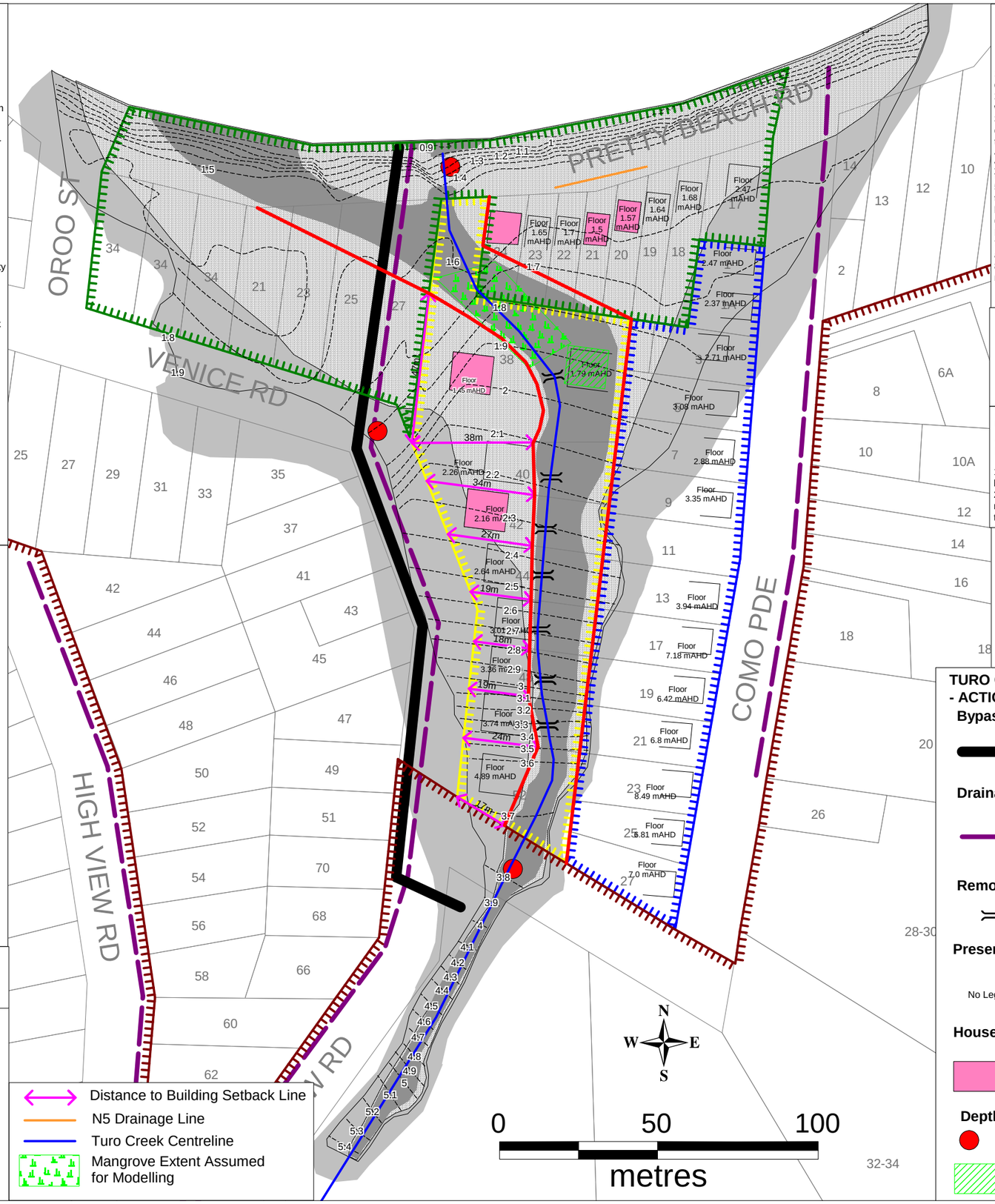
J2313\Figures & Appendices\R2241\V4\Figures\Figure 1.2 Study Area.WOR

GENERAL DEVELOPMENT CONTROLS
Applies to: All development within the floodplain (defined as the PMF extent)

1. Flood Planning Level (FPL) for setting habitable floor levels to be 100 year ARI flood level + 500 mm freeboard. The minimum FPL in the entire floodplain is 2.45 m AHD, which is derived from Brisbane Water flooding. This FPL is subject to modification following completion of the ongoing Brisbane Water Foreshore Flood Study.
2. No development allowed in high hazard area or floodway of 100 year ARI flood event.
3. No development allowed in the 100 year floodplain that is likely to obstruct overland flow or reduce the storage area of the floodplain. Certain types of development may be permissible such as carports and in-ground swimming pools.
4. Increase in dwelling density (dual occupancy, subdivision etc) not allowed for properties lying entirely within the floodplain. Properties lying partially in the floodplain may intensify dwelling density provided there is no increase in the flood risk.
5. No fences to be erected where they would obstruct overland flowpath. Where allowed, acceptable fence type would be preferably post and wire strand or grid mesh with not less than 150 mm spacing.
6. No development allowed to the creek side of the building setback lines.
7. All electrical fixtures to be located above the PMF level or FPL whichever is the highest.
8. All proposed development located in proximity of watercourses to address structural stability issues.
9. All development within 40m from top of banks of Turo Creek will require separate approval from the Department of Environment and Climate Change under Rivers and Foreshore Improvement Act.
10. No development allowed that increases flood risk eg risk to increased flood damages, risk to life both for occupants and emergency crew accessing floodplain, etc.
11. Mangrove planting or growth should be controlled to the current levels in the lower reaches of Turo Creek to avoid possible flood impact. New mangrove or other flora planting is allowed only after detailed flood impact analysis.
12. In addition to the controls presented here, all development to comply with DCP115 "Building in Flood Liable Areas" and other relevant Council policies/DCP/documents.
13. Council may request preparation of a localised flood study to determine the impact of the proposed development.
14. All development on piers to have minimum pier spacing of 2.0m. No enclosure or storage of equipment or materials in underfloor area permitted in flood plain. Offsets for individual piers in rows parallel to the flow shall be no more than 100mm. Cladding below floor level, irrespective of the type, is not permitted.
15. All bank and bed protection work requires Council approval.
16. All permissable development in the PMF floodplain not to adversley affect overland flows.

VENICE ROAD MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Venice Road Management Area

1. Redevelopment of properties to the east of Venice Road to be encouraged to relocate building footprint closer to Venice Road frontage to improve access during flood emergency and move away from high risk areas of the floodplain. Council to consider relaxing of building setbacks from the road to the front of the houses where appropriate. Applications to be assessed on their merit.
2. All development related to building extensions or reconstruction, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
3. For complete redevelopment of the site, filling at Venice Road frontage is permitted to gain 100 year ARI flood free access to new garages or carports only after all building development on property has been raised on piers above FPL. This should not result in net decrease in floodplain storage ie the volume of fill should be less than or equal to the volume made available under the existing building footprint. If Venice Road is not flood free in the 100 year event at the site of the development, then habitable floor levels to be at the PMF level.
4. No habitable development is permitted on the portions of properties on the eastern side of Venice Rd that lies to the east of Turo Creek due to access difficulties in a flood emergency and due to its location in high hazard area of the floodplain.
5. Erosion protection and bank stabilisation of Turo creek to be addressed through Rivercare initiative of Natural Heritage Trust or similar group.



100 Year ARI Flood Contours (mAHD)

100 Year ARI Extent

Development Control Management Areas
- Venice Road Management Area
- Pretty Beach Road Management Area
- Western Como Parade Management Area
- Upper Catchment Management Area

- Distance to Building Setback Line
- N5 Drainage Line
- Turo Creek Centreline
- Mangrove Extent Assumed for Modelling

PRETTY BEACH MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Pretty Beach Road Management Area

1. Flood Planning Level (FPL) varies across the properties. Highest FPL to be adopted for any development within the property.
2. No habitable development allowed in the public reserve fronting Pretty Beach Road that lies within the 100 year ARI flood extent.
3. No filling or obstruction allowed in the public reserve fronting Pretty Beach Road that will divert flows or remove any part of the storage area of the 100 year ARI floodplain. Lot filling not to adversely affect adjoining properties particularly with regard to overland flooding.
4. All development related to building extensions or reconstructions, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
5. Filling at Pretty Beach Road frontage permitted to gain 100 year ARI flood free access to the new garages or carports only after all flood mitigation works identified under the plan have been completed and provided that the fill area is outside the defined flood storage area.
6. Proposed carports, garages and vehicular access not to impede the flood flows through to Brisbane Water. If redeveloped, greater area for flow to be allowed, where practical.
7. Lot filling that is allowed cannot be higher than existing Pretty Beach Road level, which acts as a weir during flood events.
8. No raising of Pretty Beach Road allowed that would increase the weir level in the floodplain, resulting in adverse impact on upstream properties.

COMO PARADE MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Western Como Parade Management Area

1. All developments to consider design that reduces flood risk eg risk to life and damage to property etc. All development to have safe 100 year flood free access out of the floodplain to Como Parade.

UPPER CATCHMENT MANAGEMENT AREA
Applies to: All development within the Upper Catchment Management Area

1. Overland flow paths to be preserved and maintained through properties. The significant local feature of Waterfall to be preserved where appropriate.
2. Minimum floor level should be established at least 0.5m above the finished ground level, making sure that any earthworks does not adversely affect the adjoining properties with regard to overland flooding

- Floodplain - PMF Extent
- Combined 100 Year ARI Floodway and High Hazard Extent
- 100 Year ARI Flood Storage
- Building Setback Line

TURO CREEK FLOODPLAIN MANAGEMENT PLAN - ACTIONS TO BE IMPLMENTED

Bypass Culvert

To divert flows from Turo Creek upstream of Como Parade directly to Brisbane Water

Drainage Infrustructue Upgrade

New drainage pipe to convey stormwater flows directly to Brisbane Water. Pipe under Venice Road to run parallel to proposed Bypass Culvert.

Removal/Modification of Unapproved Private Access Bridges

Existing access bridges

Preservation of Overland Flowpaths in the Upper Catchment

No Legend — Applies to entire upper catchment, specifically incorporated into Development Controls for Eastern Como Parade Management Area.

House Raising

Houses identified for house raising. Some houses may need to be verified for suitablity in terms of foundation type and floor level.

Depth Markers at Major Road Crossings

Proposed depth marker.

Voluntary House Purchase (Building Only)

Cardno Lawson Treloar

J2313/R2241/V4
July 2007

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.1a
FLOODPLAIN RISK MANAGEMENT PLAN
(Existing)

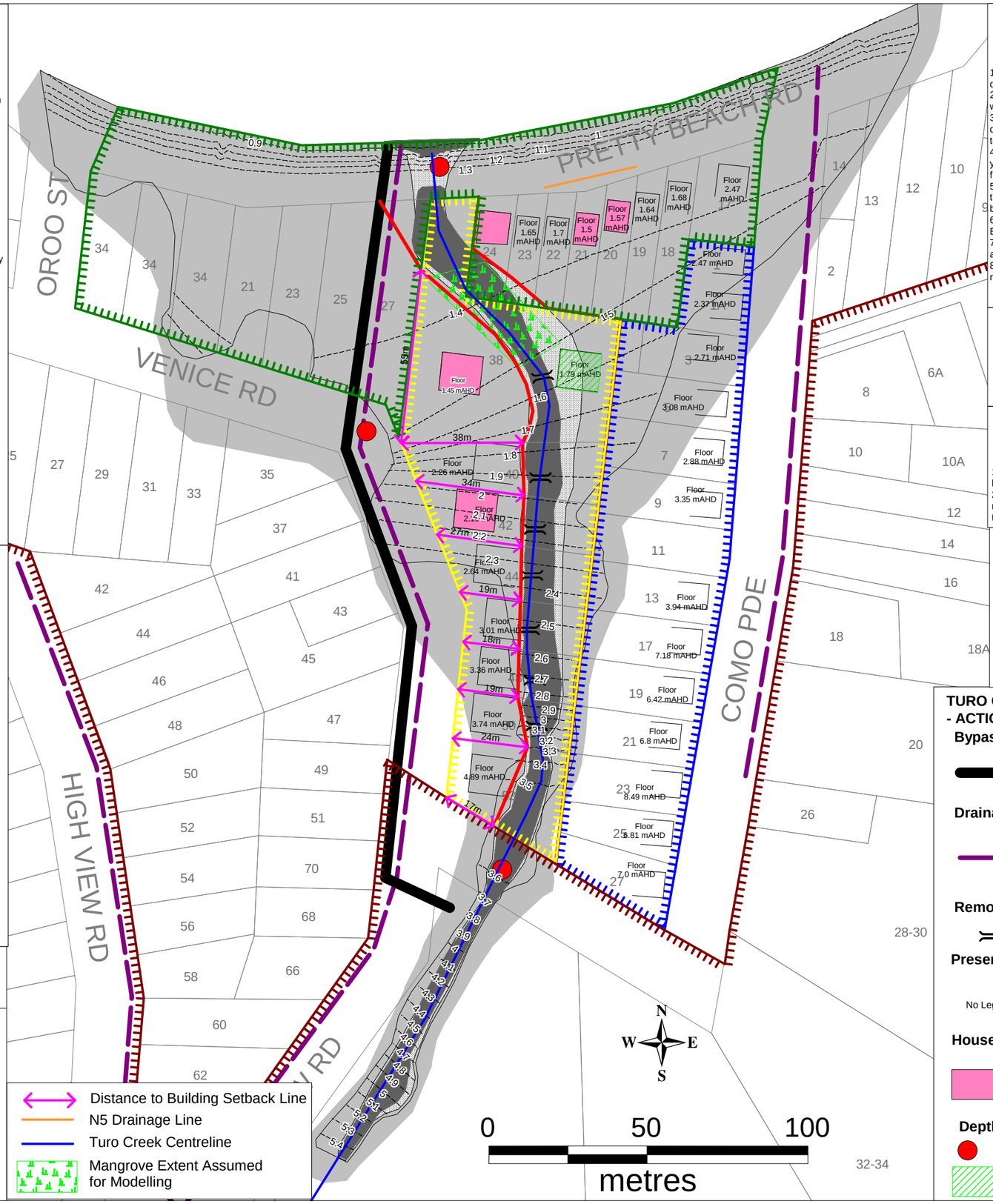
J2313 - Turo Creek FS\Figures & Appendices\R2241\V4\Figure 3.1a - FRMP - Existing -v2.wor

GENERAL DEVELOPMENT CONTROLS
Applies to: All development within the floodplain (defined as the PMF extent)

1. Flood Planning Level (FPL) for setting habitable floor levels to be 100 year ARI flood level + 500 mm freeboard. The minimum FPL in the entire floodplain is 2.45 m AHD, which is derived from Brisbane Water flooding. This FPL is subject to modification following completion of the ongoing Brisbane Water Foreshore Flood Study.
2. No development allowed in high hazard area or floodway of 100 year ARI flood event.
3. No development allowed in the 100 year floodplain that is likely to obstruct overland flow or reduce the storage area of the floodplain. Certain types of development may be permissible such as carports and in-ground swimming pools.
4. Increase in dwelling density (dual occupancy, subdivision etc) not allowed for properties lying entirely within the floodplain. Properties lying partially in the floodplain may intensify dwelling density provided there is no increase in the flood risk.
5. No fences to be erected where they would obstruct overland flowpath. Where allowed, acceptable fence type would be preferably post and wire strand or grid mesh with not less than 150 mm spacing.
6. No development allowed to the creek side of the building setback lines.
7. All electrical fixtures to be located above the PMF level or FPL whichever is the highest.
8. All proposed development located in proximity of watercourses to address structural stability issues.
9. All development within 40m from top of banks of Turo Creek will require separate approval from the Department of Environment and Climate Change under Rivers and Foreshore Improvement Act.
10. No development allowed that increases flood risk eg risk to increased flood damages, risk to life both for occupants and emergency crew accessing floodplain, etc.
11. Mangrove planting or growth should be controlled to the current levels in the lower reaches of Turo Creek to avoid possible flood impact. New mangrove or other flora planting is allowed only after detailed flood impact analysis.
12. In addition to the controls presented here, all development to comply with DCP115 "Building in Flood Liable Areas" and other relevant Council policies/DCP/documents.
13. Council may request preparation of a localised flood study to determine the impact of the proposed development.
14. All development on piers to have minimum pier spacing of 2.0m. No enclosure or storage of equipment or materials in underfloor area permitted in flood plain. Offsets for individual piers in rows parallel to the flow shall be no more than 100mm. Cladding below floor level, irrespective of the type, is not permitted.
15. All bank and bed protection work requires Council approval.
16. All permissable development in the PMF floodplain not to adversley affect overland flows.

VENICE ROAD MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Venice Road Management Area

1. Redevelopment of properties to the east of Venice Road to be encouraged to relocate building footprint closer to Venice Road frontage to improve access during flood emergency and move away from high risk areas of the floodplain. Council to consider relaxing of building setbacks from the road to the front of the houses where appropriate. Applications to be assessed on their merit.
2. All development related to building extensions or reconstruction, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
3. For complete redevelopment of the site, filling at Venice Road frontage is permitted to gain 100 year ARI flood free access to new garages or carports only after all building development on property has been raised on piers above FPL. This should not result in net decrease in floodplain storage ie the volume of fill should be less than or equal to the volume made available under the existing building footprint. If Venice Road is not flood free in the 100 year event at the site of the development, then habitable floor levels to be at the PMF level.
4. No habitable development is permitted on the portions of properties on the eastern side of Venice Rd that lies to the east of Turo Creek due to access difficulties in a flood emergency and due to its location in high hazard area of the floodplain.
5. Erosion protection and bank stabilisation of Turo creek to be addressed through Rivercare initiative of Natural Heritage Trust or similar group.



100 Year ARI Flood Contours (mAHD)
100 Year ARI Extent

Development Control Management Areas

- Venice Road Management Area
- Pretty Beach Road Management Area
- Western Como Parade Management Area
- Upper Catchment Management Area

- Distance to Building Setback Line
- N5 Drainage Line
- Turo Creek Centreline
- Mangrove Extent Assumed for Modelling

PRETTY BEACH MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Pretty Beach Road Management Area

1. Flood Planning Level (FPL) varies across the properties. Highest FPL to be adopted for any development within the property.
2. No habitable development allowed in the public reserve fronting Pretty Beach Road that lies within the 100 year ARI flood extent.
3. No filling or obstruction allowed in the public reserve fronting Pretty Beach Road that will divert flows or remove any part of the storage area of the 100 year ARI floodplain. Lot filling not to adversely affect adjoining properties particularly with regard to overland flooding.
4. All development related to building extensions or reconstructions, which lies within the 100 year ARI floodplain, to be located above FPL and on piers to allow the free passage of floodwaters under the building.
5. Filling at Pretty Beach Road frontage permitted to gain 100 year ARI flood free access to the new garages or carports only after all flood mitigation works identified under the plan have been completed and provided that the fill area is outside the defined flood storage area.
6. Proposed carports, garages and vehicular access not to impede the flood flows through to Brisbane Water. If redeveloped, greater area for flow to be allowed, where practical.
7. Lot filling that is allowed cannot be higher than existing Pretty Beach Road level, which acts as a weir during flood events.
8. No raising of Pretty Beach Road allowed that would increase the weir level in the floodplain, resulting in adverse impact on upstream properties.

COMO PARADE MANAGEMENT AREA - DEVELOPMENT CONTROLS
Applies to: All development within the Western Como Parade Management Area

1. All developments to consider design that reduces flood risk eg risk to life and damage to property etc. All development to have safe 100 year flood free access out of the floodplain to Como Parade.

UPPER CATCHMENT MANAGEMENT AREA
Applies to: All development within the Upper Catchment Management Area

1. Overland flow paths to be preserved and maintained through properties. The significant local feature of Waterfall to be preserved where appropriate.
2. Minimum floor level should be established at least 0.5m above the finished ground level, making sure that any earthworks does not adversely affect the adjoining properties with regard to overland flooding

- Floodplain - PMF Extent
- Combined 100 Year ARI Floodway and High Hazard
- Building Setback Line
- 100 Year ARI Flood Storage

TURO CREEK FLOODPLAIN MANAGEMENT PLAN - ACTIONS TO BE IMPLMENTED

Bypass Culvert

To divert flows from Turo Creek upstream of Como Parade directly to Brisbane Water

Drainage Infrustructue Upgrade

New drainage pipe to convey stormwater flows directly to Brisbane Water. Pipe under Venice Road to run parallel to proposed Bypass Culvert.

Removal/Modification of Unapproved Private Access Bridges

Existing access bridges

Preservation of Overland Flowpaths in the Upper Catchment

No Legend — Applies to entire upper catchment, specifically incorporated into Development Controls for Eastern Como Parade Management Area.

House Raising

Houses identified for house raising. Some houses may need to be verified for suitablity in terms of foundation type and floor level.

Depth Markers at Major Road Crossings

Proposed depth marker.

Voluntary House Purchase (Building Only)

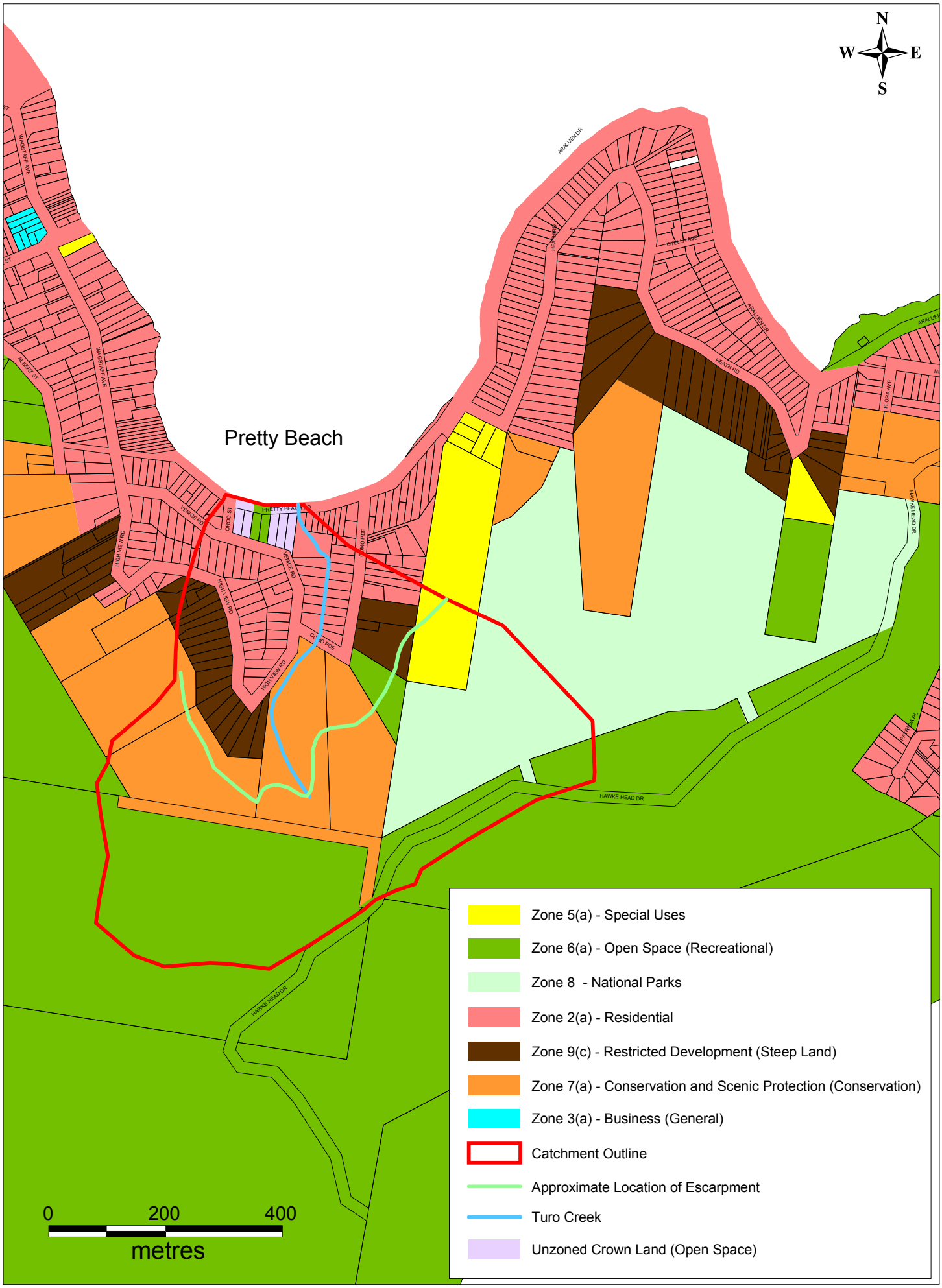
Cardno Lawson Treloar

J2313/R2241/V3
July 2007

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.1b
FLOODPLAIN RISK MANAGEMENT PLAN
(After Implementation of Options)

J2313 - Turo Creek FS\Figures & Appendices\R2241\V3\Figure 3.1b FRMP After Implementation.WOR



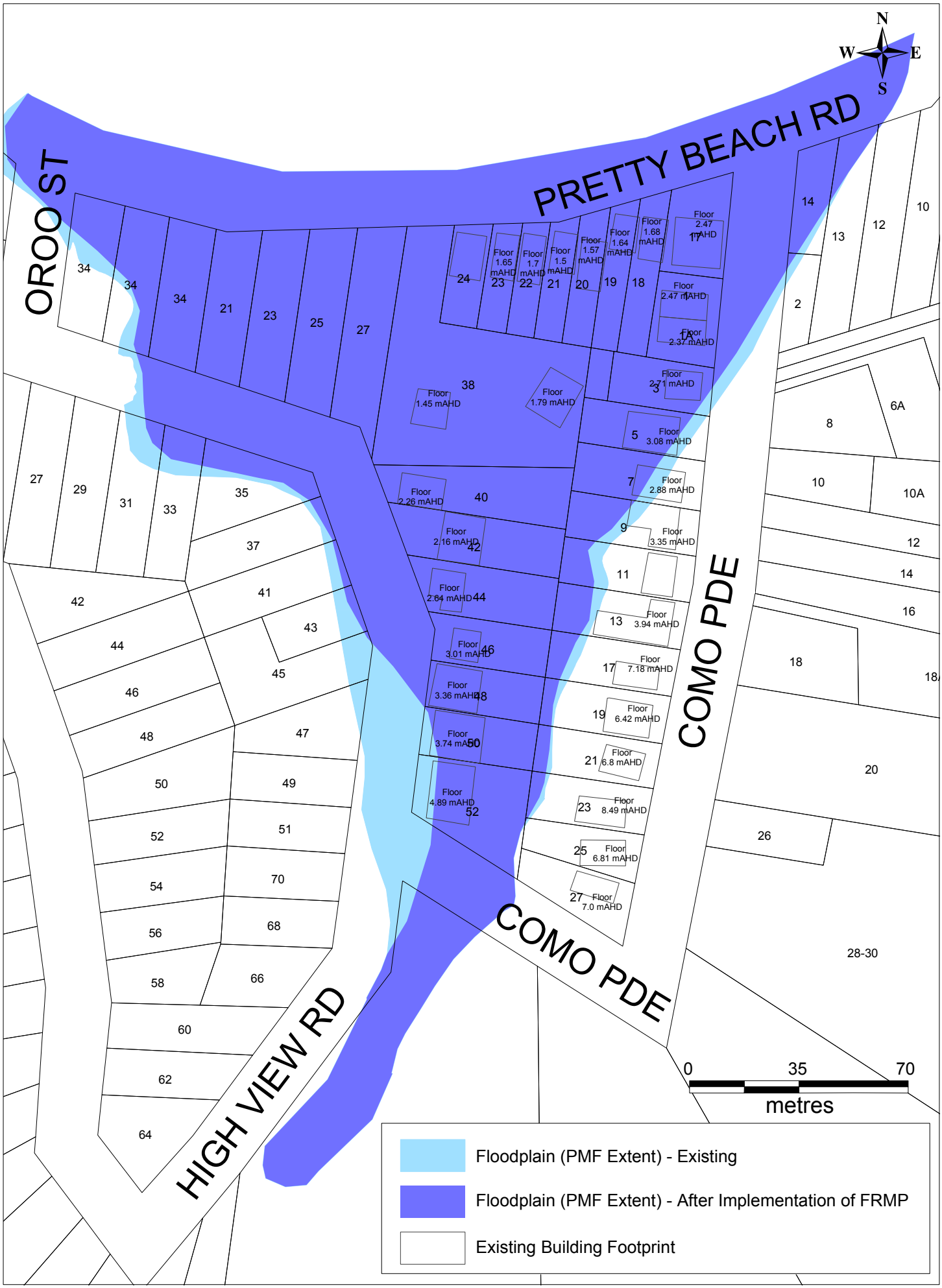
Cardno Lawson Treloar

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.2
LAND USE ZONING

J2313/R2241/V4
October 2006

J2313\Figures and Appendices\R2241\V4\Figures\Figure 3.2 Land Use Zoning.Wor



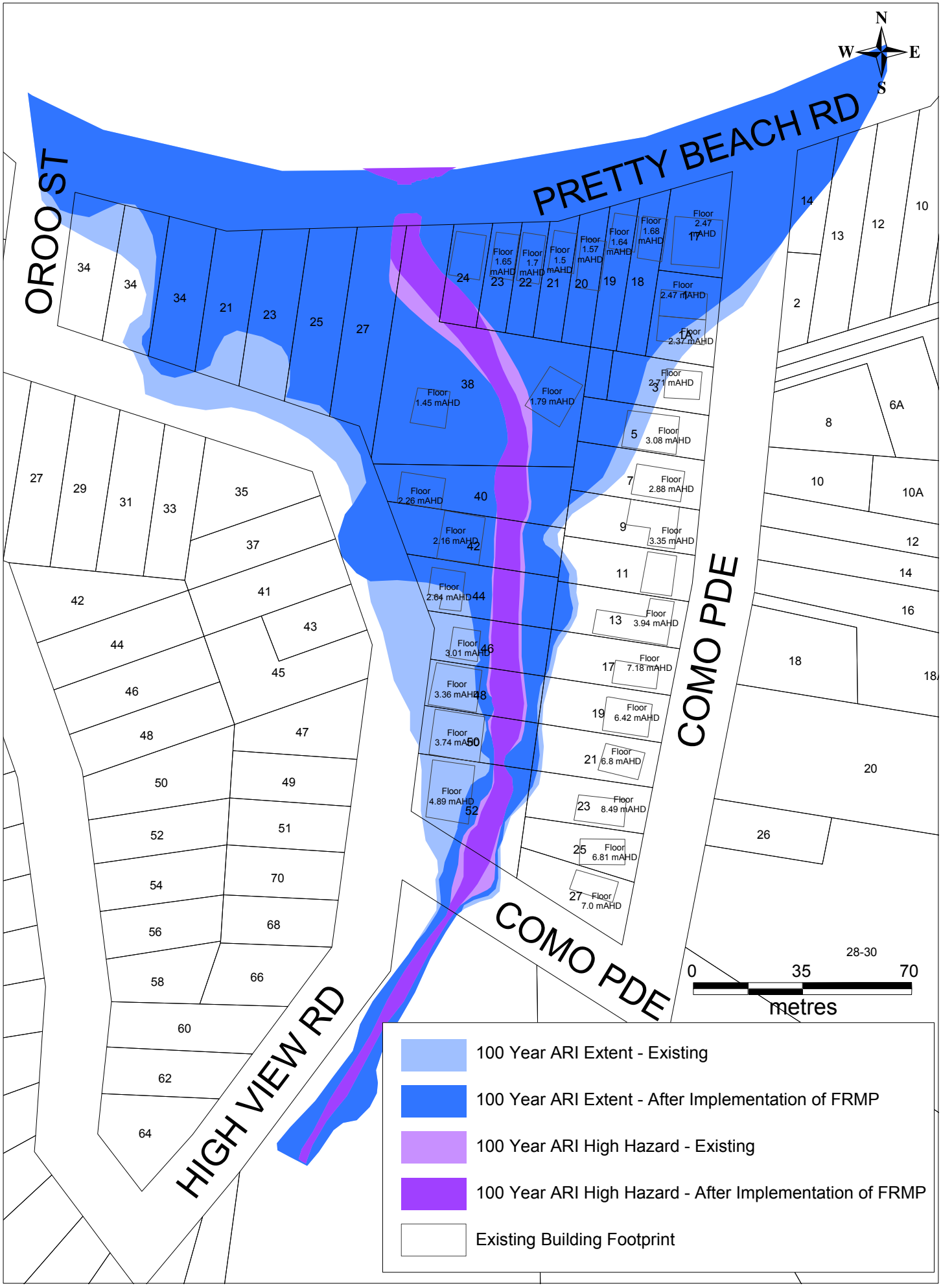
Cardno Lawson Treloar

Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.3
REDUCTION IN FLOODPLAIN EXTENT (PMF)

J2313/R2241/V4
October 2006

J2313\Figures and Appendices\R2241\V4\Figures\Figure 3.3 Floodplain.Wor



Cardno Lawson Treloar

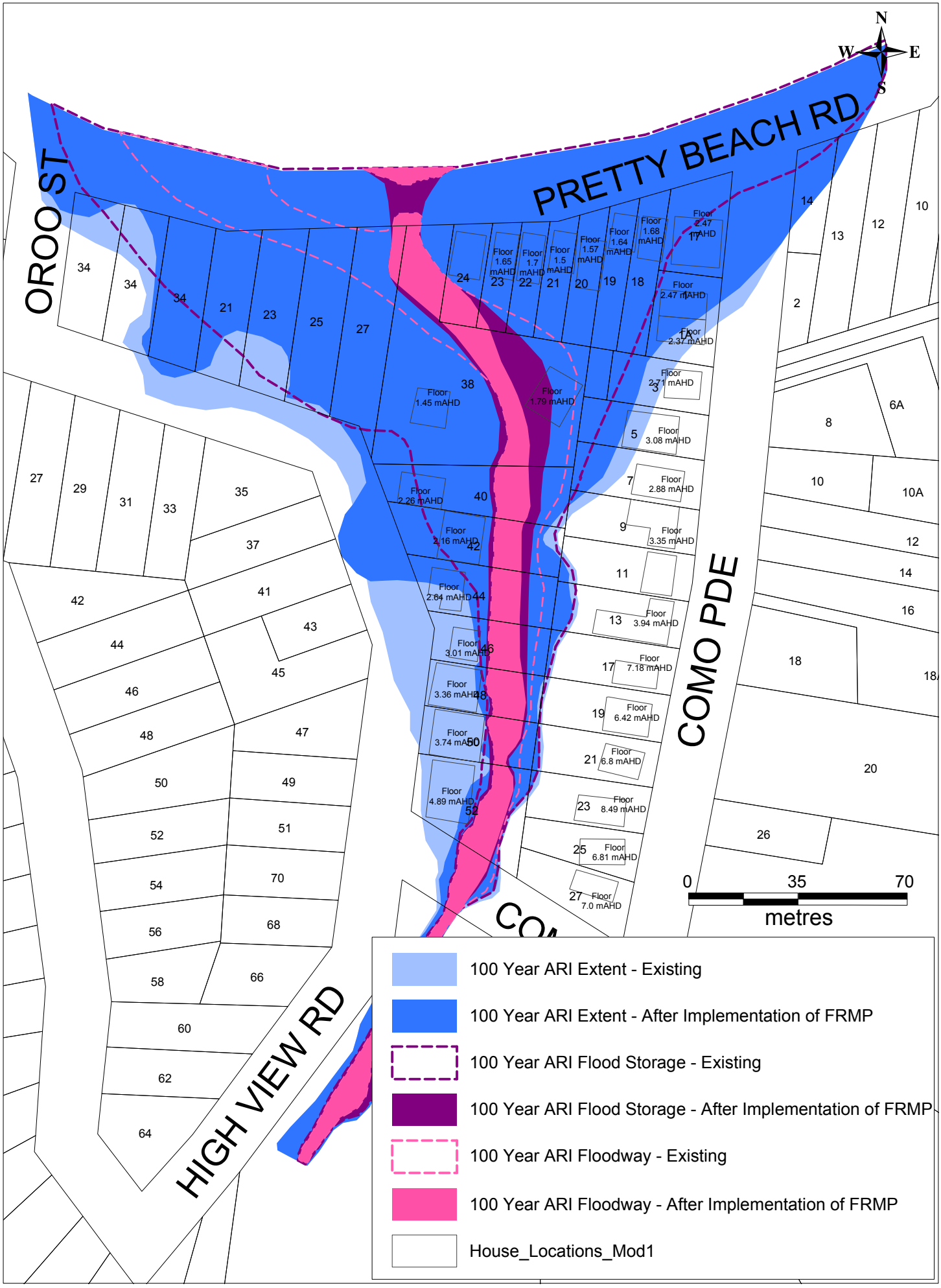
Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.4

100 YEAR ARI EXTENT AND HAZARD BENEFIT OF FRMP

J2313/R2241/V4
October 2006

J2313\Figures and Appendices\R2241\V4\Figures\Figure 3.4 100yr extent and hazard.Wor



Cardno Lawson Treloar

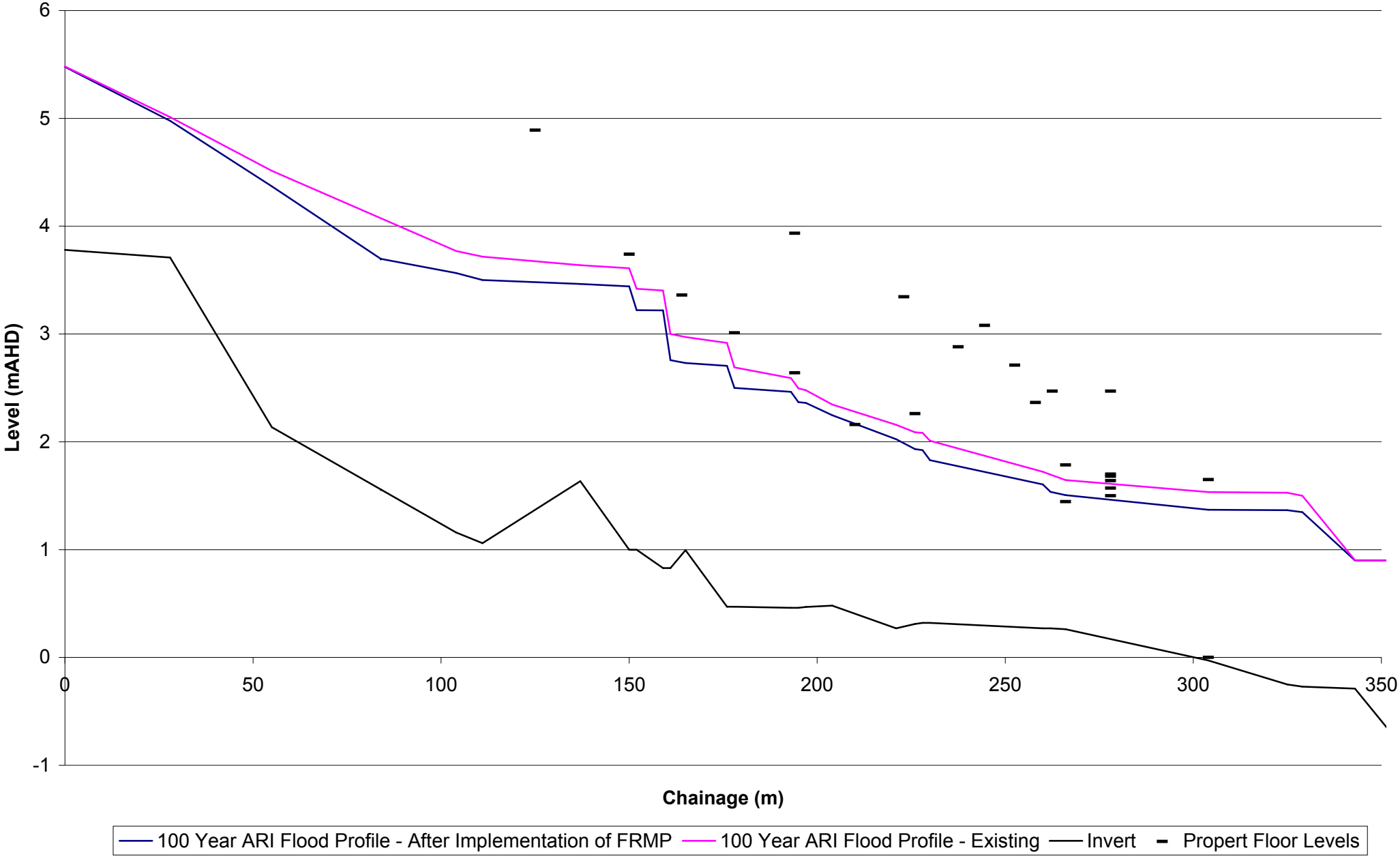
Turo Creek Pretty Beach Floodplain Risk Management Plan

FIGURE 3.5

100 YEAR ARI HYDRAULIC CATEGORIES BENEFIT OF FRMP

J2313/R2241/V4
October 2006

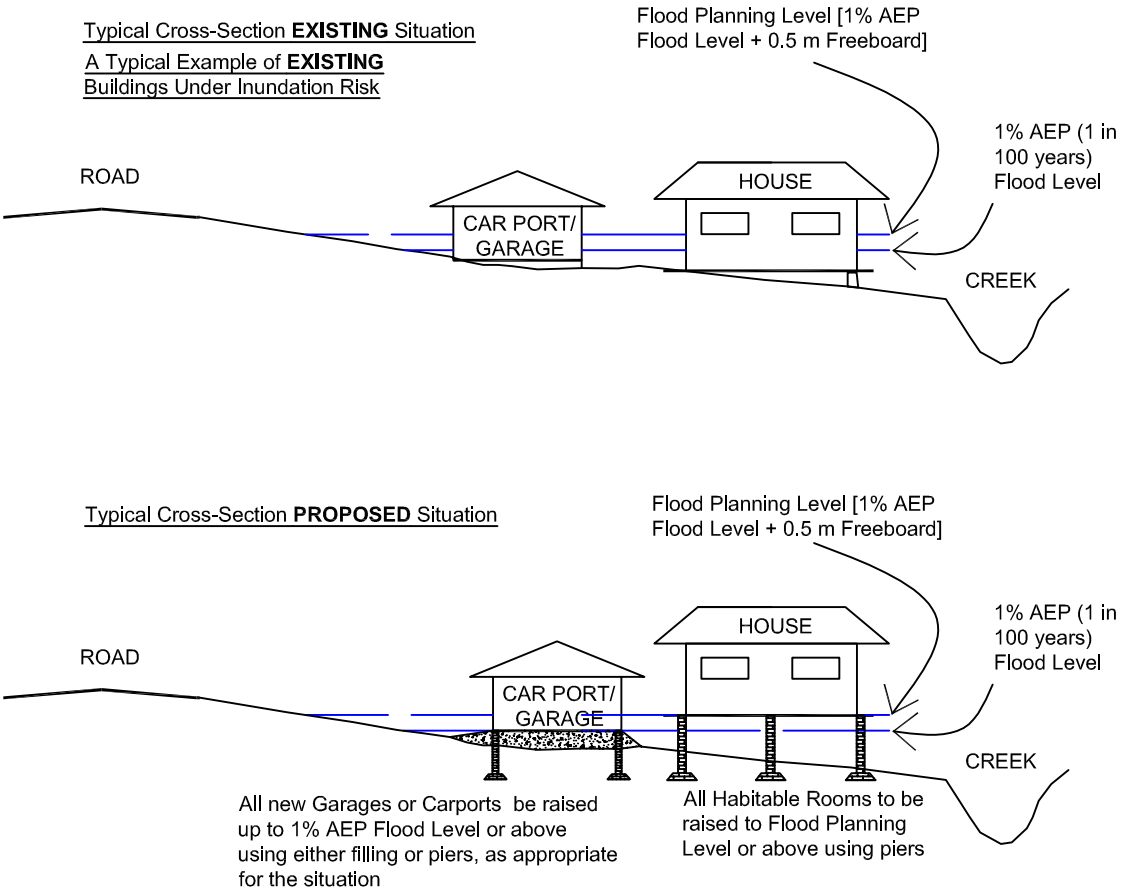
J2313\Figures and Appendices\R2241\V4\Figures\Figure 3.5 100yr hydraulic categories.Wor

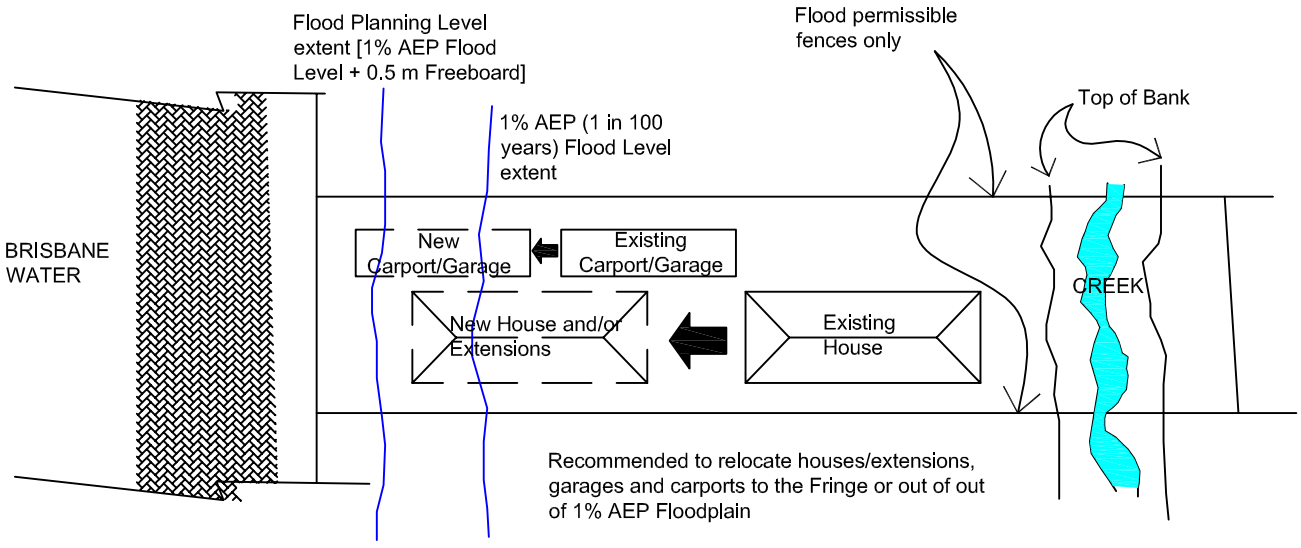


Turo Creek, Pretty Beach, Floodplain Risk Management Plan

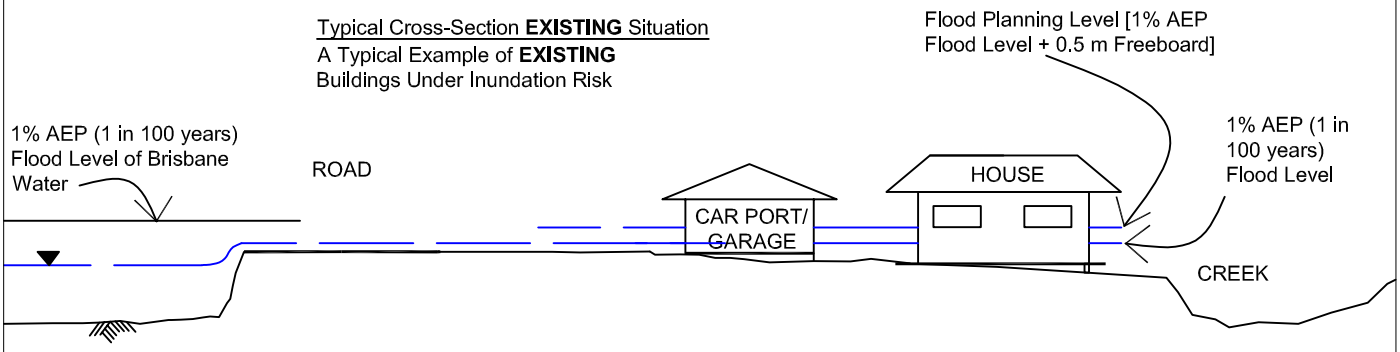
FIGURE 3.6
REDUCTION IN 100 YEAR ARI FLOOD LEVELS

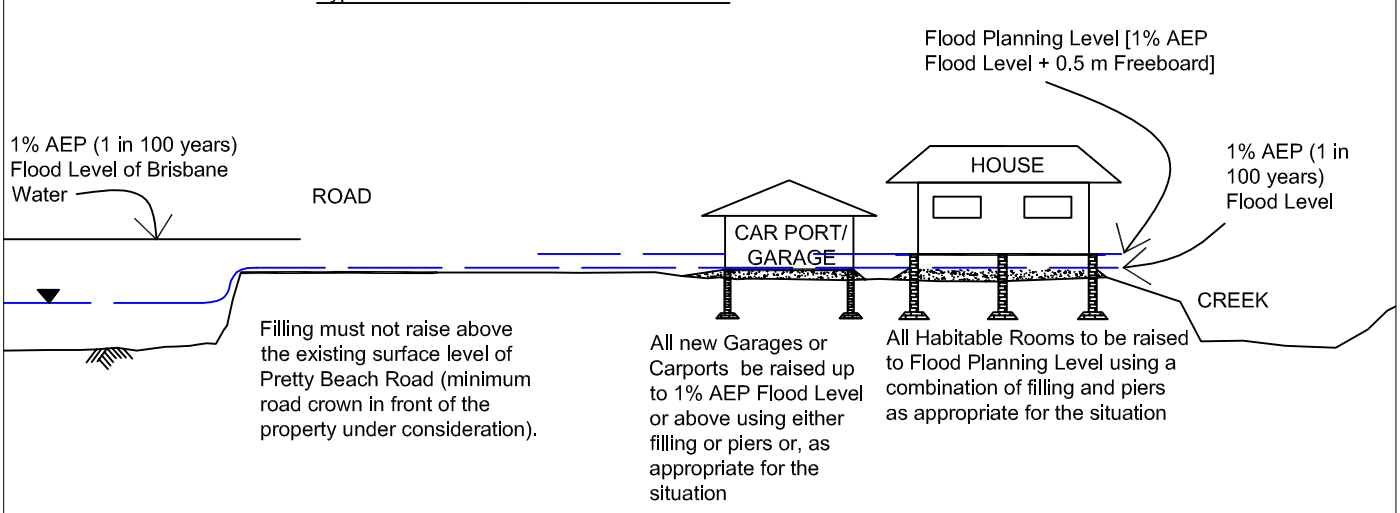
VENICE ROAD MANAGEMENT AREA
Property Modification Guidelines

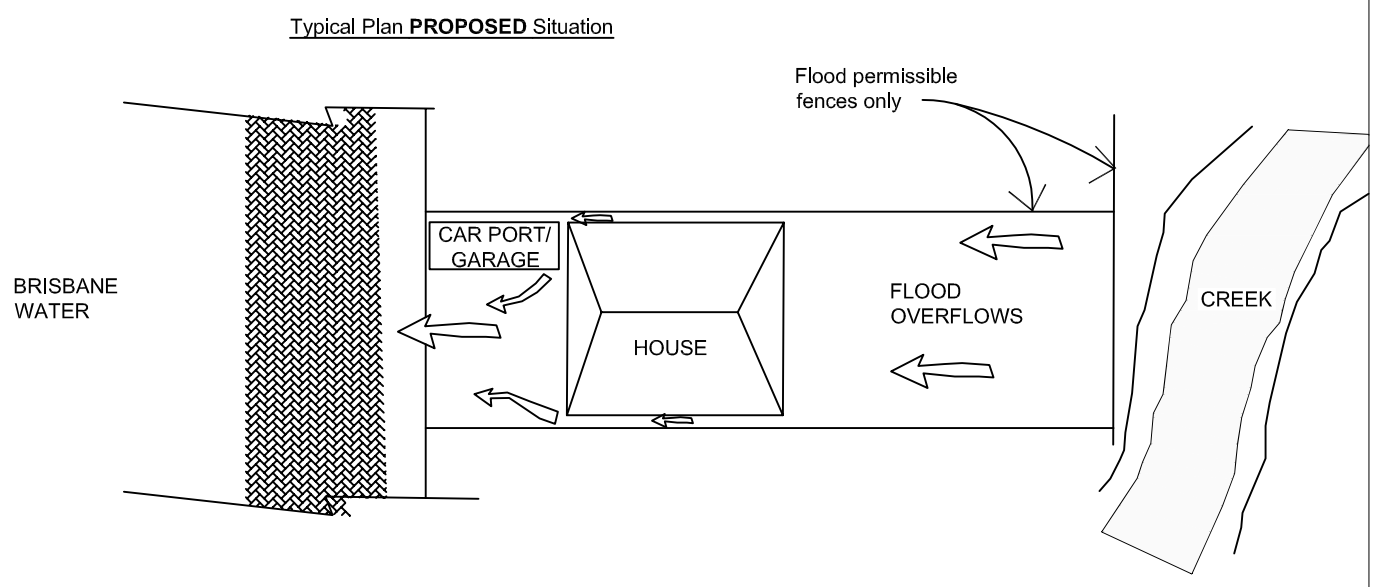




PRETTY BEACH MANAGEMENT AREA
Property Modification Guidelines







Appendix A

Letter from Department of Primary Industries

Letter from Darkinjung Local Aboriginal Land Council

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Our ref:
Your ref:

9 January 2007

Moazzam Shah
Gosford City Council
49 Mann Street
GOSFORD NSW 2250

Dear Sir

Re: Draft Floodplain Risk Management Study for Truro Creek, Pretty Beach

Thank you for giving DPI Fisheries the opportunity to comment on the above proposal.

The Department recognises the importance of proper floodplain risk management and the onus paced on Council to protect both the Environment and the residents of floodprone areas. The Department therefore supports the Council position of setting a benchmark level for vegetation in the creek and maintaining that level to allow for balance in the creek system.

Consequently its recommended that the clause in the plan be amended to read:

11. Mangrove community to be maintained at current levels and water flows be maintained in the lower reaches of Truro Creek to avoid possible flood impact. Present mangrove extent is to be benchmarked with the help of land and aerial photos to provide a basis for creek management in the future. Future management of mangroves is to be carried out in consultation with Department of Primary Industries (*S.204-5 Fisheries Management Act*)

For further information please contact me on 02 4916 3931.

Yours faithfully

Scott Carter
Senior Conservation Manager - Central

Aquatic Habitat Protection
NSW Department of Primary Industries
Locked Bag 1
NELSON BAY NSW 2315

ABN 51 734 124 190
www.dpi.nsw.gov.au
Tel: 02 4916 3931
Fax: 02 4982 2306

DARKINJUNG LOCAL ABORIGINAL LAND COUNCIL

SHOP 3, 61 HOWARTH STREET, WYONG
POSTAL ADDRESS:
P.O. BOX 401, WYONG NSW 2259
A.B.N. 99 583 297 167

TELEPHONE: (02) 4351 2930
FAX: (02) 4351 2946
EMAIL: darkinjung@dlalc.org.au

Gosford City Council.
Level 9, 49 Mann St.Gosford.,
Mr.Moazzam Shah.
9/02/2007.

Dear Mr. Shah, Re.the proposed Box Culvert ,Venice Rd.Pretty Beach.
Darkinjung Land Council has no issues with this work being carried out
Providing every care is taken to avoid impacting on any possible
cultural/heritage site that may be in the vicinity of the proposed work.

RogerSentance.
Administration Manager.

Appendix B

Turo Creek Condition Survey (2 January 2007)

Photo 1: Panoramic view of Turo Creek before it crosses Pretty Beach Road (Looking east from public park (creek flows left)

Photo 2: Corner of 38 Venice Rd and public park, looking north from Location 3 in Photo 1

Photo 3: Looking upstream from Location 1 in Photo 1

Photo 4: Looking west from Location 2 in Photo 1.

Photo 5: Bridge in 38 Venice Rd - Taken from upstream, left bank

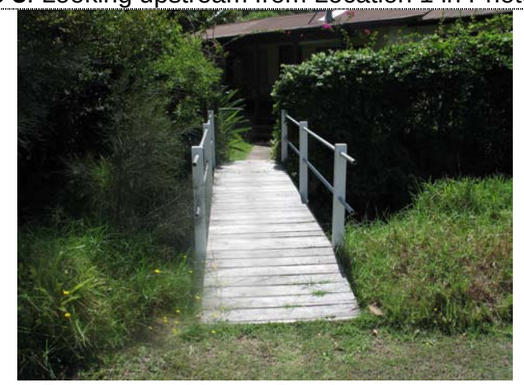


Photo 6: Bridge in 38 Venice Rd - Looking east, showing the bridge deck and railing

Photo 7: Bridge in 38 Venice Rd - Taken from downstream, left bank

Photo 8: Turo Creek in 38 Venice Rd, looking upstream from the bridge

Photo 9: Turo Creek in 38 Venice Rd, looking downstream from the bridge

Appendix B
Condition Survey of Turo Creek in Pretty Beach

Photos taiken by Gosford City Council on 2 January 2007

Beach Rd, taken from backyard of 38 Venice Rd

Photo 10: Rear of Properties in Pretty

Photo 11: Panoramic View from middle of 38 Venice Rd looking West.

Photo 12: Panoramic View from middle of 38 Venice Rd looking East.

Photo 13: Bridge in 40 Venice Rd - Taken from 38 Venice Rd, looking upstream

Photo 14: Bridge in 40 Venice Rd - Taken from 42 Venice Rd, looking downstream

Photo 15: Creek Confinement in 42 Venice Rd, looking from downstream

Photo 16: Creek Confinement in 42 Venice Rd, looking from upstream left bank.

Photo 17: Bridge in 44 Venice Rd, looking from downstream

Photo 18: Bridge in 44 Venice Rd, looking East

Appendix B
Condition Survey of Turo Creek in Pretty Beach

Photos taken by Gosford City Council on 2 January, 2007

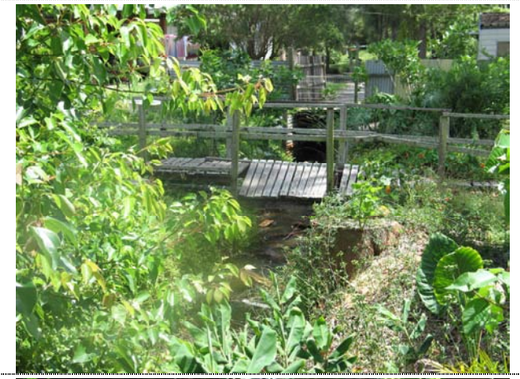


Photo 19: Bridge in 44 Venice Rd, View from deck-bridge of 46 Venice Rd (looking down-stream))

Photo 20: Turo Creek as seen from the bridge in 44 Venice Rd, looking up-stream.

Photo 21: Deck-Bridge in 46 Venice Rd. Seen from the eastern side of Turo Creek, looking west.

Photo 22: Deck-Bridge in 46 Venice Rd. Seen from the eastern side of Turo Creek, looking west showing downstream side of the bridge. 46 Venice Rd is the most heavily vegetated property with a large gum tree in the left bank of Turo Creek.

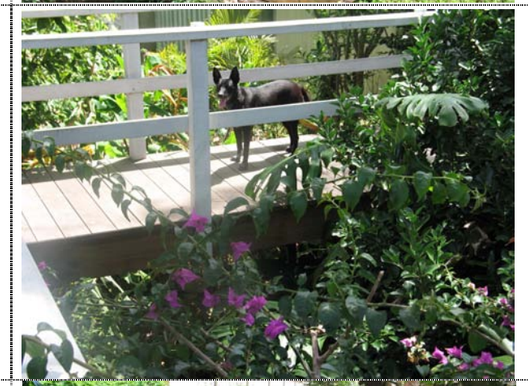


Photo 23: Deck-Bridge in 46 Venice Rd. Seen from the western side of Turo Creek, showing downstream side of the bridge.

Photo 24: Bridge in 48 Venice Rd - Photo taken from 46 Venice Rd from the right bank of the creek, looking upstream

Photo 25: Bridge in 48 Venice Rd - Photo taken from 46 Venice Rd from the left bank of the creek, looking upstream

Photo 26: Bridge in 48 Venice Rd. Looking west

Photo 27: Bridge in 48 Venice Rd. Looking east

Appendix B
Condition Survey of Turo Creek in Pretty Beach

Photos taken by Gosford City Council on 2 January, 2007

Photo 28: Panoramic view of the right bank of Turo Creek in 48 Venice Rd. Photo taken from the right bank looking west

Photo 29: Creek confinement in 50 Venice Rd. Seen from the left bank of the creek looking upstream. Creek is confined with metal sheets supported on two side walls.

Photo 31: Downstream edge of the creek confinement in 50 Venice Rd.

Photo 32: Bridge in 52 Venice Rd looking upstream at the downstream face of the bridge.

Photo 33: Bridge in 52 Venice Rd, looking downstream at the upstream face of the bridge.

Photo 34: Culvert in Como Pde, as seen from downstream

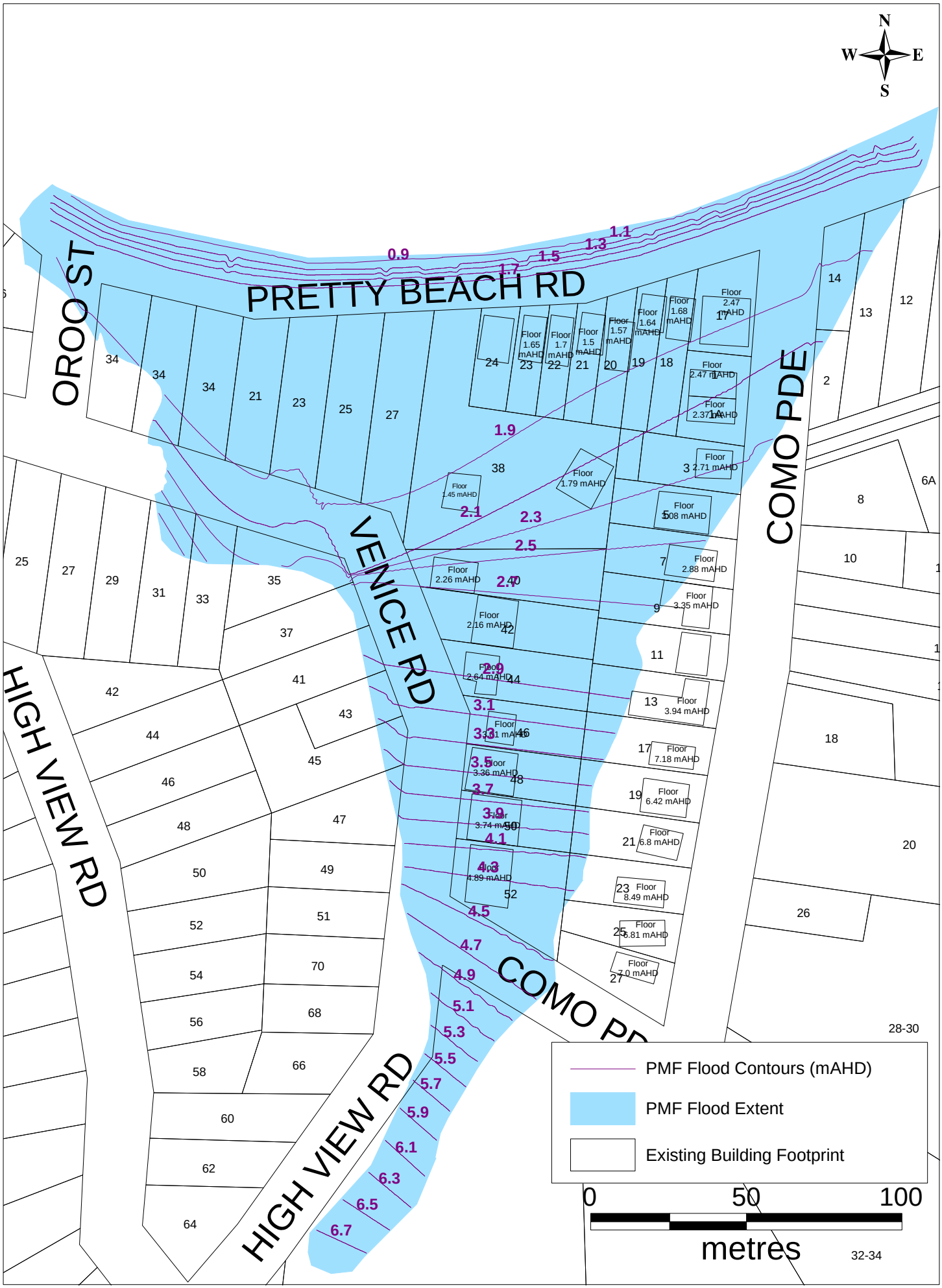
Photo 35: Culvert in Como Pde, as it looks from upstream

Appendix B
Condition Survey of Turo Creek in Pretty Beach

Photos taken by Gosford City Council on 2 January, 2007

Appendix C

PMF FLOOD EXTENT



Cardno Lawson Treloar

Turo Creek Pretty Beach Floodplain Risk Management Plan

APPENDIX C
PMF FLOOD EXTENT

J2313/R2182/V6
August 2007

J:\WR\J2313 - Turo Creek FS\Figures & Appendices\R2182\V6\Figures\FPRMP AppC PMF Flood Extent.WOR