



**CLARENCE VALLEY COUNCIL**



**YAMBA FLOODPLAIN RISK  
MANAGEMENT STUDY**

**OCTOBER 2008**

**WEBB, McKEOWN & ASSOCIATES PTY LTD**



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# YAMBA FLOODPLAIN RISK MANAGEMENT STUDY

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# FOREWORD

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

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

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

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

The Yamba Floodplain Risk Management Study constitutes the second stage of the management process for the township of Yamba. It has been developed for Clarence Valley Council and prepared by Webb, McKeown & Associates for the future management of flood liable lands in the area.

# SUMMARY

## **LOWER CLARENCE VALLEY**

The Clarence River has a catchment area of some 21,900 km<sup>2</sup> to its mouth at Yamba, and some 19,800 km<sup>2</sup> to Grafton. Grafton is the main commercial centre in the region and the most upstream river crossing point on the lower Clarence River floodplain. Downstream of Grafton the Clarence River meanders in a general north-east direction entering the Pacific Ocean through the training walls at Yamba.

The township of Yamba lies on the southern bank of the Clarence River and represents a major urban centre in the lower Clarence River valley. It has a permanent population of some 6,000 residents which doubles during the Christmas season.

## **HISTORY OF FLOODING**

There is a long flood history on the lower Clarence River floodplain, particularly at Grafton. At Yamba there is only a limited flood history as flooding has not caused the devastating damage that has occurred elsewhere. The last significant flood on the Clarence River was in March 2001 but this did not cause damage to the township. The May 1996 flood recorded lower levels upstream in the Clarence River but resulted in more flooding problems at Yamba than in March 2001 due to higher ocean levels at the time of the flood.

## **LOWER CLARENCE RIVER FLOOD STUDY**

The Lower Clarence River Flood Study Review (March 2004) established a 2D hydraulic model and determined design flood levels for the lower Clarence River floodplain from upstream of Grafton to the Pacific Ocean. This study supercedes a previous Public Works, Clarence River Flood Study (December 1998).

The Lower Clarence River Flood Study Review determined design flood levels, depths and hazards for the 5y, 20y, 100y, 500y ARI and Extreme events. One notable feature of the study is that the construction of levees in the last 100+ years near Grafton has raised flood levels at Grafton by up to 0.9 m. However, at Yamba any increase in flood level due to upstream levee construction is likely to be insignificant.

## **FLOOD HAZARD**

Flooding at Yamba can occur as a result of a combination of high flows in the Clarence River, high ocean levels, wind wave action along the foreshore or from intense rain over the local catchment. Only the first two mechanisms have been considered in detail in this Study. The risk to life due to river flooding is considered to be low as inundation occurs gradually and with several hours (or days) warning. Similarly, flood hazard resulting from ocean storm surge is also considered low as there is likely to be several hours warning of an event, with the peak of the storm lasting for less than a day. It should be noted however that the flood hazard can become high if the low lying community to the

west of the town does not respond to flood warnings as the available high ground is only accessible by Yamba Road, which is readily cut by floodwaters. The only road out of Yamba to the Pacific Highway is also inundated in 10y ARI and greater flood events.

### EXISTING FLOOD PROBLEM

A flood damages assessment for existing development at Yamba was undertaken across a range of design events. Due to the lack of surveyed floor level data this assessment was based on approximations derived from fill levels and road survey and is thus indicative only. Table i) indicates the estimated number of properties which are likely to be flooded for a range of event magnitudes and the corresponding tangible damages. No consideration has been given for damages to public structures or utilities (bridges, roads, pumping stations) or for the complete collapse of structures.

**Table i):** Summary of Flood Damages

Design Flood	House Floors Inundated (total assessed 2156)	Tangible Damages
5y ARI	0	\$0
20y ARI	122	\$1,930,200
100y ARI	1223	\$27,491,200
500y ARI	1226	\$31,741,300
Extreme	2144	\$113,769,100
<b>Average Annual Damages</b>		<b>\$1,108,400</b>

**Note:** Excludes all non-residential damages.

### FLOODPLAIN RISK MANAGEMENT MEASURES

A list of all possible floodplain risk management measures which could be applied in the study area were initially developed for consideration. The assessment extended to examination of potential future development (whether intensification within existing urban zonings or the proposed rezoning at West Yamba). The measures were assessed in terms of their suitability and effectiveness for reducing the social, ecological, environmental, cultural and economic impacts of flooding. As part of this process a number of measures were identified as not being worthy of further consideration.

A summary of the various floodplain management measures considered during the course of the study is presented in Table ii) together with a brief assessment of their viability for implementation as part of the Floodplain Risk Management Plan for Yamba.



Table ii): Review of Floodplain Management Measures

MEASURE	REFER SECTION	PURPOSE	COMMENT	ECONOMIC ASSESSMENT	IMPLEMENTATION VIABILITY
<b>FLOOD MODIFICATION:</b>					
DAMS AND RETARDING BASINS	Section 4.2.1	Reduce flows from upper catchment areas.	Many issues (cost, environmental, social) would need to be addressed and it is unlikely that they would be effective at Yamba due to its location near the mouth of a large river system and because flood levels are dominated by ocean levels.	Generally not viable from a purely flooding perspective.	Not appropriate.
CHANNEL MODIFICATIONS	Section 4.2.2	Increase waterway conveyance to reduce flood levels.	Many issues (cost, maintenance, environmental, social) and not effective on large river systems.	High capital, maintenance and environmental costs.	Not appropriate.
LEVEES, FLOOD GATES AND PUMPS	Section 4.2.3	Prevents or reduces the frequency of inundation of protected areas, assists in reducing problems with local runoff issues.	High cost measure but it would provide benefit to a large number of properties and would assist in enabling a flood-free access to high ground in Yamba. There are a number of issues, particularly landtake, access, visual, social and environmental.	High benefit cost ratio due to the large number of properties protected but other issues (landtake, access, aesthetics etc) are unresolved. Measure could become more economically viable if incorporated into the proposed Yamba bypass or West Yamba development.	To be considered once decisions have been made regarding the Yamba bypass and the West Yamba development.
LOCAL DRAINAGE	Section 4.2.4	To identify and reduce local drainage problems.	The undulating nature of roads within Yamba result in ponding and/or diversion of runoff into footpaths and private properties. No significant damage occurs as a result of these issues but they are an inconvenience to residents. Establishment of a database would enable Council to identify issues and to determine an approach to resolve them.	Low cost.	Recommended that a database be established.
STORM SURGE, OCEAN LEVELS, WAVE RUNUP	Section 4.2.5	To identify the effects of ocean anomalies at Yamba.	As Yamba is located at the entrance of the Clarence River to the Pacific Ocean,	Moderate cost.	Recommended.

MEASURE	REFER SECTION	PURPOSE	COMMENT	ECONOMIC ASSESSMENT	IMPLEMENTATION VIABILITY
			the flood levels are dominated by ocean anomalies (a combination of elevated ocean levels (tides), storm surge and wave runup) and can produce flooding on the northern foreshore of Yamba as well as possible foreshore erosion. A study should be undertaken to determine the effects of these factors on flooding, erosion as well as the structural integrity of any foreshore structures.		
<b>RESPONSE MODIFICATION:</b>					
FLOOD WARNING	Section 4.3.1	Enable people to evacuate and take measures to reduce flood damages.	Flood warning is critical at Yamba because evacuation routes (out of the township as well as to high ground) are cut early. The existing system is sufficient, however consideration should be given to providing advice on the deadlines when Yamba residents need to evacuate to high ground within Yamba and ensuring best practice is employed for providing advice on storm surge.	Low cost.	Recommended that consideration be given to providing advice on evacuation deadlines and review of storm surge impacts.
EVACUATION PLANNING	Section 4.3.2	To ensure that evacuation to high ground within Yamba can be undertaken in a safe and efficient manner.	The SES are currently updating the Evacuation Plans for all villages isolated during floods along the Clarence River, including Yamba.	Relatively low cost. At Yamba the primary emphasis is on "self-help" (due to limited SES resources being spread across the valley) so an effective evacuation plan to high ground in Yamba is crucial.	Recommended.
PUBLIC INFORMATION AND RAISING FLOOD AWARENESS	Section 4.3.3	Educate people to minimise flood damages and reduce the flood risk.	A cheap and effective method but requires continued effort. Examples of methods are provided.	Benefits likely to be significant for relatively low cost. Effectiveness reduces with time since last flood event.	Recommended.
<b>PROPERTY MODIFICATION MEASURES</b>					
DEVELOPMENT CONTROL PLANNING Fill (or excavation)	Sections 4.4.1, 5.3.3 and 6.4.3	Ensure all new developments take into account flood hazard.	Draft Development Control Plans for the Clarence Valley have already been prepared, and include Yamba. Alterations	Relatively low cost.	Recommended.

MEASURE	REFER SECTION	PURPOSE	COMMENT	ECONOMIC ASSESSMENT	IMPLEMENTATION VIABILITY
<ul style="list-style-type: none"> <li>· Building Materials</li> <li>· Structural Soundness</li> <li>· Fencing</li> <li>· Public Assets</li> <li>· Flood Planning Levels</li> <li>· Rezoning Land</li> </ul>			to the Flood Planning Level to increase it from the 100y ARI flood level + 0.3 m to 100y ARI flood level + 0.5 m is recommended.		
CONTROLS ON CARAVAN PARKS IN THE FLOODPLAIN	Section 4.4.2	Ensure that caravan parks do not pose a significant hazard during a flood.	There are three caravan parks within Yamba which can represent a significant hazard during a flood by means of: short term residents having little flood awareness, large number of vans may be vacant increasing the workload of rescuers and vans become mobilised by floodwaters and cause increased damages. Preparation of Evacuation Plans to high ground for each site would help minimise the hazard.	Relatively low cost.	Recommended that an Evacuation Plan to high ground for each caravan park be prepared and/or updated.
HOUSE RAISING	Section 4.4.3	Prevent flooding of existing buildings by raising habitable floor levels.	Potential to be applied to some houses in the township, however further investigations are required.	High cost per property. May introduce social problems.	Further investigations are recommended.
<b>FUTURE DEVELOPMENT</b>					
DEVELOPMENT INTENSIFICATION	Chapter 5	To ensure that development intensification at Yamba does not increase the flood hazard.	Development intensification occurs within the existing urban zone but may also involve the rezoning of land to allow for higher densities. This can add additional strain on existing infrastructure and services. Planning controls should be implemented to ensure floors and access routes to high ground remain flood free in events up to the 100y ARI, key services remain operable during times of flood, local drainage issues are addressed and appropriate building materials are used.	Relatively low cost.	Recommended that development control plans are prepared specifically to cater for development intensification.
PROPOSED WEST YAMBA	Chapter 6	To ensure that if the proposed development at West Yamba proceeds it does not increase the flood	A number of issues should be addressed prior to the development proceeding, including: impacts of fill, evacuation planning, environmental management and	Moderate cost.	Recommended that issues identified are addressed prior to rezoning the land and that development controls are put

MEASURE	REFER SECTION	PURPOSE	COMMENT	ECONOMIC ASSESSMENT	IMPLEMENTATION VIABILITY
		hazard.	compliance with policies and plans. Development controls for the development would ensure that the nature of the proposed development is appropriate for the floodplain and the flood hazard is acceptable.		in place to ensure that the hazard is acceptable. The likely increase in sea level as a result of climate change should be included in any development controls for fill or floor levels.

## **FUTURE DEVELOPMENT**

All existing residential zoned land in Yamba has been developed (apart from isolated infill lots) and combined with a population and tourism growth of 3% per annum, there has been increasing pressure to develop new areas. Consequently development has been proposed for West Yamba and a draft LEP went on Public Exhibition from August to October 2006. There are a number of issues relating to this site (including flood-related) and it is not yet certain that the development will proceed. The only alternative to this is intensification of the existing developed areas. Both scenarios are discussed in this Floodplain Risk Management Study as it is imperative that any additional development does not exacerbate the existing flood problem.

## 1. INTRODUCTION

The Clarence River has a catchment area of some 21,900 km<sup>2</sup> to its mouth at the Pacific Ocean and some 19,800 km<sup>2</sup> to Grafton. The catchment is bounded to the west by the Great Dividing Range, by the Doughboy Range / Dorrigo Plateau to the south and the Great Dividing Range / McPherson Range to the north. The Richmond Range and the Coast Range separate the smaller coastal catchments from the Clarence River.

The City of Grafton is historically the regional centre servicing the Clarence Valley and its hinterland. It was founded in the mid 1800's as the port for the exporting of timber from the region. Further downstream there are several towns, including Iluka on the northern side of the river mouth and Yamba on the southern side. Yamba has a population of approximately 6,000 and is a significant urban as well as tourist centre.

The mouth of the Clarence River is restricted by a northern and southern breakwater which are up to 500 m in length and several metres high (refer Photograph 1).

Clarence Valley Council (CVC) engaged Webb, McKeown & Associates to prepare a Floodplain Risk Management Study for Yamba. The objectives of this Study are:

- to review the nature and extent of the flood hazard in light of the recently completed Lower Clarence River Flood Study Review (March 2004),
- to assess a range of management measures for existing and proposed development,
- to determine potential impacts of future development and assess options to mitigate these impacts.

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

### 1.1 Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the Floodplain Risk Management Process entails four sequential stages:

- Stage 1: Flood Study.
- Stage 2: Floodplain Risk Management Study.
- Stage 3: Floodplain Risk Management Plan.
- Stage 4: Implementation of the Plan.

The Yamba Floodplain Risk Management Study constitutes the second stage in the process. The Flood Study stage was completed in March 2004 with publication of the Lower Clarence River Flood Study Review (Reference 2). In this study a two-dimensional hydraulic model was used to determine

design flood levels for the lower Clarence River floodplain, including Yamba. This study superseded a previous Flood Study (Reference 3) completed in 1988.

## 1.2 History of Development and Flooding

The Clarence River valley was first explored by Europeans in the early 1830's with the first settlement near Grafton in 1837 on the south side of the Clarence River. Subsequently several small rural settlements developed, including the township of Yamba.

Development at Yamba has occurred in distinct stages. The original township developed near the mouth of the Clarence River, on "Yamba Hill" (Figure 1). For the most part development in this area, and in general, east of Angourie Road (Figure 2), is flood free. There is a significant area of residential development adjacent to the boat harbour along Yamba Road (referred to here as "Middle Yamba") which has occurred over the last 30 years. A large portion of this area is on low-lying land and is flood liable. To the west of this is the newer development of Yamba (termed Crystal Waters) which is for the most part flood free (constructed on fill) though there are some lower lying areas.

Flooding at Yamba can occur as a result of four main mechanisms:

1. Inundation due to high flows in the Clarence River during times of flood.
2. Inundation from the Clarence River during times of high ocean levels (storm surge activity and/or high tides).
3. Wind/wave action along the southern foreshore of the Clarence River. This mechanism is largely outside the scope of this present investigation.
4. Intense rain over the township of Yamba causing ponding in low lying areas as a result of inadequate local drainage. This mechanism is largely outside the scope of this present investigation.

Design flood levels for Yamba were derived in the Lower Clarence River Flood Study Review (Reference 2) taking into account the first two mechanisms described above.

## 1.3 Clarence River County Council (now Clarence Valley Council)

The Clarence River County Council (CRCC) was formed in 1959 to perform all the duties under Section 494 of the Local Government Act of 1919 relating to the prevention or mitigation of menace to the safety to life or property from floods. As a result of the amalgamation of local councils in early 2004 the CRCC has been renamed as the Clarence Valley Council (CVC).

Prior to formation of the CRCC, works were undertaken by the relevant Councils or by drainage unions. The majority of these works are now under the control of the CVC but some are still privately owned by landowners or drainage unions.

A summary of the activities undertaken by the CVC include:

- Construction, management and maintenance of floodplain drainage and associated infrastructure.
- Construction and maintenance of levees.
- Provision of bank protection works, including quarrying.
- Control of noxious weeds.
- Voluntary purchase schemes.
- Management of environmental, erosion and floodplain management projects.



## 1.4 Photographs



**Photo 1:** Clarence River Breakwalls



**Photo 2:** Angourie Road



**Photo 3:** Yamba soon after March 2001 flood



**Photo 4:** Oyster Channel



**Photo 5:** Light industrial area off Angourie Road



**Photo 6:** Yamba Road

## **2. STUDY AREA**

### **2.1 Description**

Yamba is located at the mouth of the Clarence River and is effectively surrounded by water with the Pacific Ocean to the east, the Clarence River to the north, Oyster Channel to the west and land extending to Lake Wooloweyah in the south (Figure 1). Yamba represents a major urban centre in the district and has a population of over 6,000 residents which doubles during the Christmas tourist season. It is predominantly a residential/tourist centre and there are three caravan parks, a small commercial/business area and an industrial estate on the floodplain.

Existing zoned land at Yamba is nearly completely developed and combined with population and tourism growth in the order of 3% per annum, there has been significant pressures to develop new areas. In 1995 the then Maclean Shire Council adopted a Strategic Land Use Plan (1995 - 2016) as the basis for the long term planning of the anticipated population growth of the shire. The Plan identified West Yamba (Figures 1 to 3) as providing additional urban land to accommodate population growth. A Local Environmental Plan (LEP) for West Yamba was placed on public exhibition from August to October 2006, however there are a number of issues with the proposal and to date the development at West Yamba remains in the planning stages. The only alternative to this site for accommodating population growth is intensification with existing developed areas.

#### **2.1.1 Land Use Activities and Key Features**

Development at Yamba is predominantly residential and tourist related with minor rural residential (Figure 2). A small commercial and business area is located near Yamba Hill on Yamba Street as well as an industrial estate within Middle Yamba (off Angourie Road). There are three caravan parks - Yamba Waters Holiday Park, Blue Dolphin Holiday Resort and Calypso Holiday Park (Figure 2). A large part of the town is on low-lying land, though Yamba Hill and Angourie (to the south) are on high ground. The design of an upgrade to the sewerage treatment plant is currently been undertaken for the township, which will provide an increased capacity as well as improved processes.

Yamba Road is the sole access into the township and it becomes inundated in approximately the 10y ARI or greater events. An additional access road into the town (from east of Oyster Channel to Yamba Hill) has been proposed (Yamba Bypass - Figure 4) however it remains in the concept stages and details regarding length, capacity, road level etc., have not yet been determined. As at November 2007 it is assumed that the bypass will not be flood free. A number of internal roads west of Angourie Road also become inundated during significant flooding events (10y ARI and greater).

The Flood Planning Level (FPL) provides minimum floor levels for development in flood-liable areas to minimise the effects of flooding. This is presently set at the 100y ARI flood level plus 0.3 m freeboard (2.64 mAHD). It should be noted that the majority of Councils in NSW adopt a 0.5 freeboard. At Yamba the designated FPL (or equivalent) has changed over the years, resulting in a number of existing buildings with floor levels below the current FPL. Figure 4 indicates the areas of fill within Yamba and the designated level to which it was undertaken. It should be noted that detailed survey to check these fill levels has not been undertaken. Also house floors may have been constructed exactly at the fill level (slab on ground) or slightly raised.

## 2.2 Previous Studies

A number of studies (economic, hydraulic and others) into flooding at Yamba have been undertaken. The following are the key references pertaining to this present study.

### 2.2.1 Lower Clarence River Flood Study Review, 2004 (Reference 2)

This study established and calibrated a two-dimensional (2D) hydraulic model of the Lower Clarence River floodplain. The model extended from approximately 15 kms upstream of Grafton Bridge to the Pacific Ocean at Yamba and was based on a digital elevation model (DEM) of the floodplain. A grid size of 60 m by 60 m was adopted. The following historical floods were used in the model calibration and verification process:

- January 1968,
- May 1980,
- April 1988,
- May 1996,
- March 2001.

The 1974 and 1976 floods were not used for calibration. The design inflows on the Clarence River were derived from flood frequency analysis of historical inflows at the Prince Street gauge (Grafton) rather than a rainfall/runoff approach. A single rating curve at the Prince Street gauge (relationship between gauge height and flow) could not be used as the changing levee system at Grafton over the last 100+ years has affected the rating curve. As a result four rating curves for the following periods were devised:

- pre 1910,
- 1910 to 1974,
- 1974 to 1996,
- 1996 to 2002.

The Lower Clarence River Flood Study Review determined design flood levels, depths and hazards for the 5y, 20y, 100y, 500y ARI and Extreme events. One notable feature of the study is that the construction of levees in the last 100+ years near Grafton have raised flood levels at Grafton by up to 0.9 m. However, any increase in flood level at Yamba due to upstream levee construction is likely to be insignificant.

The current design flood levels at Yamba taken from Reference 2 are provided in Table 1.

**Table 1:** Design Flood Levels

Event	Flood Level (mAHD)	Assumed Peak Ocean Level (mAHD)
Extreme	3.39	2.6
500y ARI	2.39	2.6
100y ARI	2.34	2.6
20y ARI	1.8	2.1
5y ARI	1.5*	0.8

\* The Flood Study Review indicates a level of 0.4 mAHD for the 5y ARI event at Yamba. This has been increased to 1.5 mAHD as 1.0 mAHD is approximately the peak tide level each year, thus the 5y ARI event must be greater than this, but less than 1.8 mAHD. If a more precise 5y ARI level is required it should be more accurately calculated and the above level represents an 'order of magnitude' only.

**Note:** Figure 5.1 of Reference 2 indicates that the design flood profiles of the Clarence River are approximately flat over the final 10 kilometres to the Pacific Ocean. This indicates the significant influence of the high ocean levels in the lower reaches of the Clarence River.

## 2.2.2 Clarence Valley Floodplain Management Study, 1980 (Reference 4)

This study provided the most comprehensive review of flood information for the Lower Clarence Valley at the time. Information on the hydraulic, environmental and economic implications of flooding were included with suggested mitigation measures also investigated.

## 2.2.3 Lower Clarence River Floodplain Management Study, 1993 (Reference 5)

This study assessed the flooding problem and examined potential management measures for the Clarence River floodplain within the Maclean Shire, which included Yamba. The study determined that there were 419 flood-liaible buildings within Yamba. The floor level database on which this figure is based was not comprehensive and was based on estimated rather than surveyed floor levels. The key measures identified for the township were levee construction and development controls (requiring minimum floor levels).

### **2.2.4 Lower Clarence River Floodplain Management Plan, 1999 (Reference 6)**

The Management Plan followed on from Reference 5 and identified the proposed flood management measures for all the flood affected townships within the Maclean Shire. At Yamba this was limited to setting minimum floor levels at the 100y ARI flood level with a 0.3 m freeboard. Levees were not considered feasible due to social impacts and problems associated with constructing the levees on residential lots.

### **2.2.5 Grafton and Lower Clarence Floodplain Risk Management Plan, 2007 (Reference 7)**

The purpose of this study was to review and amalgamate the findings of several previous studies. It was concluded that most of the previously recommended structural flood mitigation measures have already been constructed. Thus the remaining outstanding valley wide measures are non-structural (flood warning, emergency management, voluntary house purchase and raising works, community awareness and planning considerations). This present study endorses the valley wide measures proposed in Reference 7.

## **2.3 Public Consultation Program**

A rigorous public consultation program was carried out as part of this study. This included:

- floodplain management committee meetings,
- site inspections,
- public exhibition of Draft Reports from 11<sup>th</sup> August to 26<sup>th</sup> September 2008,
- telephone interviews with residents/stakeholders,
- public meeting/interview on 17<sup>th</sup> September 2008 at Yamba,
- review of submissions and incorporation into the final report.

### 3. EXISTING FLOOD PROBLEM

#### 3.1 Flooding Mechanism

Flooding can occur as a result of four main mechanisms:

1. Inundation due to high flows in the Clarence River during times of flood.
2. Inundation from the Clarence River during times of high ocean levels (storm surge activity and/or high tides).
3. Wind/wave action along the southern foreshore of the Clarence River. This mechanism is largely outside the scope of this present investigation.
4. Intense rain over the township of Yamba causing ponding in low lying areas as a result of inadequate local drainage. This mechanism is largely outside the scope of this present investigation.

Design flood levels for Yamba were derived in the Lower Clarence River Flood Study Review (Reference 2) taking into account the first two mechanisms described above and are provided in Table 1. The flood warning/time till inundation for the first two mechanisms are of the similar magnitude, approximately 24 hours. However as with all forms of warning it will vary from event to event and be dependent upon the circumstances at the time.

#### 3.2 Hydraulic Classification

The Floodplain Development Manual defines three hydraulic categories which can be applied to areas of the floodplain.

*“Floodways* are those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.”

*“Flood storage* areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.”

*“Flood fringe* is the remaining area of flood prone land after floodway and flood storage areas have been defined.”

Based on these definitions the majority of Yamba would be classified as flood storage with the Clarence River classified as floodway. However at a local level there will be floodways within Yamba that take flood waters from the south to the Clarence River.

The only major creek system linking the Clarence River to the floodplain south of Yamba Road is the unnamed creek between Endeavour and Freeburn Streets. However the capacity of this creek to convey significant flows across Yamba Road is severely restricted due to the small culvert capacity under Yamba Road, the height of Yamba Road at this point (approximately 1.5 mAHD) and the surrounding buildings and fences.

The height of Yamba Road (lowest point 1.4 mAHD and highest point 2 mAHD) and adjoining buildings on either side means that there is no clearly defined floodway taking a significant amount of flow across Yamba Road in events up to the 100y ARI.

### 3.3 Flood Hazard Classification

Provisional hazard categorisation based on depth and velocity indicate that the majority of the existing developed areas on the floodplain is Low Hazard in the 100y ARI event but High Hazard in the PMF (Figure 5).

*Flood hazard* is a measure of the overall adverse effects of flooding. It incorporates threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production. These factors are not included in the provisional (hydraulic) hazard assessment. The more comprehensive classification is a qualitative assessment based on a number of factors as listed in Table 2 where land is classified as either *low* or *high* hazard for a range of flood events.

**Table 2:** Hazard Classification

Criteria	Weight <sup>(1)</sup>	Comment
Rate of Rise of Floodwaters	Low	Residents will be aware that the river is rising but may be surprised at how rapidly the floodplain becomes inundated. Ocean storm surge occurs more quickly than Clarence River flooding.
Duration of Flooding	Low	The duration of river flooding is of the order of one or two days. Ocean storm surge may last for a similar period but the peak period (on a high tide) is likely to last a few hours only.
Effective Flood Access	High	Access into Yamba is only possible via Yamba Road, which is inundated in events of 10y ARI magnitude or greater. Internal access roads are also flood liable.
Size of the Flood	Medium	Up to a 5y ARI event there is no direct inundation from the Clarence River. In the 10y ARI event and greater the majority of the floodplain is inundated.
Effective Warning and Times for Evacuation to high ground	Low	The existing BOM flood warning system should provide adequate warning (Section 4.3.1) for Clarence River flooding. Similarly, the low pressure systems which initiate ocean storm surge can be predicted a day in advance. The key concern is whether the warning is acted upon.

Criteria	Weight <sup>(1)</sup>	Comment
Additional Concerns such as Bank Erosion, Debris, Wind Wave Action	Medium	There are likely to be a number of additional concerns which will increase the potential hazard. Debris and wind wave action may also cause damage to structures and increase the risk to life.
Evacuation Difficulties	High	These are likely to be high on account of: <ul style="list-style-type: none"> <li>• the distance to high ground,</li> <li>• Yamba Road will be cut early making access difficult,</li> <li>• the roads will quickly be inundated by up to 1 m depth or greater,</li> <li>• the emergency services (SES, Police) will be “stretched” answering calls throughout the area.</li> </ul>
Flood Awareness of the Community	High	The permanent population of Yamba are likely to have a moderate level of awareness. However the population doubles during the Christmas season and this visiting population would not be aware of the potential risks. Thus the residents of Yamba at any one time (permanent and visitors) would have a low level of awareness.
Depth and Velocity of Floodwaters	Low	Velocities will be low (1 m/s or less) as will be the depth of floodwaters (generally 1 m or less) in the 100y ARI event.

**Note:** (1) Relative weighting in assessing the hazard.

Based upon the above, a comprehensive assessment of the flood hazard indicates that the majority of the floodplain has a High flood hazard classification for flood events greater than a 10y ARI Clarence River event.

### 3.4 Flood Damages

The cost of flood damages and the extent of the disruption to the community depends upon many factors including:

- the magnitude (depth, velocity and duration) of the flood,
- land usage and susceptibility to damage,
- awareness of the community to flooding,
- effective warning time,
- the availability of an evacuation plan (to high ground) or damage minimisation program,
- physical factors such as erosion of the river bank, flood borne debris, sedimentation.

Flood damages can be defined as being “tangible” or “intangible”. Tangible damages are those for which a monetary value can be assigned, in contrast to intangible damages, which cannot easily be attributed a monetary value (stress, injury, loss to life, etc.).

While the total likely damages in a given flood is useful to get a “feel” for the magnitude of the flood problem, it is of little value for absolute economic evaluation. When considering the economic effectiveness of a proposed mitigation option, the key question is what are the total damages prevented over the life of the option? This is a function not only of the high damages which occur in large floods but also of the lesser but more frequent damages which occur in small floods.



The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by taking into account the probability of a flood occurrence. By this means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

A flood damages assessment was undertaken for existing development at Yamba. Due to the lack of surveyed property data (floor levels) the damages assessment was based on the fill level for each developed area (Figure 4). For some properties along Yamba Road this information was not available, in which case floor levels were estimated as a height above road level (for which a limited survey of Yamba Road was available).

The damages assessment considered multiple houses per property (units, etc.) as well as two storey houses (habitable/non-habitable ground floor) and applied an adjustment factor to represent the anticipated damages. It only took into account residential properties as it was not possible to estimate floor levels for commercial/light industrial buildings. Damages to tourist facilities (caravan parks) and public structures have also not been assessed.

For these reasons the flood damages are indicative only and should only be used in the context for which they were intended - to give a indication of the magnitude of the flood problem and to provide preliminary estimates of benefit cost ratios for flood mitigation measures.

The summary of residential flood damages is provided in Table i).

### **3.5 Flood Behaviour**

As noted in Section 3.1 there are four different flooding mechanisms which can affect Yamba. The mechanism producing the highest flood levels is inundation from the Clarence River during times of high ocean levels (storm surge). The hydraulic model established in the Flood Study provides limited detailed information on flood behaviour as it is on a 60 m grid, thus it cannot account for small flow paths or blockage by buildings, etc. It is recommended that a finer detailed model, say on a 10 m grid, be established if better definition of the flow paths across the floodplain at Yamba is required (for example if further filling or development on the floodplain is proposed). This more detailed modelling would allow hydrographs (water level or flow versus time) to be obtained which would allow a greater understanding of the timing of the sequence of inundation.

The information presently available in the Flood Study is sufficient for use in this present Floodplain Risk Management Study.

## 4. FLOODPLAIN RISK MANAGEMENT MEASURES

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

**Flood modification measures** modify the flood's physical behaviour (depth, velocity) and include flood mitigation dams, retarding basins and levees.

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

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

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option on a relative basis enabling ranking against similar projects in other areas. The benefit/cost ratio is the ratio of the Net Present Worth of the reduction in flood damage (benefit) compared to the cost of the works. Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles such as anxiety, risk to life, ill health and other social and environmental effects. In this study the reduction in tangible damages to public utilities, non-residential and agricultural activities as a result of implementation of a floodplain management measure has not been included.

The potential environmental or social impacts of any proposed flood mitigation measure are of great concern to society and these cannot be evaluated using the classical benefit/cost approach. The public consultation program (Section 2.3) has ensured that identifiable social and environmental factors were considered in the decision making process.

The social factors identified largely relate to aesthetic and access concerns and apply to many measures including levees, house raising and flood proofing of buildings. In many flood liable communities these concerns have limited the construction of levees or the "take up" of house raising. Voluntary purchase of housing is also rejected by many due to social factors relating to the price and break up of the social fabric of the area.

Environmental factors largely apply to flood modification measures (dredging, dam construction). As none of these measures were applicable at Yamba the importance of environmental factors in the management measures decision making process was of lesser importance to the social, economic and hydraulic factors.

For several measures (further studies, flood warning, evacuation planning, flood awareness program) social and environmental factors are of little relevance.

## **4.1 Management Measures for Existing Development**

The following sections discuss measures for the management of flooding for the existing residential development of Yamba. Existing development includes houses already constructed, those with development approval to be constructed and infill development. Future residential development is discussed separately in Chapters 5 and 6.

## **4.2 Flood Modification Measures**

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

- dams,
- retarding basins,
- channel modifications,
- levees,
- flood gates,
- pumps.

### **4.2.1 Dams and Retarding Basins**

Flood mitigation dams and their smaller urban counterparts termed retarding basins have frequently been used in NSW to reduce peak flows downstream. Dams are rarely used as a flood mitigation measure for existing development on account of the:

- high cost of construction,
- high environmental damage caused by construction,
- possible sterilisation of land within the dam area,
- high cost of land purchase,
- risk of failure on the dam wall,
- likely low benefit cost ratio,
- lack of suitable sites. A considerable volume of water needs to be impounded by the dam in order to provide a significant reduction in flood level downstream. This is particularly true for large river systems, like the Clarence River,
- a dam would have minimal impact at Yamba where high ocean levels have a significant impact on flood levels.

This measure was not considered further for the above reasons.

## 4.2.2 Channel Modifications

This includes dredging and vegetation clearing to increase the waterway area, which in turn can reduce the flood levels. Channel modifications are rarely used today as a flood modification measure due to:

- the likely high environmental damage caused by the works,
- the subsequent possible change in ecology,
- the ongoing maintenance requirement,
- if maintenance is not undertaken and a flood occurs then there may be some liability issues for Council,
- there is no guarantee the works will be undertaken immediately prior to a flood. Also the early part of the flood or period of heavy rain prior to flooding may bring down sediments and debris,
- in large rivers the impacts of the channel modifications on flood levels is likely to be negligible.

This measure was not considered further for the above reasons.

## 4.2.3 Levees, Flood Gates and Pumps

### DESCRIPTION

Levees are built to exclude previously inundated areas from the floodplain of the river up to a certain design event. There are currently no levees within Yamba township however three scenarios were considered as part of the 1993 Management Study (Reference 5). Despite having a high benefit/cost ratio, levees were not included in the Management Plan (Reference 6) due to the social impacts and problems associated with constructing a levee on residential lots.

Due to the location of Yamba (being almost completely surrounded by water) any levee system would need to completely enclose the township. The design suggested in the 1993 Management Study (Reference 5) remains the most likely option. This involves the construction of a levee along the foreshore of Yamba Bay, from the boat harbour to beyond the end of Shores Drive and along Melaleuca Drive on the western side of Reedy Creek. Approximately four kilometres of levee would need to be constructed along the southern edge of the urban areas to prevent floodwaters from Oyster Channel inundating the area. It may also be necessary to fill isolated low spots along the shoreline of the man-made canals and lakes in Crystal Waters.

Flood gates can be considered as a separate modification measure or as part of the levee design. Flood gates allow local waters to be drained from the area when the level of the Clarence River is low, but when the river is elevated the gates prevent floodwaters from entering (or exiting) the protected area. If a levee system was built all drains discharging to Yamba Bay would require the installation of floodgates.

Pumps are generally also associated with levee designs. They are installed to remove local floodwaters behind levees when flood gates are closed or there are no flood gates. They are generally only suitable for small volumes of floodwaters and are prone to failure due to either lack of maintenance or power failure during the flood. However this can be addressed through appropriate design and maintenance.

## DISCUSSION

Whilst a concept design and alignment of a levee system to protect the existing developments along Yamba Road could be undertaken, it is considered worthwhile to wait until resolution of the West Yamba rezoning and bypass design. Both of which would have significant impact on the design of any levee system at West Yamba to protect existing developments. For this reason a hydraulic assessment (using the established 2D hydraulic model) was not undertaken, however the impacts of the levee on flood levels are likely to be minimal (due to the close proximity to the ocean entrance and the extensive floodplain in the lower Clarence River). It should be noted that there are a few nearby buildings outside the leveed area which would be adversely affected by any increase in flood level.

A levee is constructed to eliminate inundation up to a given design event. Typically this is the 100y ARI however many levee systems are constructed to provide a lower level of protection. The recently constructed levee system at Lismore for example only provides protection to a 10y ARI event. At Yamba, as there are few buildings inundated in the more frequent events (none in the 5y ARI), for the levee to be economically viable a higher level of protection is required. Based on a preliminary assessment the minimum level of protection would probably have to be the 50y ARI. The adopted design height of the levee would be based on a rigorous cost benefit and social (aesthetics, views) analysis. It is unlikely that environmental factors would be relevant in determining the design height. Freeboard is added to this level to provide for wind wave action, subsidence, construction tolerances, erosion etc. Generally for an earth levee the freeboard is 1.0 m but is reduced to 0.5 m for concrete or other fixed surface levels. At the detailed design stage a review of the necessary freeboard should be undertaken which would consider a lesser fixed freeboard.

**Possible Levee Design:** A possible levee alignment is shown on Figure 4. It should be noted that this alignment presents many problems including:

- **Access to the Clarence River:** Most residents live or holiday in this region because they want ready access to the Clarence River for boating, fishing or other water based recreational activities. Whilst ramps etc. can be built access will always be more restrictive than at present and may influence peoples decision to live or holiday in the area.
- **Aesthetics:** The levee will have a significant impact on the vista from adjoining houses as well as within the community itself. It is impossible to negate this issue, though in time this issue will become of less importance.

- **Construction material:** Where space is available, an earthen levee is the most economical and aesthetic approach. Typically the crest would be 1-2 m wide with batters at 1:3 grade maximum. The earthen levee would have a crest with say a 1 m freeboard above the 100y ARI flood level (3.3 mAHD). The height above ground would vary but in low lying areas (ground say at 1.5 mAHD) the crest would be 1.8 m above the ground, however in other places it may be only 1 m high. The base width would be a maximum of 14 m. Where land is limited a concrete levee would be needed. Visually this would be more obtrusive (Iluka has a concrete levee). Typically a concrete levee requires a 0.5 m freeboard as it does not experience subsidence or an uneven crest which can occur with an earthen levee.
- **Road access:** Raised crests would need to be formed on the roads which are crossed by the levee. These will restrict the traffic flow unless extended over a considerable distance (say 100 m+).
- **Climate change:** An additional 0.5 m freeboard should be included on the levee crest height to account for a sea level increase due to climate change over the next 50 years.
- **Wind wave effects:** The levee facing the Clarence River would need to be designed to ensure it does not exacerbate any wind wave action.
- **Environmental impacts:** The levee is unlikely to have a significant impact on the flora or fauna of the region but some vegetation removal may be required.

**Costs:** Regardless of the exact design configuration, construction costs of a levee system are likely to be in excess of \$5 million as well as ongoing maintenance costs in the order of \$100,000 per annum. The construction cost could be reduced if the Yamba Bypass was incorporated into the levee design, or similarly if access roads to West Yamba could be incorporated into the design.

**Benefits:** Assuming the levee was constructed to the 100y ARI flood level (2.34 mAHD) + freeboard it would provide benefit to more than 1200 houses, including reduction in internal and external property damages as well providing a flood-free access (up to the 100y ARI event) to high ground within the township. It would also provide a benefit to non-residential floodplain users. Floodgates and pumps associated with the levee may also provide benefit in alleviating local drainage issues. It should be noted that a levee is generally only used as a means of protecting existing development from inundation and not as a means of permitting further development. The benefit/cost ratio (assuming all properties are protected to the 100y ARI level and a \$5 million cost) is 2+ which indicates that economically a levee may be viable (it will protect over 1000 buildings). A more detailed costing of the levee and flood damages assessment is required to confirm this preliminary estimate.

**Dis-benefits:** Any levee system would not eliminate the problems associated with evacuation to high ground, isolation of the township during a flood and the risk to life during floods. Yamba Road, west of the levee, would still be inundated in the 10y ARI event or greater. Thus although the town would not be inundated in events smaller than the levee crest level, evacuation from the township (for medical reasons, supplies etc.) to the Pacific Highway during a flood would not be possible, although it would provide time for evacuation to high ground in Yamba. Unless a levee is built to prevent inundation in the largest possible event (termed the Probable Maximum Flood or PMF), which would generally be unacceptable economically and socially, the levee system will eventually be overtopped in a very large event. Failure of the levee system may also occur during a flood event, prior to overtopping. There is therefore a risk that a levee will provide a “false sense of security” and if failure occurs the damage may be worse than if no levee was built and residents relied on other means of preventing damage.

The levee system at Yamba would need to be extensive and because of this is likely to have a number of social impacts. This would include aesthetics (obstruction of river/channel views) and access (to the marina, river, bay or channels). There would also be landtake issues as the levee would need to pass through a number of private properties.

Levees may also exacerbate river bank erosion or collapse and this, as well as other potential environmental impacts, would require investigation.

There may be some hydraulic dis-benefits (raising of flood levels) and this would have to be evaluated using a detailed hydraulic model (say 10 m grid). However as the levee is protecting all buildings in Yamba there are few buildings and significant land areas remaining on the floodplain that would be adversely affected. Flood levels at Iluka would not be affected by construction of a levee at Yamba.

Whilst flood gates and pumps have been used successfully at a number of locations throughout NSW over many years, they require ongoing maintenance to ensure their continued success. Vandalism, corrosion, damage or vegetation growth can all result in failure at critical times. Some form of ongoing maintenance program is therefore required. Ensuring the power supply for pumps remains operable during times of flood can also be problematic.

## **OUTCOMES**

A levee system is a high-cost measure but it would provide benefit to a large number of properties and will assist in enabling a flood-free access to high ground. However, there are a number of issues that would need further investigation including landtake and social/environmental impacts (aesthetics, access, bank erosion). Until final decisions are made regarding Yamba Bypass and/or further development at West Yamba, a levee system should not be considered further as these developments would have significant impacts on the overall configuration and construction.

## **ACTIONS**

Assuming that the social and logistic (landtake) issues could be resolved, a levee system for Yamba should be reconsidered when decisions are finalised on the Yamba Bypass and the West Yamba development as this could provide the opportunity to reduce construction costs (by incorporating the fill or road embankments into the levee design).

### **4.2.4 Local Drainage Issues**

#### **DESCRIPTION**

Yamba has a kerb and gutter drainage system with an underground pipe network. Local drainage issues are likely to be limited to possible surcharging of pipes due to high tailwater levels, potential blockage of pipes and/or drains as well as ponding of local runoff. The roads in Yamba are undulating which may result in ponding and/or diversion of runoff into footpaths and private properties. No significant damage occurs as a result of these issues but they would be an inconvenience to residents.

#### **DISCUSSION**

Local drainage issues are found in all urban communities and generally occur as a result of historical circumstances (basic or no road and drainage system at the time of development, limited or no controls on minimum building floor levels, little or no kerb and guttering) and the nature of the topography (land never graded to form flow paths). Local drainage issues generally do not result in any significant damage to properties and there is minimal (if any) risk to life. However it does cause significant inconvenience to residents who take pride in the appearance of their community and it may influence tourist activities.

As a general guide a building floor should be constructed a minimum of 300 mm above the surrounding ground level, even in non-flood prone areas. This will generally ensure that these minor drainage issues do not inundate building floors.

It is possible that Council could undertake further minor clearing or construction works that would alleviate the problem. In the first instance a detailed record of the problem areas needs to be obtained to determine the scale and nature of the problem.

#### **OUTCOMES**

Local drainage issues are a significant issue in small towns such as Yamba which have developed over a period of years with limited development controls.

#### **ACTIONS**

Local residents should ensure that all such issues are adequately documented (written and photographic) and reported to Council. Council will address these issues where appropriate. Council will also prepare a drainage plan (if not already completed) showing the major drainage lines and pipe



sizes, topography and the location of any flap gated culverts. This will assist in identifying problem areas.

#### **4.2.5 Storm Surge/Ocean Levels/Wave Runup**

##### **DESCRIPTION**

As Yamba is located at the entrance to the Clarence River, on the Pacific Ocean, the flood levels are dominated by ocean anomalies (a combination of elevated ocean levels (tides), storm surge) and wave runup. Flooding in the Clarence River could occur at the same time, or independently to ocean anomalies and thus must still be considered.

Wave runup is confined to the nearshore area and is highly dependent on factors such as the wave height, wave length, water depth and embayment slope. The action of these waves may cause inundation of property and foreshore erosion. Wave runup effects will generally only occur over a small percentage of the foreshore in a given event (in the prevailing wind direction). The effects will vary in time and space as a result of changing foreshore profiles, which may occur naturally (sedimentation, erosion, vegetation growth) or as a result of human activities (construction of seawalls, levees or similar). There is no record of significant wave runup activity at Yamba.

##### **DISCUSSION**

Wave runup activity and ocean anomalies can produce flooding on the northern foreshore of Yamba as well as possible foreshore erosion. These effects also require that the structural integrity of any proposed structure near the foreshore be more closely examined, as in general no allowance is made for the potential impacts of wave runup. To accommodate the effects of wave runup Councils generally adopt a freeboard (for setting floor levels of residential buildings) above the adopted design flood level, of which a component is to cater for the effects of wave runup. The damages resulting from wave runup are difficult to accurately quantify as little data are available.

Foreshore protection (using vegetation or seawalls) are measures which can be used to reduce the impacts of wave runup.

##### **OUTCOMES**

The effects of wave runup on the foreshore, as well houses fronting on to the foreshore needs to be considered further. At present a study has not been undertaken which considers the effects of wave runup for the Yamba township, however such a study is recommended in order to quantify the impacts on houses, as well as on possible flood mitigation measures (levees).

##### **ACTIONS**

A study into the effects of wave runup should be undertaken for the township of Yamba. Until such time, the potential impacts should be considered when evaluating mitigation measures (such as setting minimal floor levels and quantifying the level of protection provided by future flood mitigation

structures - particularly levees). The existing mangroves on the western foreshore of Yamba should be preserved so as to minimise the impacts of wave runup.

## **4.3 Response Modification Measures**

### **4.3.1 Flood Warning**

#### **DESCRIPTION**

It will be necessary for a number of residents in Yamba to evacuate their homes in a major flood or ocean event. Whilst not all will have their house floors inundated, it is likely that their power, gas, water and sewerage systems will be affected. Many residents may leave on their own accord with the State Emergency Services (SES) having the responsibility of evacuating people in a life threatening situation.

The amount of time for evacuation of low lying communities to high ground depends on the available warning time. This is critical for Yamba as access out of the township to the Pacific Highway has been cut in the past due to flooding and local roads have been inundated. Providing sufficient warning time has the potential to reduce the social impacts of the flood as well as reducing the strain on emergency services.

Adequate flood warning gives residents time to move goods and vehicles above the reach of floodwaters and to evacuate from the immediate local area or even out of the town. The effectiveness of a flood warning scheme depends on:

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

At Yamba flooding is from a combination of runoff in the Clarence River and elevated ocean levels (high tide, ocean storm surge), however the peak level for the design events is dominated by ocean storm surge.

#### **DISCUSSION**

Flood warning, and the implementation of evacuation procedures by the SES, are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BOM) is responsible for flood warnings on major river systems such as the Clarence River. The flood warning system is based on stations which automatically record rainfall or river levels at upstream locations and telemeter the information to a central location. Consideration is also given to ocean storm surge (where applicable) by the use of a simple tidal algorithm. Analysis is then undertaken to determine the expected time, duration and height of the flood peak.

Although Council monitors the situation during flood events the responsibility for preparing regional flood warning rests with the BOM. Based on this information the SES issues community level warnings. Council does not issue warnings but assists the SES with road closures and evacuations.

Studies have shown that flood warning systems generally have high benefit/cost ratios if sufficient warning time is provided. Even with an effective flood warning system, some tangible and intangible flood damages will still occur.

At Yamba there are two critical stages for receiving flood warnings. The first is before the main access road into Yamba from the Pacific Highway is cut and the second is before inundation of the township itself.

Whilst in general one would expect Yamba to have up to 24 hours of an approaching flood (either from the ocean or from Clarence River flooding) this should not be taken as a definitive timeframe. In the absence of oceanic effects, 24 hours is realistic, taking into account the time for the flood wave to travel down the river from upstream. However in the majority of floods there is an associated oceanic effect, as a result of the same meteorological conditions that caused the flood producing rainfall. The magnitude and timing of this effect are very difficult to predict and can develop in less than 12 hours. The situation is further compounded as most residents will be “unfamiliar” with the likely impacts of oceanic effects and are therefore unlikely to respond in the same manner as they might if given advanced warning of river flooding.

It is impossible therefore to provide a definitive timeframe of the available flood warning time. At a minimum this is likely to be 6 hours and a maximum of over 24 hours. However each flood will respond in a different manner.

## **OUTCOMES**

The BOM already has a comprehensive flood warning system for the Clarence River, which has been tested in the 1996 and 2001 floods. A review of current practices involving estimating the impacts of ocean storm surge should be undertaken to ensure that current best practice is employed.

## **ACTIONS**

The existing flood warning program for Yamba is considered to be sufficient. However possible improvements include providing advice on the deadline when Yamba residents can evacuate the township to high ground and ensuring best practice is employed on providing advice on ocean storm surge and wave runup activity. The program should be reviewed every two years (or after a significant flood event) so as to ensure it remains the best practice available.

### **4.3.2 Evacuation Planning**

#### **DESCRIPTION**

Yamba Road is the sole evacuation route out of Yamba to the Pacific Highway and it becomes inundated during flood events (10y ARI or greater). Similarly there are a number of internal roads which are also inundated in flood events. This means evacuation from the town is problematic and can only occur prior to Yamba Road being cut by floodwaters. There is a permanent SES team located within Yamba however they also service the neighbouring towns which are often affected by the same flood events.

It is accepted that in a major flood the township of Yamba (and many other urban centres in the region) will be isolated and will need to be able to “survive” without outside assistance for 2-3 days. Yamba is large enough that it has sufficient accommodation, medical services and food for this period. The only exception would be a major medical disaster. The aim of evacuation planning for Yamba is to ensure that the community is “together” on “dry” ground and can obtain the use of the facilities in Yamba. It is not proposed that the population be moved elsewhere during a flood.

An Evacuation Plan for moving low lying residents to high ground is therefore necessary for the town of Yamba as it has been isolated in the past and will be isolated again in future floods. Any plan should give consideration to flood preparedness, response and recovery as well as SES access into Yamba when road routes from the Pacific Highway are cut.

## **DISCUSSION**

At present, there is no SES Flood Evacuation Plan specifically for Yamba, though it is considered under the old Maclean Shire Flood Plan. This plan is currently being updated by the SES to include Evacuation Plans for all villages isolated during a flood, including Yamba.

The main problems with all flood evacuations are:

- they must be carried out quickly and efficiently,
- they are hazardous for both the rescuers and the evacuees,
- residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers,
- evacuation routes along Yamba Road to high ground may be cut some distance from their houses and people do not appreciate the dangers.

If necessary, additional supplies could be provided by boat or by air, however we presume that there would already be sufficient supplies of food and water within the township to cater for several days isolation.

The need for evacuation from the township to another centre in the region is therefore only likely to be for medical reasons, related or not to the flood hazard. The SES would need to evaluate this risk within the proposed Flood Evacuation Plan and incorporate sufficient management measures.

An Evacuation Plan should also consider access to high ground within the township during times of flood and ensure that flood-free access routes are identified.

It is difficult to identify the critical point or stage in a flood where access along Yamba Road will be cut, as it is likely to depend upon a combination of ponding of local runoff, Clarence River floodwaters and ocean inundation. The importance of each contributor will vary for each event. Based on the available survey (Figure 4) the lowest points (1.5 mAHD) on Yamba Road are between Goldings and Freeburn Streets in the east and near Treelands Drive in the west. Yamba Road has a maximum height variation of approximately 0.5 m west of Angourie Road. To the east of Angourie Road, Yamba Road rises to high ground.

Ocean inundation and high flows in the Clarence River can be produced from the same meteorological event. However in some events the ocean inundation occurs first, prior to the peak rainfall and thus peak Clarence River flood level while in other events it occurs later. Thus it is possible that flooding from ocean inundation may occur well before the peak of the Clarence River flooding occurs. For this reason it is essential that the flood warning predictions take account of ocean effects (refer Section 4.3.1).

For the above reason it is not possible to provide an accurate assessment of the available warning time to assist in evacuations to high ground. At Grafton (Clarence River) and Maitland (Hunter River) and other towns on major river systems this can be relatively accurately determined from up river gauging stations. However at Yamba this is complicated by the timing of the ocean effects. Generally a 12 hour warning should be available for an impending ocean event.

A detailed survey of evacuation shelters (clubs, hotels) and resources has not been undertaken, this would be undertaken by the SES as part of their Flood Evacuation Plan. The Plan would need to assess where evacuees would be accommodated and what resources (food, water, beds, medical) are likely to be available. If the flood happened during the peak holiday season it is likely that accommodation and resources would be extremely stretched. If road access was cut to the Pacific Highway for a long period (loss of bridge or road) food would be quickly in short supply. The SES Flood Evacuation Plan would need to address this issue.

## **OUTCOMES**

The SES are currently preparing an Evacuation Plan for Yamba and other villages along the Clarence River. Consideration should be given to the additional floor level, flood level and flood related data provided in this report. Priority should be given to the implementation of this plan once completed, which will involve ongoing community education and awareness.

## **ACTIONS**

An Evacuation Plan for Yamba residents to high ground should be completed and made available to the residents of Yamba as well as local authorities (such as the Rural Fire Services). The key features would include:

- incorporating floor and flood related data contained in this report,
- food and accommodation requirements,
- evacuation routes,

- timeframe for evacuations,
- implications of ocean inundation.

### 4.3.3 Public Information and Raising Flood Awareness

#### DESCRIPTION

The success of any flood warning system and the evacuation process to high ground within Yamba depends on:

*Flood Awareness:* How aware is the community to the threat of flooding? Has it been adequately informed and educated?

*Flood Preparedness:* How prepared is the community to react to the threat? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?

*Flood Evacuation:* How prepared are the authorities and the residents to evacuate households to high ground to minimise damages and the potential risk to life? How will the evacuation be done, where will the evacuees be moved to within Yamba?

#### DISCUSSION

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

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

- *Frequency and impact of previous floods.* A major flood causing a high degree of flood damage in relatively recent times (previous few years) will increase flood awareness. If no floods have occurred, or there have been a number of small floods which cause little damage or inconvenience, then the level of flood awareness may be low. The recent floods of May 1996 and March 2001 means that the community generally has a medium level of awareness at this time. The level of awareness would probably be higher if these floods had caused a greater hazard at Yamba.

- *History of residence.* Families who have owned properties for generations will have established a considerable depth of knowledge regarding flooding and a high level of flood awareness. A community which predominantly rents homes and stays for a short time will have a low level of flood awareness. It would appear that there is a mixture of residents at Yamba, with an older community on Yamba Hill (which is flood free) and newer development on the lower areas. There are also a number of tourists in the town at any one time, with the population doubling during the Christmas season and they would not be familiar with the hazard. Furthermore, they are the people most likely to attempt to evacuate from the town in order to prevent being isolated.
- *Whether an effective public awareness program has been implemented.* It is understood that no large scale awareness program has been implemented, however the SES and Council have made available booklets on how to deal with flooding.

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

A major hurdle is often convincing residents that major floods (larger than March 2001 or May 1996) will occur in the future.

## **OUTCOMES**

Based on feedback and general discussions, the residents at any one time (permanent or visitors) of Yamba have a low level of flood awareness and preparedness. This is due to a number of factors including:

- highly mobile population (the 2001 Census indicates that 50% of the population have moved within a 5 year period),
- relatively long time since last event (March 2001),
- no history of major flooding or visual indicators (levees, signs) that flooding will affect Yamba.

The SES has a medium level of awareness of the problem and the requirements necessary to effect evacuations. As the time since the last significant flood (March 2001) increases, the direct experience of the SES units with historical floods will diminish. It is important that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program. Table 3 provide examples of methods that can be used.

**Table 3:** Flood Awareness Methods

Method	Comment
Letter/Pamphlet from Council	These may be sent (annually or biannually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of subsidies, changes to flood levels or any other relevant information.
School Project or Local Historical Society	This provides an excellent means of informing the younger generation about flooding. It may involve talks from various authorities and can be combined with topics relating to water quality, estuary management, etc.
Displays at Council Offices, Library, Schools, Shopping Centres, Local Fairs	This is an inexpensive way of informing the community and may be combined with related displays.
Historical Flood Markers or Depth Indicators on Roads	Signs or marks can be prominently displayed in parks, on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators on roads advise drivers of potential hazards.
Articles in Local Newspapers	Ongoing articles in the newspapers will ensure that the problem is not forgotten. Historical features and remembrance of the anniversary of past events make good copy.
Collection of Data from Future Floods	Collection of data assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible.
Types of Information Available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the 149 Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, regarding flood information currently available, how it can be obtained and the cost.
Establishment of a Flood Affection Database	A database would provide information on (say) which houses require evacuation, which roads will be affected (or damaged) and cannot be used for rescue vehicles, which public structures will be affected (e.g. sewage pumps to be switched off, telephone or power cuts). This database should be reviewed after each flood event. It could be developed by various authorities (SES, Police, Council).
Flood Preparedness Program	Providing information to the community regarding flooding helps to inform it of the problem and associated implications. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program would ensure that the community is adequately prepared. The SES would take a lead role in this.
Foster Community Ownership of the Problem	Flood damages in future events can be minimised if the community is aware of the problem and takes steps to find solutions. For example, Council should have a maintenance program to ensure that its drainage systems are regularly maintained. Residents have a responsibility to advise Council if they see a maintenance problem such as a blocked drain or a flood gate that is jammed. This process can be linked to water quality or other water related issues including estuary management.

**ACTIONS**

A Flood Awareness Program should be implemented.



## 4.4 Property Modification Measures

### 4.4.1 Development Control Planning & Flood Planning Levels

#### DESCRIPTION

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

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

Development controls for Yamba are included in a number of planning documents including the Maclean Local Environmental Plan 2001, and the recently exhibited draft Development Control Plans for the region.

#### DISCUSSION

The following issues need to be addressed when considering flood related development control policies.

- **Ensure Adequate Access:** Emergency access during times of flooding is one of the key problems for Yamba, with the sole road into/out of Yamba to the Pacific Highway cut during floods (approximately 10y ARI or greater) as well as a number of internal roads. This issue needs to be addressed to ensure safe evacuation to high ground within Yamba is possible in times of flood. An alternative is to provide vertical evacuation within the building (i.e. constructing two storey buildings with the 2<sup>nd</sup> floor dry in the PMF). Vertical evacuation would need to be discussed with the SES.
- **Fill (or excavation) in the Floodplain:** Filling of land for development can result in it no longer being flood liable, however it can also affect flow patterns or even cause flood levels to rise. These effects are likely to be minimal at Yamba as it is situated at the mouth of a major river system with a large floodplain area. Filling for building pads within existing zoned areas should therefore be permitted as long as it does not affect local drainage issues. The cumulative effects of this method of filling should be monitored (i.e. collected in a database) but are unlikely to present a major concern in the future. However filling on a larger scale such as on land rezoned for development should only be permitted following a rigorous hydraulic and environmental assessment.

- **Building Materials:** Some building materials are less susceptible to damage by floodwaters, or are easier to clean after a flood. By using such materials, flood damages can be minimised.
- **Structural Soundness when Inundated:** Floodwaters can impact upon the structural soundness of buildings in a number of ways relating to flow velocities, depths and associated debris loads. These should all be considered in relation to certification of the soundness of structures for the local hydraulic conditions.
- **Fencing:** Fences, whether solid or open, can impact upon flood behaviour by altering flow paths. This impact will depend upon the type of fence and its location relative to the flow path. In Yamba this is unlikely to be a significant issue for Clarence River flooding but is of relevance for local catchment runoff.
- **Public Assets:** It is essential that all public assets which may be damaged by floodwaters are located to minimise (or hopefully eliminate) such damage. Of particular concern is the proposed sewerage system for Yamba which is currently being designed. Council must ensure that adequate flood protection is provided.
- **Flood Planning Levels:** The flood planning level (FPL) is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in the flood affected areas must be built. The FPL includes a freeboard above the design flood level. It is common practice to set minimum floor levels for residential buildings as this reduces the frequency and extent of flood damages. Freeboards provide reasonable certainty that the level of risk exposure selected (by deciding upon a particular event to provide flood protection for) is actually provided. It is common practice throughout NSW to use a FPL of the 100y ARI event plus a 0.5 m freeboard (i.e. 2.84 mAHD at Yamba). However, as adopted in the Maclean Local Environmental Plan (2001) areas zoned 2(a), 2(b) and 2(t) within Yamba (and Iluka) have a FPL of the 100y ARI event plus 0.3 m. It is recommended that this be altered to the 100y ARI level plus 0.5 m for consistency, adoption of best practice and to minimise confusion/local objections. Similarly, stipulating a minimum floor level-above-ground for house pads (say 0.3 m) will minimise the risk of local drainage issues.
- **Effect on Local Drainage:** The proposed development should not produce a significant adverse impact on local drainage.
- **Basement Car Parks:** Basement car parks in the floodplain represent a significant risk to life and damage if inundation occurs. Council should ensure a suitable Flood Planning Level is applied compatible with the level of flood risk.

- **Rezoning Land:** In some flood prone areas rezoning of land has been undertaken to eliminate further development and/or to promote redevelopment of existing low lying properties with development at a higher level. Generally some form of rezoning to a higher density is required to “entice” developers to purchase low lying properties and to achieve the same or greater number of houses on a smaller land area. This measure is probably not appropriate for Yamba due to the nature of the existing residential development in the flood liable parts of the township. The existing residents have chosen to live in this area because they value the quality of lifestyle. This is likely to be significantly changed if detached houses are replaced with high rise units or similar. The proposed development at West Yamba would involve rezoning land from Rural Investigation to a combination of residential, environmental conservation, industrial and business zones. This is discussed further in Section 6.
- **The Grafton and Lower Clarence Floodplain Risk Management Plan (Reference 7):** This report recommended several planning measures (Section 6.1.7 of the report) and all these measures are endorsed in this present study.

## OUTCOMES

Development control planning can reduce the effects of flooding on future development by minimising flood damages and managing risk. In some areas where the FPL or other criteria can only be achieved at considerable additional cost, there is community resistance to implementing these measures. However at Yamba these measures are unlikely to involve such resistance.

## ACTIONS

Draft Development Control Plans for the Maclean Shire went on Public Exhibition for the entire shire from August to September 2006. These plans included Yamba, and stipulated that the FPL for residential properties in areas zoned 2(a), 2(b) or 2(t) is the 100y ARI design event plus 0.3 m freeboard. Alterations to these plans should be made so that the new FPL is the 100y ARI event plus 0.5 m freeboard (2.85 mAHD) and minimum floor-above-ground level of 0.3 m. Consideration should be given to other measures discussed above including:

- ensuring adequate access,
- effects of fill on flood levels,
- building materials,
- structural soundness of buildings,
- fencing,
- public assets,
- basement car parks,
- effect on local drainage,
- planning measures (Section 6.1.7) recommended in Reference 7.

## 4.4.2 Controls on Caravan Parks in the Floodplain

### DESCRIPTION

There are currently three caravan parks located at Yamba; Blue Dolphin Holiday Resort, Yamba Waters Holiday Park and Calypso Holiday Park (Figure 2). Whilst these are referred to as caravan parks it is recognised that much of the accommodation may be in cabins. An accurate estimate of flood damages on caravan parks is not possible, due to the large variability in the number of vans at any point in time, as well as the potential for vans to be moved during times of flood.

Caravan parks within the floodplain present their own unique problems, these may include:

- there is generally poor access with a single entrance/exit which may be controlled by gates,
- only a poor (or no) site map is generally available to show the internal road system or the types of vans,
- fixed annexes which may contain high cost equipment such as freezers or stoves,
- there is poor internal lighting which may fail during a flood,
- there is generally no flood emergency plan or it has not been tested recently,
- there is a problem in communicating to the residents due to the lack of or failure of the public address system or telephone network,
- short term residents will have little flood awareness of the flood risk or damage minimisation measures,
- a large number of vans may be vacant thus increasing the workload and possible risk to life for the “rescuers” involved with removing the vans,
- there is the risk that vans may float and crash into each other or obstruct exit routes,
- caravans have little structural integrity and thus can easily be damaged by flowing water,
- the internal fittings (cupboards, fridges, beds) are usually non-removable and made from materials quickly damaged by floodwaters.

### DISCUSSION

In theory caravans can be easily moved to high ground in a flood, however, in practice experience has shown that this is unlikely to occur for some of the above reasons.

The Clarence River has a much slower rate of rise than a small river system and there is nearby high ground where vans could be moved (however access roads do become inundated during times of flooding). In events up to the 20y ARI the risk to life is low. In larger events the risk increases significantly as vans may “float” and crash into each other.

Some Councils have special provisions for caravan parks on the floodplain such as:

- rapid knock down annexes,
- quick release ties on the vans to prevent them floating away,
- an effective evacuation strategy documented in a Flood Action Plan,
- restrictions on the type of vans, e.g. untowable vans not permitted in certain areas, no rigid annexes,

- specific inclusion of caravan parks in the SES Local Flood Plan.

At present there is no proposal for a new caravan park within the study area. Should this arise a detailed review of the flood hazard is required as part of the development approval process.

## **OUTCOMES**

Caravan parks on the floodplain can represent a significant hazard during a flood. This issue should be investigated further through a detailed inspection by the park manager and the SES to accurately assess the hazard. Following this, consideration should be given to implementing adequate safety provisions which would probably mean updating their existing flood evacuation plan. Consideration should also be given to introducing some of the special provisions indicated above. At a minimum “at risk” parks should be clearly identified in the SES Local Flood Plan.

One of the major issues with implementation of an evacuation plan for caravan parks is determining the level of responsibility between the caravan park owners, the Council and the SES. This would need to be agreed upon between the three parties and formulated into some form of agreement.

## **ACTIONS**

The owners of Blue Dolphin Holiday Resort, Yamba Waters Holiday Park and Calypso Holiday Park should prepare/update an Evacuation Plan for the sites and they should be reviewed every two years or after a significant flood. Council, the park owners and the SES need to agree upon the level of responsibility for implementation of such a plan. A flood hazard assessment is required as part of the development approval process for a new caravan park in the floodplain.

### **4.4.3 House Raising**

#### **DESCRIPTION**

House raising has been widely used throughout NSW to eliminate inundation from habitable floors. However it has limited application as it is not suitable for all building types. It is also more common in areas where there is a greater depth of inundation than at Yamba and raising the buildings allows creation of an underfloor garage or non-habitable room area.

#### **DISCUSSION**

House raising is suitable for most non-brick single storey buildings on piers and is particularly relevant to those situated in low hazard areas on the floodplain. The benefit of house raising is that it eliminates inundation to the height of the floor and consequently reduces the flood damages. A number of houses (approximately 14) have been identified on Figure 4 as having the potential to be raised, however more information regarding construction materials and cost effectiveness is required before definitive recommendations can be made. An indicative cost for house raising is \$50,000.

An alternative to house raising for buildings that cannot be raised is flood proofing or sealing of the entry points to the buildings. This measure has the advantage that it is generally less expensive than

house raising and causes less social disruption. However this measure is really only suitable for commercial and industrial buildings where there are only limited entry points and aesthetic considerations are less of an issue. Based upon our experience we do not consider flood proofing a viable measure for residential buildings in Yamba.

The Grafton and Lower Clarence Floodplain Risk Management Plan (Reference 7) considered house raising in some detail and recommended a partial subsidy scheme (i.e. only part of the cost is paid) for the valley (300 dwellings at a total cost of \$4.5M or \$15,000 each).

## **OUTCOMES**

House raising could be a viable means of flood protection at Yamba for a limited number of properties. In most cases, the building material prevents the measure from having a widespread application at Yamba.

## **ACTIONS**

House raising should be further investigated for those houses identified on Figure 4 (approximately 14), and where appropriate, included in the Yamba Floodplain Risk Management Plan. The final scheme may be either a full subsidy or a partial subsidy scheme as proposed in Reference 7. If the levee is constructed house raising should not be undertaken unless the house does not receive protection from the levee.

## **5. FUTURE DEVELOPMENT - INTENSIFICATION**

### **5.1 General**

Consideration of future development in Yamba has been included as part of this Floodplain Risk Management Study as it is inevitable that some will occur. Yamba has a population and tourism growth in the order of 3% per annum, and combined with similar rates throughout other towns in the Clarence Valley there is increasing pressure to develop new areas. The only options for future development at Yamba are intensification within existing zoned land or green development at West Yamba. This chapter details the issues that need to be addressed prior to approving any future development intensification within the existing urban area. Issues relating to the proposed development of West Yamba are discussed in Chapter 6.

Development intensification within the existing town limits involves either the rezoning of residential/rural residential land to allow for higher densities (for example, from single dwellings to duplexes/units or from rural residential to residential lots etc.) or as a result of intensification within the existing zoning (dual occupancies). It results in a change in the appearance of the town as well as placing increased pressures on the existing infrastructure.

### **5.2 Key Issues for Development Intensification**

#### **5.2.1 Emergency Access**

Emergency access is a key concern within the existing developed areas at Yamba as the main road from the Pacific Highway, as well as some internal roads, are inundated during flood events (approximately 10y ARI). This leads to problems with isolation of the township during floods, even though house floors may not be inundated.

Development intensification would result in a larger population being isolated during a major flood event. This would add strain on the SES and may stretch existing resources (in terms of temporary housing, food/water supplies etc.). New development resulting in a significant increase in the town population should not be approved unless an emergency access route, to either high ground within Yamba or away from the town, is provided. This access should be flood-free in events up to the 100y ARI event. This is likely to require modification of public-owned roads as well as private property (driveways etc.).

## **5.2.2 No Hydraulic/Hydrologic Impact on Existing Development**

Any new development should not produce a significant adverse impact upon existing development, in terms of increasing flood levels, altering flow paths or causing an adverse effect on local drainage. Filling of house pads or lots is likely to occur with any new development. It should be ensured that this filling does not result in local drainage issues or increased flood levels. Similarly, an intensification of development may result in more of the lot area being used for buildings (less gardens, less pervious areas) which may affect local drainage flow paths or infiltration areas. All development should be compatible with the principles of water sensitive urban design.

## **5.2.3 Evacuation Planning**

As highlighted previously, a key issue with Yamba is the lack of emergency access and thus difficulties with evacuation to high ground within Yamba. Although the SES is permanently located within Yamba, its resources are usually stretched to include other towns along the floodplain (which flood at the same time). The general approach is one of 'self-help' for the majority of residents with the SES only getting involved in extreme situations (such as medical reasons, risk to life, etc.). Any new development should have an appropriate evacuation plan to high ground in case of flooding. This would obviously be linked to providing a flood-free access but should also include resident awareness, identification of evacuation routes to high ground, etc.

## **5.3 Floodplain Risk Management Measures**

As identified above the key issues with development intensification are ensuring a flood-free access to facilitate evacuation to high ground and that the development does not produce a significant adverse impact upon flood levels and local drainage for existing development. Where appropriate, all proposed management measures adopted for the protection of existing development at Yamba should also be applied to new development when it occurs. Specific management measures for new development are considered below.

### **5.3.1 Flood Modification Measures**

The use of flood modification measures to facilitate future development is generally not undertaken. It is preferred that future development is designed in a manner that eliminates the need for such measures, and for this reason flood modification measures were not considered further.



### 5.3.2 Response Modification Measures

The response modification measures recommended for existing development at Yamba (regarding flood warning, public information and raising community awareness) would be appropriate for new development.

Prior to approving any new development a comprehensive evacuation plan needs to be developed by the SES. The plan should consider evacuation routes to high ground as well as ensuring that emergency evacuation sites (such as clubs, etc., on Yamba Hill) would be able to accommodate the increased population, or alternatives need to be located.

### 5.3.3 Property Modification Measures

The use of planning controls for new development would reduce the impacts of flooding. At a minimum the controls should ensure that the:

- lowest habitable flood is at 100y ARI + 0.5 m level (2.85 mAHD),
- floor pad should be a minimum of 0.3 m above ground level (to reduce local drainage issues),
- access from the property must be flood-free up to the 100y ARI event and traversable in events greater than this, up to the PMF. An alternative is to provide for vertical evacuation within the building (i.e. constructing two storey buildings with the 2<sup>nd</sup> floor dry in the PMF),
- key services such as power and sewerage remain operable during times of flood,
- local drainage issues are adequately addressed and do not adversely impact upon existing development,
- consideration is given to building material used/fences, etc. in the floodplain.

These issues have been discussed in greater detail in Section 4.4.1.

## 5.4 Conclusions

The main issues with development intensification of existing residential/rural residential lands is ensuring that the “new” residents experience minimal flood damages and risk to life in events up to the 100y ARI +0.5 m. The general principle is that the SES and other rescue organisations are “set up” to cater for the demands from the presently zoned urban community. However they do not have the capacity to cater for “additional” urban densities. Thus if the intensification can be achieved with no additional demands on the SES this type of development can be undertaken.

The necessary flood related controls for approval of development intensifications on the floodplain are included in Section 4.4.1.

## **6. FUTURE DEVELOPMENT - PROPOSED REZONING AT WEST YAMBA**

### **6.1 Background**

West Yamba is a 690 hectare site of undeveloped land to the west of the existing township of Yamba (Figures 1, 6 and 7). Rezoning of this land has been part of Council's development strategy since its adoption into the Strategic Land Use Plan in 1995. The land is flood liable and would require appropriate floodplain management measures to overcome this.

Council commissioned a two-stage Local Environmental Study (LES) to be undertaken for West Yamba. Stage 1 was completed in 1996 and undertook an environmental assessment of the 690 hectare site. The study concluded that about 50% of the area was of high conservation value and 25% of medium conservation value, leaving approximately 170 hectares as having urban development potential. Stage 2 was completed in 1997 and focussed on these 170 hectares. The study recommended that managed development at West Yamba for a population of 4,400 should occur when upgrading of the Yamba sewerage treatment works has been completed. In 1998 Council adopted in principle the findings of the West Yamba LES.

Since then there have been significant changes to the planning context, as well as additional feedback from relevant government agencies and the community which warranted a review of the LES. This was undertaken by Council in 2003. One significant outcome was the reduction in the ultimate population to 2,000 - 2,500 people. This reduction takes into account the community feedback received from the "Yamba in the Future" survey undertaken in 2001. The survey asked the respondents to consider four development futures for Yamba. The majority (68%) of respondents expressed support for some growth to the town, with declining support for scenarios as population increased.

There are a number of issues with the proposed development at West Yamba. One major obstacle is that the land is flood liable and will require extensive amounts of fill to overcome this. In accordance with the North Coast Regional Control Plan, the rezoning of flood liable land can only proceed after the completion of a Floodplain Risk Management Plan.

In August to October 2006, a draft Local Environmental Plan (LEP) for West Yamba went on public exhibition.

### **6.2 Proposed Land Use**

West Yamba covers an area of 690 hectares of land highlighted on Figure 6 and is currently zoned Rural Investigation. In 1999, 11 hectares of land was rezoned for industrial purposes and just under five hectares for 3(a) Business to meet the needs of the community. The current proposed use of the remaining land is shown on Figure 6 and Table 4.

**Table 4:** Proposed Rezoning of West Yamba

<b>Zone</b>	<b>Area (ha)</b>
Urban Residential	106
Rural Residential	40.2
Special Uses	4.1
Open Space	3.8
Environmental Protection	449.3
Environmental Protection Buffer	30.9
National Parks	41.3
<b>TOTAL</b>	<b>675.6</b>

The existing topography of the land generally lies between 1 - 1.5 mAHD and is flood liable (Figure 7) - the 100y ARI flood level at Yamba is 2.34 mAHD. To overcome this, it is proposed that the land be filled. Preliminary hydraulic modelling suggests that the impacts of this fill can largely be negated by the development of a designated floodway area (Figure 6).

### 6.3 Issues

There are a number of issues regarding the proposed development at West Yamba, but those of direct relevance to this study are:

- source and impacts of fill,
- difficulties with the evacuation of residents to high ground, within the new development or within Yamba township,
- potential environmental impacts,
- new development in the floodplain and the use of flood mitigation measures to facilitate new development,
- compliance with relevant policies.

A comprehensive assessment of these issues is beyond the scope of the present study however their significance in relation to the proposed development is discussed in the following sections. These issues should be assessed and resolved prior to rezoning of the land for development. Floodplain risk management measures are discussed in Section 6.4.

#### 6.3.1 Fill

The LES Review estimated that an average of 0.8 m of fill is required across the site to meet current Council guidelines. The fill would be graded within the development to cater for local drainage. This equates to fill requirements of 1.3 million m<sup>3</sup>. Such a large volume of material raises questions regarding the source and possible environmental impact of the fill.

**Source of fill:** The original LES (Stage 2) assumed that the fill could be sourced from dredging of the Port of Yamba. Since then, approval requirements have changed and it unlikely that such a large volume would be approved. There is valid operating consent for Newman's and Tabbimobile quarries that has been approved for extraction of 200,000 tonnes of fill sand per annum. There are no known time limits on the consent nor any known limitations to the supply.

This site confirms that the demand for fill has the potential to be met from an approved source. However, transporting such a large amount of fill into Yamba creates other problems such as the effects of trucks on local roads, traffic conditions and noise environment, etc. Based on the estimated 1.34 million m<sup>3</sup> of fill required for the West Yamba development and the extraction capacity of the above site being 200,000 tonnes per annum (which equates to approximately 140,000 m<sup>3</sup> of compacted fill) it would take some 9.5 years to transport the necessary quantity of fill into Yamba. Furthermore, assuming that trucks were operable 52 weeks a year and have a 20 tonne haulage, this would equate to almost one truck trip every six minutes (includes return trip) for eight hours a day, five days a week over that 9.5 year period.

The draft LEP for West Yamba allows for the source of fill to remain unknown until the development application stage (that is, after rezoning of the land has occurred).

**Impacts of fill:** As mentioned previously, transporting fill into Yamba will impact local roads, traffic and the noise environment. However there would be additional impacts on the environment from which it was sourced as well as where it is placed. These latter impacts have been addressed elsewhere.

Preliminary investigations into the hydraulic impacts of the fill were undertaken as part of the LES Review. The two-dimensional hydraulic model established as part of the Lower Clarence River Flood Study Review (Reference 2) was modified to assess the hydraulic impacts at Yamba. The model used a coarse (60 m) grid and concluded that flood level impacts could be negated by the use of a floodway (Figure 6). This model was only run for the 100y ARI design flood event.

Although this modelling addresses the broadscale potential hydraulic impacts of filling, it does not address other concerns such as:

- are there affects on neighbouring areas in floods greater or smaller than the 100y AIR event?
- does the use of a floodway create other issues such as flood hazard?

These would need to be addressed with more detailed hydraulic modelling at a subsequent stage. It is possible that there are other environmental impacts of the fill being used at West Yamba. Should they arise they would need to be addressed as appropriate. An Environmental Protection License will not be required for these works.

### 6.3.2 Evacuation Planning

Even if internal roads of West Yamba are built above the 100y ARI flood level, residents in the area will still be isolated in times of flood as Yamba Road (sole road in/out of Yamba) becomes inundated in events greater than approximately the 10y ARI. Similarly, although house floors would be built above the 100y ARI flood level (with a freeboard), it is not sufficient to assume all residents will be safe within their homes - people may need to leave for medical reasons, or to collect children etc. Thus evacuation to high ground in Yamba remains an unresolved issue for the new development.

Some suggestions for addressing this issue are forming a flood free road to high ground in Yamba (possible as part of the Yamba bypass) and/or creating mounds above the PMF within the development (the PMF is approximately 1 m above the 100y ARI flood level). These refuges are generally not supported by the SES but do allow residents to remain “dry” even in a PMF. A community building or such could be constructed on these mounds to act as shelter.

If either of these approaches are undertaken then they would need to be completed at the same time as the first development is completed and would require significant “up front” costs.

### 6.3.3 Environmental Impacts

This Floodplain Risk Management Study is primarily concerned with environmental issues relating to flooding. Other impacts are considered in other documentation. Thus the following provides only a brief comment on these other impacts.

The LES and LES Review concluded that 340 hectares of the land at West Yamba exhibit high flora and fauna conservation values and/or significant aboriginal archaeological and cultural value. A further 180 hectares was classed as having medium value. The assessment was based on aerial photography with some limited ground truthing. It did not include rare or threatened species, or fauna (and its habitat). The National Parks and Wildlife Service (NPWS) commented in the LES Review that “the flora survey conducted for Stage 1 is considered insufficient for the development of detailed planning strategy for West Yamba”.

To address this concern the LEP proposes that a flora and fauna assessment under the EP&A Act would be required to form a Master Plan to be approved by Council prior to lodgement of a Development Application (DA) for the subdivision.

As far as possible the process should endeavour to achieve a holistic strategy to ensure that the development is integrated and does not create problems when attempting to address cumulative issues (such as potential impacts of increased human activity - nutrients, sedimentation, runoff - on the nearby exclusion zones during a flood or ocean event when WSUD capacities are exceeded).

Most of the areas of high heritage and cultural significance coincide with areas of high botanical and habitat significance in the eastern part of the study area and have been adequately identified. However if any expansion of the Angourie water reserve was required then a detailed site specific archaeological assessment would be needed. An assessment of three recorded sites north of Sullivan Road requires further investigation prior to any DAs being granted.

### **6.3.4 New Development in the Floodplain and the use of Flood Mitigation Measures to Facilitate New Development**

One key consideration in assessing the appropriateness of future development at West Yamba is whether new development on flood liable land and the use of flood mitigation measures to facilitate this new development is compatible with current floodplain management practice. The only land available for new development is this area at West Yamba, however that in itself does not necessarily justify the proposal. Developing on flood liable land has environmental, social and economic impacts and requires careful consideration. Similarly, although there are ways to manage the flooding problem, it is not possible to completely eliminate the effects of flooding. Thus, by allowing development the new residents are accepting a certain level of risk.

As the existing township is flood-labile, additional development is adding to this problem, and will exacerbate it to some degree.

### **6.3.5 Compliance with Relevant Policies and Plans**

As part of the LES Review, West Yamba was assessed for compliance with key policies governing the area. The Review considered the West Yamba development to be compliant with the Maclean Shire Council Strategic Land Use Plan and the North Coast Urban Planning Strategy (1995). However there were a number of plans/policies for which some issues remained.

#### *Clarence Valley Settlement Strategy*

- “Requires that urban development is consistent with any floodplain, estuary or coastline management plan and is free of flood or any other environmental hazard”

Urban development at West Yamba does require filling to provide a flood-free development area and the only Floodplain Management Plan completed was Reference 6. This report did not specifically address redevelopment at West Yamba but recommended that further site specific assessments would be required. These have been completed as part of the additional hydraulic modelling (refer Section 6.3.1).

#### *Healthy Rivers Commission Inquiry into NSW Coastal Lakes*

- Lake Wooloweyah is classified as ‘significant protection’ and states that... “*limit any new urban and rural-residential to within existing boundaries of such developed areas. Limit any*

*other type of new development outside such areas to those that are determined as being sustainable, that is, those where any potential adverse impacts can be contained on site. Apply strong controls to ensure that effects are contained.”.*

Development at West Yamba extends beyond the existing development boundaries and it is questionable whether the development can be considered sustainable (use of a finite resource to fill the land). The LES Review considers impacts of the development to be manageable onsite, but it is unknown to what extent this issue was assessed.

In 2006, the Lake Wooloweyah Sustainability Assessment Report (Reference 8) was prepared based on the results of the Coastal lake Assessment and Management (CLAM) tool developed for Lake Wooloweyah. The CLAM model had been developed by the Australian National University as part of the Northern Rivers Catchment Management Authority assessment of sustainable development around coastal lakes and considered a number of different development scenarios and their potential impact on the lake. Five urban development scenarios for West Yamba were addressed, including a no-development option. The scenario most representative of the current draft LEP indicated that there is unlikely to be any impact on any of the 18 values tested. This scenario assumed a population of 2,000 developed with best practice WSUD and ESD principles. Whilst not conclusive, the CLAM provides some confidence that the draft LEP is sustainable in terms of its potential environmental impacts on Lake Wooloweyah.

#### *Coastal Design Guidelines for NSW*

- The Guidelines do not encourage development to be located on lands subject to sea level rise, frequent flood hazard or where cut and fill is required to overcome flood hazard or coastal processes.

West Yamba is subject to the above constraints and according to the Guidelines is therefore not an area encouraged for development.

#### *North Coast REP (clause 45A)*

- Does not allow draft LEP to rezone land to residential resulting in the need for flood mitigation measures, unless justified by a floodplain management plan.

The LEP for West Yamba has already been on public exhibition although there was no Floodplain Risk Management Plan (Reference 6) which specifically addressed this issue. In response to this, Council have commented that this does not apply to draft LEPs that had previously received a Section 65 Certificate, which is the case with the draft West Yamba LEP. Hence the direction does not apply in a statutory sense to the current draft LEP, although by considering the potential implications of development at West Yamba in this FRMS, the process is consistent with the intent of the Direction. Additionally, the Department of Planning have issued the draft LEP with a Section 65 certificate which means that the Department either concur that the draft Plan is consistent with its range of State and

Regional policies or that any inconsistencies are warranted in so far as allowing the draft LEP to be exhibited.

*Grafton and Lower Clarence Floodplain Risk Management Plan (Reference 7)*

This report makes the following statement (Section 6.1.7):

- As a general principle, it is preferable that new urban areas are located outside of the floodplain and intensification of existing urban areas be restricted to a level that can be accommodated within the evacuation capacity of the State Emergency Services.

### **6.3.6 Justification for Development at West Yamba**

In 2001 the former Maclean Shire Council conducted a community survey as part of reviewing and progressing the West Yamba LEP. It was a values based approach that required respondents to consider how the following range of development scenarios may impact on the things they value in their community.

- |             |  |
|-------------|--|
| Scenario 1: | No further urban expansion (38%)                     |
| Scenario 2: | Growth loosely based on draft - LEP (27%)            |
| Scenario 3: | Growth loosely based on double the draft - LEP (21%) |
| Scenario 4: | A higher growth scenario (12%)                       |

The majority (62%) express support for some growth of the town. Respondents were also asked to identify the three most important factors in arriving at their preference. Town character and environmental impacts were dominant although those in support of higher growth placed greater emphasis on employment and economic impacts.

As a result of this survey Council adopted Scenario 2 in their draft - LEP and ensured that the draft LEP address the concerns of those supporting Scenario 1.

Council has previously undertaken a study (not reviewed) that concluded that West Yamba was the most suitable site for further development in the local area.

It has been suggested that provision of a flood refuge within the new development would also assist the existing residents of the area who have no such facility. However for this to be successful access needs to be provided from their existing areas to the refuge. A wharf has also been suggested but such a facility is unlikely to be practical during a flood due to strong winds and wind wave action. Also an elevated water level will make access to/from the wharf extremely difficult and dangerous.



### 6.3.7 Climate Change

Current advice from world experts indicate that climate change will have adverse impacts upon sea level and rainfalls in NSW. Both of which may have significant influence on flood behaviour, depending upon the specific location under consideration.

At Yamba which is at the mouth of the Clarence River, the dominant mechanism determining design flood levels is the ocean influence. Thus it is likely that any increase in design rainfall will not have a large impact on design levels. Unfortunately there is no technical information in the Flood Study to confirm this. The only information available is that a 500y ARI event is 50 mm higher at Yamba than the 100y ARI and this results from a 5% increase in peak flow upstream of Grafton. Thus a 10% increase in design rainfall might increase flood levels by 100 mm at Yamba. The above methodology is very crude and should only be used as a guide. To date there is no definitive information from the Bureau of Meteorology regarding increases in design rainfalls as a result of climate change.

The impact of a sea level rise is likely to be more significant than any increase in design rainfalls. Also there is more certainty that sea levels will rise as a result of climate change than any increase in flood producing design rainfalls.

The latest (2007) Intergovernmental Panel on Climate Change (IPCC) information suggests sea level rises of between 0.18 m to 0.59 m by between 2090 and 2100 (estimates ignore ice flow melt). Taking into account ice flow melt and recent CSIRO modelling indicates a possible sea level rise of 0.18 m to 0.91 m by between 2090 and 2100.

However there is an opinion amongst coastal experts that the 100y ARI peak ocean level adopted in the 2004 Flood Study (Reference 2) of 2.6 mAHD is conservative and a more realistic level is 2.2 mAHD. Thus it could be argued that the presently adopted peak level is “conservative” and already includes a component that could allow for a climate change increase. A detailed review of ocean levels on the North Coast would need to be undertaken in order to confirm this approach.

It is prudent to include some climate change allowance for setting floor levels and evacuation routes for any significant new development at Yamba. A suggested climate change increase in the 100y ARI event is 0.4 m which would be in addition to the proposed “normal” freeboard of 0.5 m above the 100y ARI design flood level.

Thus the FPL would be:

- 100y ARI level of 2.34 mAHD,
- plus 0.5 m freeboard,
- plus 0.4 m climate change increase in flood level,
- i.e. a FPL of 3.24 mAHD.

The rationale for adopting a 0.4 m climate change increase in the 100y ARI flood level at Yamba assumes:

- a maximum climate change increase of 0.9 m over the lifespan of the project (assumed to be 90+ years),
- a reduction of 0.1 m as the existing 0.5 m freeboard partially accounts for a climate change increase,
- a further reduction of 0.4 m as there is an opinion amongst coastal experts that the adopted design 100y ARI ocean level peak of 2.6 mAHD includes a conservative estimate of wave setup component and a more realistic level is 2.2 mAHD,
- thus 0.9 m increase - 0.1 m - 0.4 m = 0.4 m increase.

## **6.4 Floodplain Risk Management Measures**

As identified above the key flood-related issues are regarding evacuation planning, emergency access and the use of fill. Again, where appropriate, all measures adopted for the existing development at Yamba should also be applied to new development if/when it occurs. Specific management measures for West Yamba are considered below.

### **6.4.1 Flood Modification Measures**

Flood modification measures have not been considered for West Yamba as the development should be designed so that such measures are not required. The exception to this is the use of a floodway, which is included in the overall design, to negate the negative impacts on flood levels caused by extensive filling. Other flood modification measures were not considered.

### **6.4.2 Response Modification Measures**

The response modification measures recommended for existing development at Yamba (regarding flood warning, public information and raising community awareness) would be appropriate for new development.

Prior to approving any new development a comprehensive evacuation plan needs to be developed. The plan should consider evacuation routes to high ground, flood refuge sites, flood preparedness, clean up etc.

It is proposed that a flood refuge above the PMF level be incorporated into the West Yamba development. This is discussed further in Section 6.3.2.

### 6.4.3 Property Modification Measures

The use of planning controls for new development would reduce the impacts of flooding. At a minimum controls to ensure that the following points are met should be incorporated into the West Yamba Development Control Plan.

- lowest habitable floor is at 100y ARI + 0.5 m level,
- floor pad should be a minimum of 0.3 m above ground level (to reduce local drainage issues),
- access from the property to high ground (where residents can remain safe for say 24 hours) must be flood free up to the 100y ARI event with consideration given to evacuation to high ground in the PMF event,
- key services remain operable during times of flood up to at least the 100y ARI +0.5 m level,
- local drainage system designed so as to avoid local ponding, stormwater runoff not to impact on Oyster Channel or Lake Wooloweyah or adversely affect existing development,
- consideration given to building materials used, fences, etc.,
- flood-free emergency access to high ground (where residents can remain safe for 24 hours) must be provided prior to approval of residences,
- the likely increase in design flood levels as a result of climate change (sea level rise) should be incorporated into the above.

### 6.4.4 Other Measures

As an alternative to evacuation of the residents of West Yamba to high ground on Yamba Hill, it has been proposed that an area specifically zoned for flood refuge be incorporated into the West Yamba LEP/zoning map. This area, to be built at or above the PMF level, would need to be of sufficient size to accommodate all the West Yamba residents (giving consideration to additional influxes during holiday periods) for a period of 1 - 2 days. The site should not be used for any secondary commercial purposes although it could be integrated into the overall design through use as open space/community hall etc. Flood-free access to this site from all areas within the West Yamba development must be provided (at least to the 100y ARI event).

This measure, as an alternative to providing flood free access to high ground, would need to be evaluated at the design stage.

## **6.5 Conclusions**

There are a number of flood related issues regarding the proposed West Yamba development. These have been discussed in the previous sections as well as possible floodplain risk management measures. This flood related review does not provide a definitive statement regarding whether the development should proceed or not as the decision by Council requires consideration of other non-flood matters. Should approval be given for the West Yamba development to proceed it must include suitable flood and water related development controls.

## **7. ACKNOWLEDGMENTS**

This study was carried out by Webb, McKeown & Associates Pty Ltd and funded by Clarence Valley Council and the Department of Environment and Climate Change. The assistance of the following in providing data and guidance to the study is gratefully acknowledged:

- Clarence Valley Council,
- Department of Environment and Climate Change,
- Floodplain Management Committee,
- residents of Yamba.

We also acknowledge the valley wide flood planning works undertaken in Reference 7 and the need for consistent flood policies across the Clarence Valley.

## 8. REFERENCES

1. **Floodplain Development Manual**  
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WBM Oceanics, March 2004.
3. Public Works  
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December 1988.
4. Soros-Longworth & McKenzie  
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December 1980.
5. Maclean Shire Council  
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Paterson Consultants Pty Ltd, August 1993.
6. Maclean Shire Council  
**Lower Clarence River Floodplain Management Plan**  
September 1999.
7. Clarence Valley Council  
**Grafton and Lower Clarence Floodplain Risk Management Plan**  
Bewsher Consultants Pty Ltd, June 2007.
8. Clarence Valley Council  
**Lake Wooloweyah Sustainability Report**  
Australian National University, 2006  
Integrated Catchment, Assessment and Management Centre.

## FIGURES



FIGURE 1  
LOCALITY PLAN



IMAGES COURTESY GOOGLE EARTH

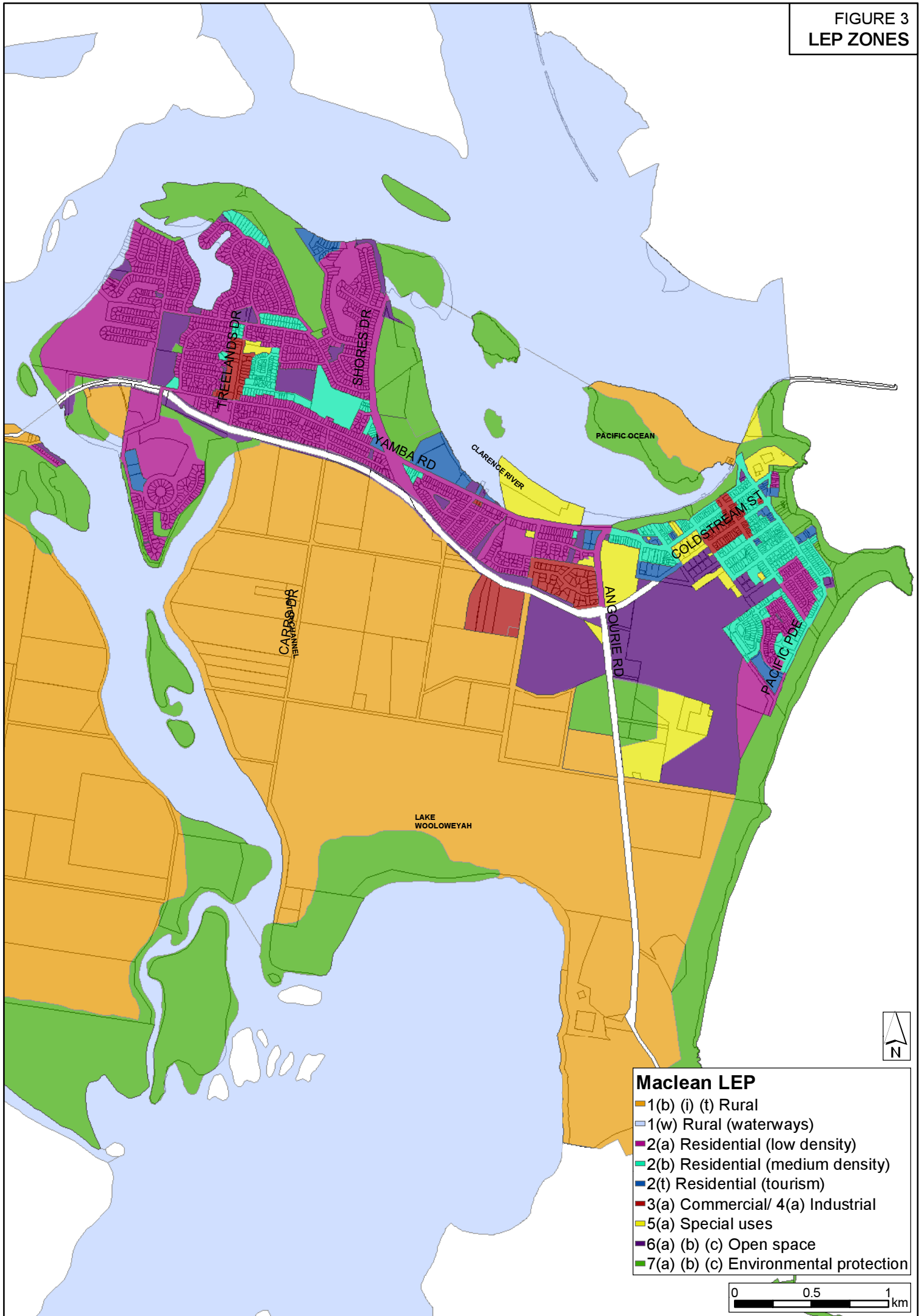




FIGURE 2  
STUDY AREA



FIGURE 3  
LEP ZONES



- Maclean LEP**
- 1(b) (i) (t) Rural
  - 1(w) Rural (waterways)
  - 2(a) Residential (low density)
  - 2(b) Residential (medium density)
  - 2(t) Residential (tourism)
  - 3(a) Commercial/ 4(a) Industrial
  - 5(a) Special uses
  - 6(a) (b) (c) Open space
  - 7(a) (b) (c) Environmental protection

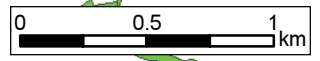
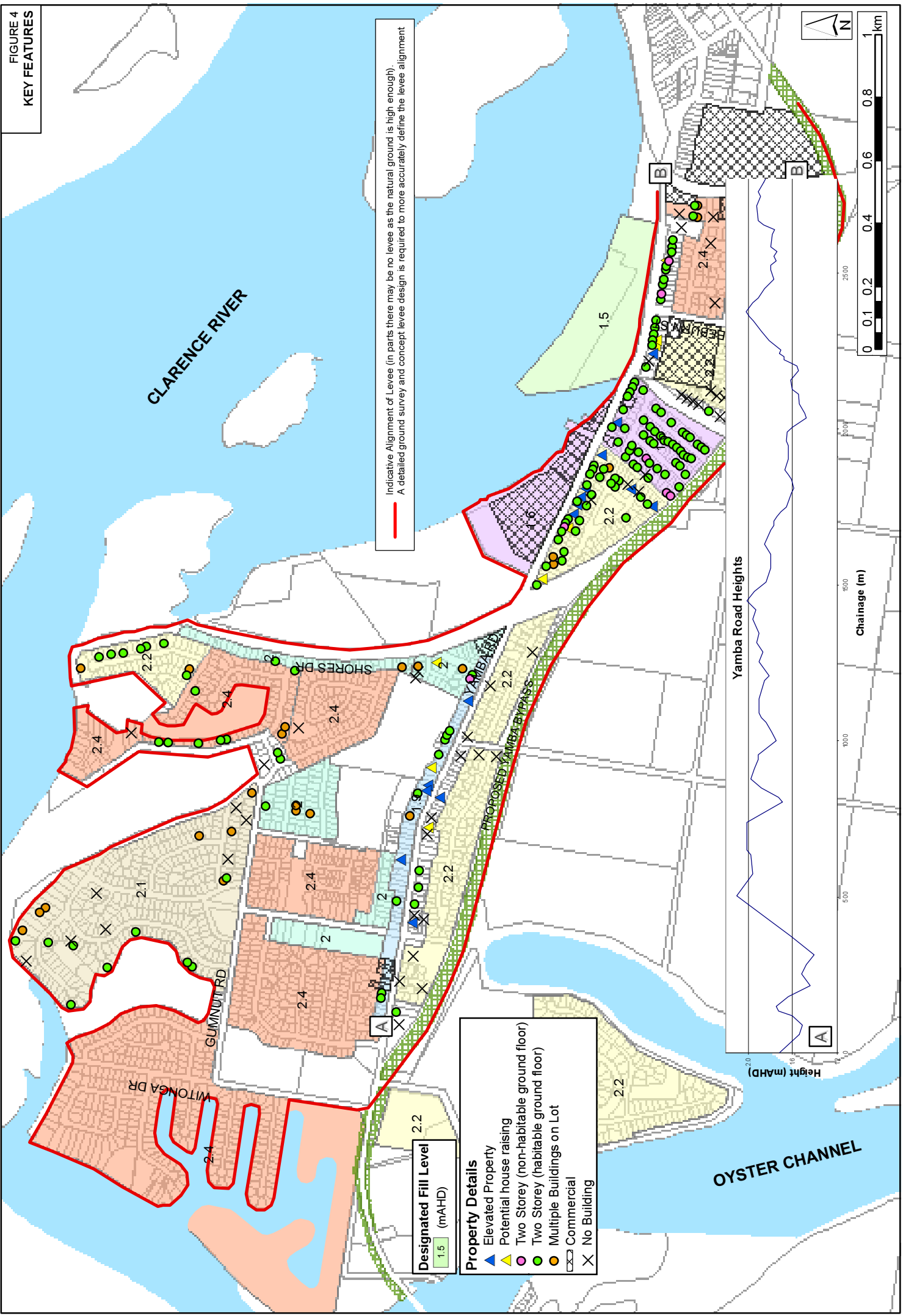


FIGURE 4  
KEY FEATURES



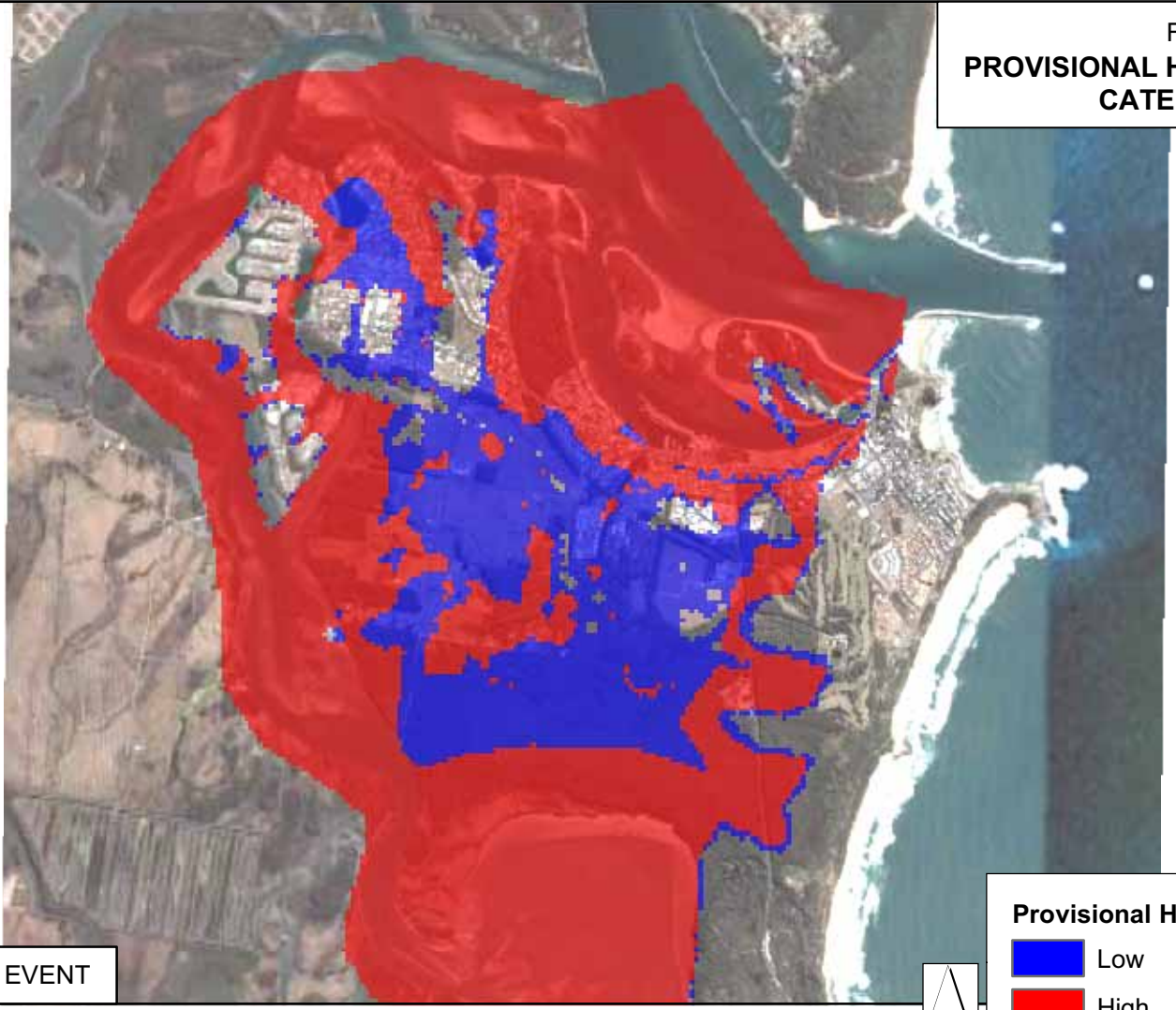
— Indicative Alignment of Levee (in parts there may be no levee as the natural ground is high enough).  
 — A detailed ground survey and concept levee design is required to more accurately define the levee alignment.

**Designated Fill Level**  
 1.5 (mAHD)

- Property Details**
- ▲ Elevated Property
  - ▲ Potential house raising
  - ▲ Two Storey (non-habitable ground floor)
  - ▲ Two Storey (habitable ground floor)
  - ▲ Multiple Buildings on Lot
  - ▢ Commercial
  - × No Building

Note: The property details are based on a field inspection in November 2006 and have not been verified.

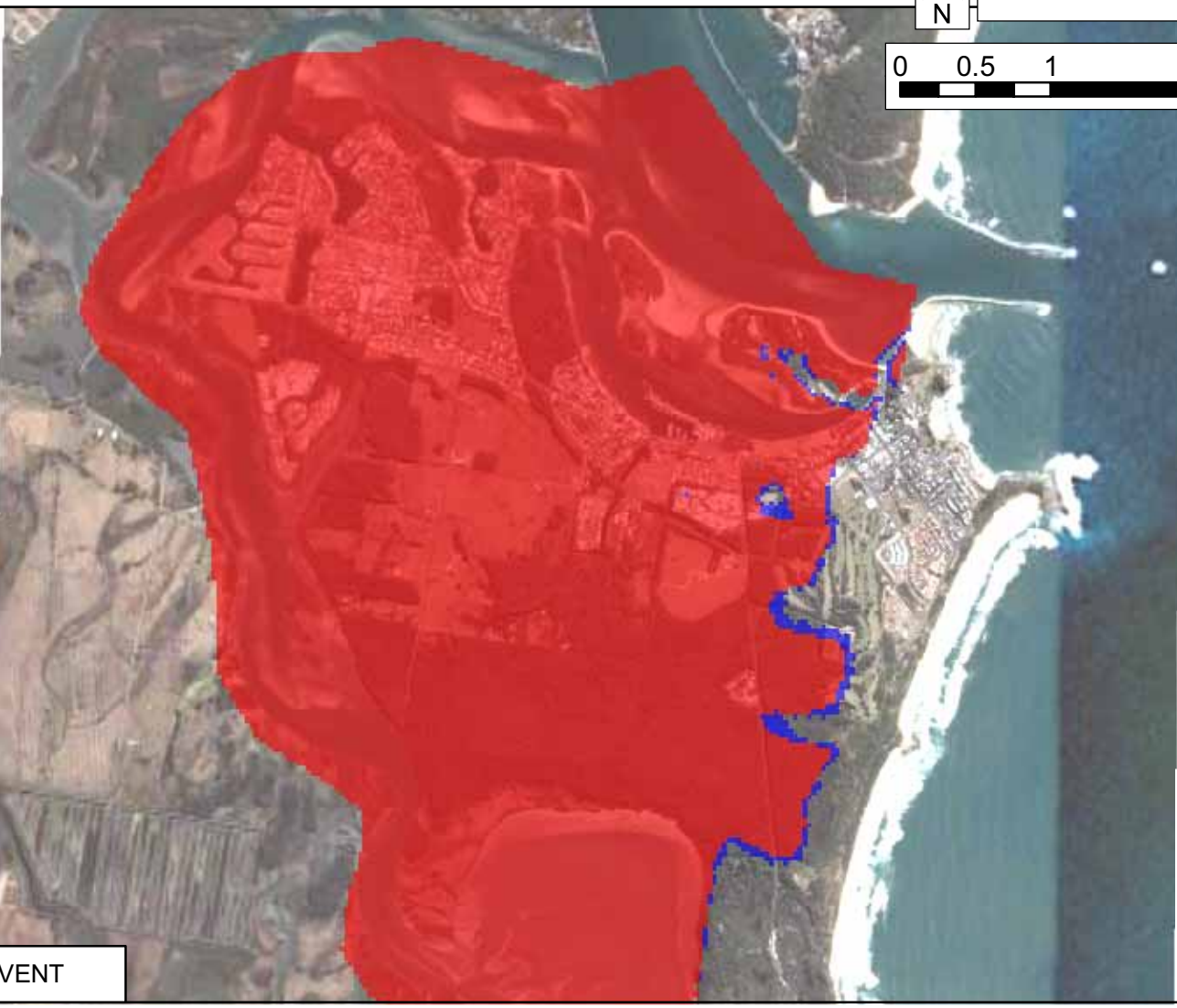
FIGURE 5  
PROVISIONAL HAZARD  
CATEGORIES



100Y ARI EVENT

**Provisional Hazard**

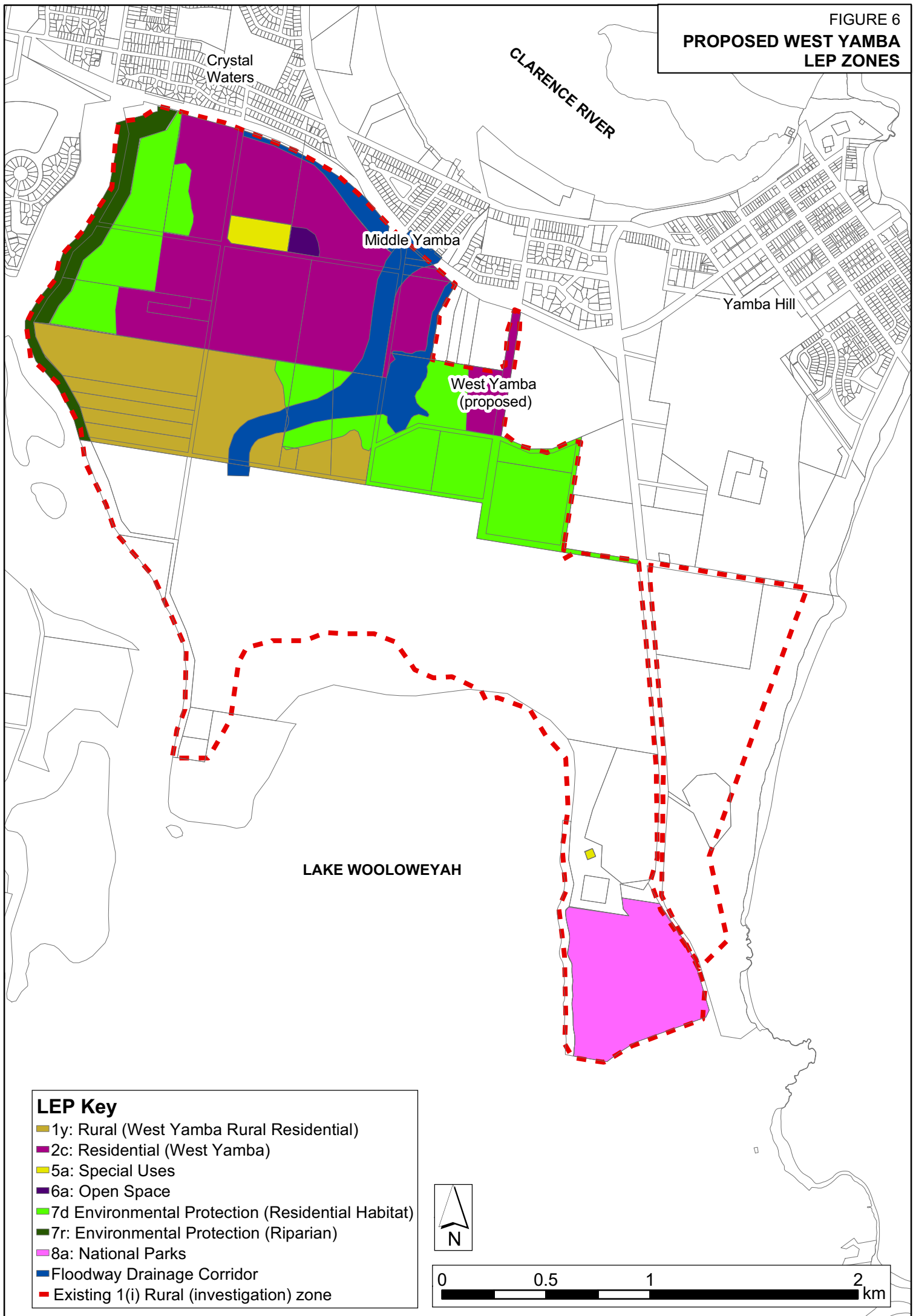
Blue	Low
Red	High



PMF EVENT

Note: Based on results from 2004 Lower Clarence Valley Flood Study Review

FIGURE 6  
**PROPOSED WEST YAMBA  
 LEP ZONES**



- LEP Key**
- 1y: Rural (West Yamba Rural Residential)
  - 2c: Residential (West Yamba)
  - 5a: Special Uses
  - 6a: Open Space
  - 7d Environmental Protection (Residential Habitat)
  - 7r: Environmental Protection (Riparian)
  - 8a: National Parks
  - Floodway Drainage Corridor
  - Existing 1(i) Rural (investigation) zone

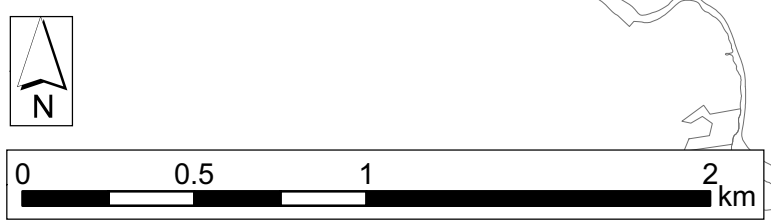
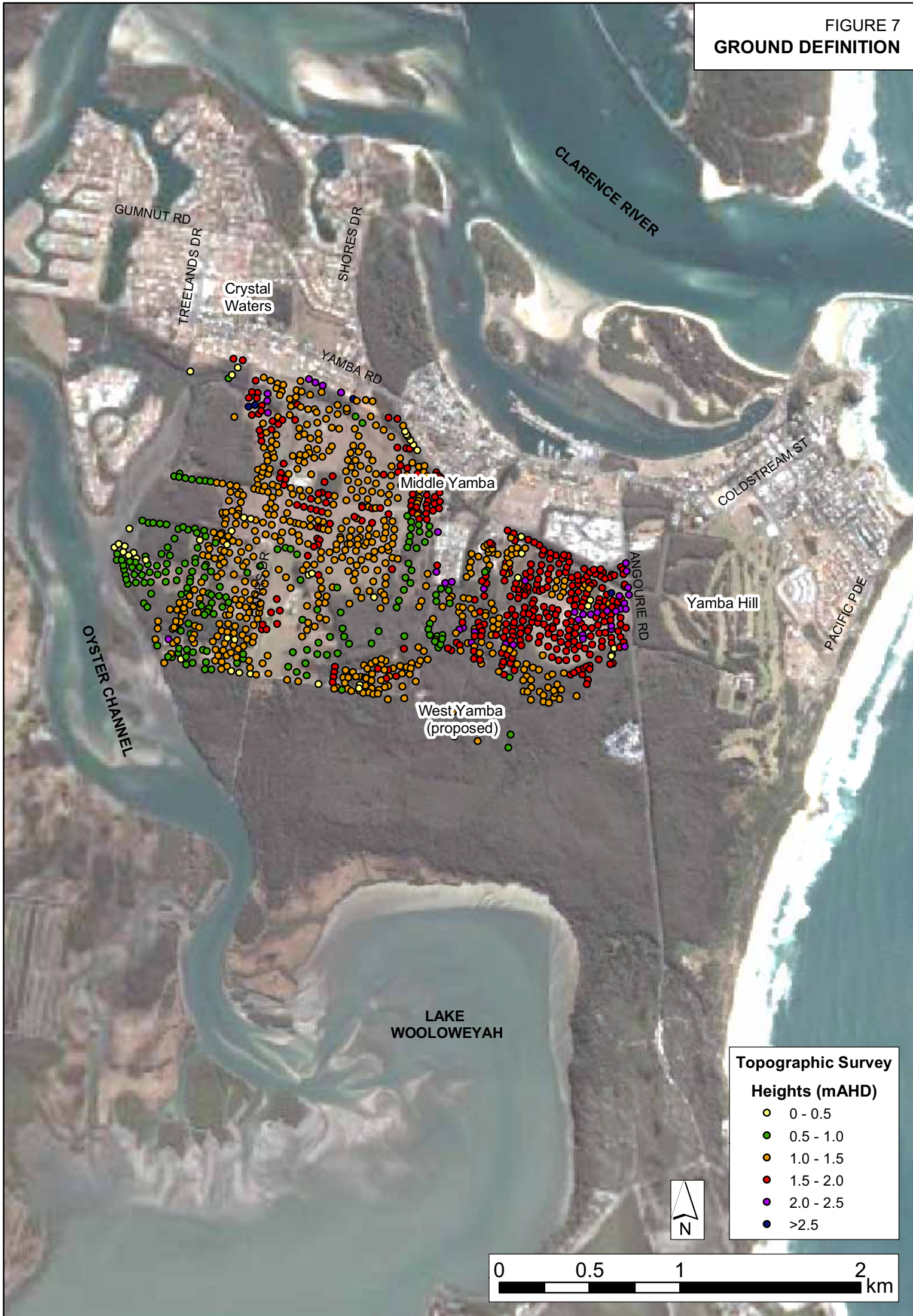


FIGURE 7  
GROUND DEFINITION



## APPENDIX A: GLOSSARY OF TERMS

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## APPENDIX A: GLOSSARY OF TERMS

Taken from the Floodplain Development Manual (April 2005 edition)

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



<b>ecologically sustainable development (ESD)</b>	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
<b>effective warning time</b>	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
<b>emergency management</b>	Arrange of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
<b>flash flooding</b>	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
<b>flood</b>	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
<b>flood awareness</b>	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
<b>flood education</b>	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
<b>flood fringe areas</b>	The remaining area of flood prone land after floodway and flood storage areas have been defined.
<b>flood liable land</b>	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
<b>flood mitigation standard</b>	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
<b>floodplain</b>	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
<b>floodplain risk management options</b>	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
<b>floodplain risk management plan</b>	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
<b>flood plan (local)</b>	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
<b>flood planning area</b>	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual.
<b>Flood Planning Levels (FPLs)</b>	FPL's are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual.

<b>flood proofing</b>	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
<b>flood prone land</b>	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
<b>flood readiness</b>	Flood readiness is an ability to react within the effective warning time.
<b>flood risk</b>	<p>Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.</p> <p><b>existing flood risk:</b> the risk a community is exposed to as a result of its location on the floodplain.</p> <p><b>future flood risk:</b> the risk a community may be exposed to as a result of new development on the floodplain.</p> <p><b>continuing flood risk:</b> the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.</p>
<b>flood storage areas</b>	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
<b>floodway areas</b>	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
<b>freeboard</b>	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
<b>habitable room</b>	<p><b>in a residential situation:</b> a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.</p> <p><b>in an industrial or commercial situation:</b> an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.</p>
<b>hazard</b>	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
<b>hydraulics</b>	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
<b>hydrograph</b>	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
<b>hydrology</b>	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
<b>local overland flooding</b>	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
<b>local drainage</b>	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
<b>mainstream flooding</b>	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

<b>major drainage</b>	<p>Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:</p> <ul style="list-style-type: none"> <li>• the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or</li> <li>• water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or</li> <li>• major overland flow paths through developed areas outside of defined drainage reserves; and/or</li> <li>• the potential to affect a number of buildings along the major flow path.</li> </ul>
<b>mathematical/computer models</b>	<p>The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.</p>
<b>merit approach</b>	<p>The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.</p> <p>The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.</p>
<b>minor, moderate and major flooding</b>	<p>Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:</p> <p><b>minor flooding:</b> causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.</p> <p><b>moderate flooding:</b> low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.</p> <p><b>major flooding:</b> appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.</p>
<b>modification measures</b>	<p>Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.</p>
<b>peak discharge</b>	<p>The maximum discharge occurring during a flood event.</p>
<b>Probable Maximum Flood (PMF)</b>	<p>The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.</p>
<b>Probable Maximum Precipitation (PMP)</b>	<p>The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.</p>

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<b>probability</b>	A statistical measure of the expected chance of flooding (see AEP).
<b>risk</b>	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
<b>runoff</b>	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
<b>stage</b>	Equivalent to "water level". Both are measured with reference to a specified datum.
<b>stage hydrograph</b>	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
<b>survey plan</b>	A plan prepared by a registered surveyor.
<b>water surface profile</b>	A graph showing the flood stage at any given location along a watercourse at a particular time.
<b>wind fetch</b>	The horizontal distance in the direction of wind over which wind waves are generated.