# WYONG SHIRE COUNCIL

## TUMBI UMBI CREEK
## FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN

## EXHIBITION REPORT

**June 2014**

Wyong Shire Council
CENTRAL COAST

**WYONG SHIRE COUNCIL**

# TUMBI UMBI CREEK
# FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN

## EXHIBITION REPORT

**June 2014**

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## FOREWORD

The NSW Government's Flood Policy recognises that flood-liable land is a valuable resource and should not be sterilised by unnecessarily precluding its development. The Policy also recognises the benefits flowing from the use, occupation and development of floodprone land. Accordingly, the Policy requires that all development proposals be treated on their merits.

The merit approach requires that flooding issues be considered along with other planning and environmental factors. Specifically, the merit approach seeks to balance social, economic, environmental and flood risk parameters to ascertain whether a particular development or use of the floodplain is appropriate and sustainable.

The prime responsibility for local planning and land management rests with local government. The study area falls under the administrative responsibility of Wyong Shire Council.

The Floodplain Risk Management process comprises the following activities:

- establishment of a Floodplain Management Committee;
- data collection;
- completion of a Flood Study;
- preparation of a Floodplain Risk Management Study;
- adoption of a Floodplain Risk Management Plan; and
- implementation of the Floodplain Risk Management Plan.

The Floodplain Risk Management process is presented schematically on Figure A1 in Appendix A, which has been derived from the Manual.

The Tumbi Umbi Creek Floodplain Risk Management Review & Plan has been prepared by Paterson Consultants Pty Limited on behalf of Wyong Shire Council Wyong Shire Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Programme. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

## GLOSSARY - Terms and Abbreviations

**Note**: A more extensive glossary is available in the 2005 Floodplain Development Manual. An extract from the Glossary of the Manual, giving a fuller description of floodways, flood storages and flood fringe, appears in Appendix B.

*Floodplain Management*

*Manual* or *Floodplain Development Manual*: The New South Wales Government publication "Floodplain Development Manual", 2005.

*Australian Height Datum (AHD):* a common notional plane of level corresponding approximately to mean sea level.

*Reduced Level (RL):* a measured height above Australian Height Datum.

*Full Supply Level (FSL):* The level of a water supply storage which corresponds to the full storage capacity.

*Flood Probability*

*Annual Exceedence Probability (AEP):* the probability of an event (say a flood) occurring or being exceeded in any one year.

*Average Recurrence Interval (ARI):* the long-term average number of years between the occurrence of a flood as big as or larger than the selected event.

*Probable Maximum Precipitation (PMP):* the rainfall calculated to be the maximum which is likely to occur.

*Probable Maximum Flood (PMF)*: the flood resulting from the PMP storm.

*Flood Damages*

*Direct Damage:* damage caused by contact with floodwater eg. structural damage to building, water damage to furniture or house contents or damage caused by silt and debris.

*Indirect Damage:* damage caused by flooding though not directly eg. loss of trade, cost of alternative accommodation or loss of wages.

*Tangible Damage:* damage that can be quantified in monetary terms, includes direct and indirect damages.

*Intangible Damage:* damage that occurs but is difficult to quantify eg. increased stress in the community or disruption to community life.

*Potential Damages:* an estimate of the flood damage that represents the maximum damage loss if no action is taken to reduce the damage.

*Actual Damage:* an estimate of the flood damage that makes allowance for any action taken to reduce the damage.

*Mean Annual Damage:* an estimate of the annual average damage from the full range of floods. It is obtained by summation of the product of damage and probability over the full range of flooding.

*Economic Factors*

*Capital Cost:* total construction cost of project, including land acquisition, survey, investigation and design.

*Amortization:* annual interest and redemption payments over the economic life of the project.

*Economic Life:* period during which a works item remains in a satisfactory working condition before being replaced.

*Recurrent Cost:* annual cost for maintenance and operation eg. power, fuel.

*Annual Cost:* sum of amortization, operation and maintenance cost for a year.

*Nett Present Value:* the sum of money which, if invested today at the adopted interest rate, would be sufficient to fund all annual costs of the project over the economic life.

*Nett Present Value-Capital Cost Ratio:* ratio of nett present value of annual costs of a project to the capital cost. This ratio reflects the relativities of capital and recurrent costs of a project.

*Benefit-Cost Ratio:* ratio of the monetary benefits of a project to the cost of a project. This ratio can be determined on an annual cost basis or nett present value basis.

*Relative Cost Effectiveness:* ratio of the relative benefit for a project to the relative cost of the project. This ratio enables a variety of projects which provide different benefits to be compared. It is also equal to the ratio of the benefit-cost ratio for a project to the benefit-cost ratio for the reference project.

*Emergency Management*

*emergency management:* a range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare far, respond to and recover from flooding.

*disaster plan (DISPLAN):* 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.

*flood plan (local):* A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.

*flood awareness:* Awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.

*flood readiness:* Readiness is an ability to react within the effective warning time.

*minor, moderate and major flooding:* both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

> *minor flooding*: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.
>
> *moderate flooding*: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.
>
> *major flooding*: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

<u>*Flood Behaviour*</u>

*flood prone land:* land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.

*Flood risk:* potential danger to personal safety and potential damage to property resulting *from* flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in the Floodplain Development Manual is divided into 3 types, existing, future and continuing risks as below:

> *existing flood risk*: the risk a community is exposed to as a result of its location on the floodplain.
>
> *future flood risk*: the risk a community may be exposed to as a result of new development on the floodplain.
>
> *continuing flood risk*: the risk a community is exposed to after floodplain risk management measures have been implemented.

*Floodway areas:* those areas of the floodplain where a significant discharge of water occurs during floods.

*flood storage areas:* those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

*flood fringe areas:* the remaining area of flood prone land after floodway and flood storage areas have been defined.

*discharge:* the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (cu m/sec).

*probable maximum precipitation:* 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.

*probable maximum flood:* 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.

*stage:* equivalent to water level (both measured with reference to a specified datum).

*stage hydrograph:* a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

*Development*

*Development:* is defined in Part 1 of the EP&A Act as the use of land, sub-division of land, erection of buildings, carrying out a work, demolition of a building or work plus any other item identified as "controlled" by an "environmental planning instrument".

For floodplain management purposes, "development" is usually divided into three categories, namely:

> *infill development*: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land.
>
> *new development*: refers to development of a completely different nature to that associated with the former land use.
>
> *redevelopment*: refers to rebuilding in an area as urban areas age.

*Flood planning levels:* 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.

*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.

*flood planning area:* the area of land below the FPL 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.

## SUMMARY

Tumbi Umbi Creek is a small, partly urbanised catchment draining to the southern perimeter of Tuggerah Lake. Parts of the catchment are classified as "flood liable" with the area inundated by the design one percent AEP flood covering some 1.1 sq kilometres, while the Probable Maximum Flood is expected to inundate some 2.3 sq kilometres.

Thirty percent of the Tumbi Umbi catchment has been developed over the past 50 years for residential purposes, while the balance of the catchment is zoned for rural residential and various conservation zones.

There have been a number of significant stormwater drainage works constructed in the Tumbi Umbi catchment over the past 40 years. The works related to riverine flooding (as opposed to localised street drainage) are:

- construction of two stormwater detention basins;
- stream clearing and bank erosion repair along Tumbi Umbi Creek;
- trunk drainage works immediately south of Wyong Road;
- construction of a major drain and levee near Beckingham Road.

There have been essentially six flood and floodplain management studies on Tumbi Umbi Creek (and the Killarney Vale tributary) over the past 40 years. These investigation programs followed the 1978 and 1981 storms and have addressed various changes to the riverine drainage system, as development in the area has progressed. Recommendations outstanding from the earlier studies relate to land use planning and waterway maintenance. The land use planning issues have been addressed in the Wyong LEP – 2013.

Whilst the bulk of Tumbi Umbi Creek and its tributaries are liable to flooding from local runoff, the lower parts of the creeks can be inundated by elevated water levels in Tuggerah Lake. The division between the areas that are dominated by inundation from local runoff and those areas dominated by Tuggerah Lake occurs approximately 1 kilometre upstream of Wyong Road on Tumbi Umbi Creek and virtually at Wyong Road for the Killarney Vale tributary.

Land use zoning through the Tumbi Umbi catchment was controlled via the Wyong Local Environment Plan (LEP – 1991). The 1991 LEP has been superseded by the Wyong Local Environmental Plan (LEP – 2013). The land use zonings can be broadly described as:

- Residential;
- Business
- Industrial;
- Recreation;
- Environmental Protection.

The residential development, post 1980, has occurred mindful of flood risk. As such, the recent developments have occurred outside the inundation limit of the design 1% AEP flood event.

Flood damages and numbers of flood liable dwellings and properties have been assessed in this study.

The house floor level data base shows that, with respect to flooding from local runoff:

- four houses have main (habitable) floor level below the design 1% AEP flood level;
- sixty houses have floor levels that do not have 0.50 m freeboard to the design 1% AEP event; and
- nine elevated houses have laundry and garage areas below the design 1% AEP flood level.

The bulk of the dwellings without freeboard (0.5m) to the design 1% AEP event are located on Tumbi Umbi Creek and the Killarney Vale tributary, downstream of Wyong Road. Within the area downstream of Wyong Road, thirty-five dwellings would be inundated by the 1% AEP elevated water level in Tuggerah Lake.

The total mean annual tangible flood damages for the Tumbi Umbi Creek study area (for local runoff) is $117,000. The bulk of the annual average flood damage is sustained by public utilities and general clean-up costs. The average annual damage sustained by existing residences from elevated Tuggerah Lake levels ($28,200) is similar to local runoff, although the number of residences affected is significantly greater.

The NSW Floodplain Development Manual suggests review of floodplain risk management practices that either alter flood behaviour or alter community responses to flood risk. The majority of floodplain management measures suggested by the Floodplain Development Manual are not relevant to this study in that:

- works have been undertaken where shown to be physically efficient and cost effective; and
- some measures are simply not applicable, given the catchment size and nature of the flood problem.

Chapter 9 details the draft floodplain risk management plan, whose components cover:

- maintenance of the existing waterways that perform a flood conveyance function (particularly the Killarney Vale tributary);

- development of a better understanding of flood behaviour, specifically:
    - assessment of flood risk immediately downstream of the Playford Road detention basin;
    - assessment of flood risk following the potential overtopping of Wyong Road near its intersection with Beckingham Road in floods larger than the design 1% AEP event;
    - review of local rainfall data, specifically comparison of the recorded 1978 and 1981 storm events against design rainfall intensities.

## 1. INTRODUCTION

Tumbi Umbi Creek has a catchment area of 14.25 square kilometres and discharges into Tuggerah Lake on the Central Coast of New South Wales. Tuggerah Lake is the largest of three interconnected coastal lakes which enter the Pacific Ocean via a single entrance at The Entrance.

The Study area is shown on Figure 1.

Tumbi Umbi Creek has three major watercourses, as shown on Figure 2, namely:

- Tumbi Umbi Creek, which drains from the coastal escarpment east of The Entrance Road;

- Killarney Vale tributary, which joins Tumbi Umbi Creek some 300 metres upstream of the Tumbi Umbi Creek outfall into Tuggerah Lake; and

- a large constructed drainage system in the north western quadrant of the Tumbi Umbi catchment, which drains an unnamed tributary, to the west of the Mingara Recreation Club, thence eastwards along Wyong Road to join Tumbi Umbi Creek, immediately upstream of Wyong Road. From an historical perspective, the components of this drain are identified as Moss Drain (parallel to Wyong Road) and Mingara Drain, upstream of the Moss Drain. A wetland has been constructed at the junction of the Mingara Drain and the Moss Drain near Wyong Road

The catchments of Tumbi Umbi Creek and the Killarney Vale tributary are 12.4 and 1.5 sq kilometres at their confluences, respectively.

The catchment of the Mingara Drain / Moss Drain tributary to Tumbi Umbi Creek is some 2.5 sq kilometres.

The total stream lengths regarding this floodplain risk management plan involve:

- Tumbi Umbi Creek: 5.5 kilometres
- Killarney Vale tributary: 2.7 kilometres
- Mingara / Moss Drain tributary: 1.5 kilometres

The total areas predicted as flood liable within the study area are 1.1 sq kilometres and 2.3 sq kilometres for the design one percent AEP flood and the Probable Maximum Flood (PMF) respectively.

The study area for this review is totally within the Wyong Shire Council's LGA.
Tumbi Umbi Creek and its tributaries and associated floodplains have limited major crossings at Wyong Road and Tumbi Road. The Mingara / Moss Drain with associated levee and wetland were constructed to limit broad overland flooding and allow the recent development of the Mingara Recreational Club, a Wyong Shire Council sponsored athletic field, and Glengarry Retirement Village.

The existing development within the study area can be categorised as:

- original residential development along the Tuggerah Lake foreshores;
- maintenance of the lowest parts of the floodplain for wetland and open space;
- rural residential development along the western side of the Tumbi Umbi catchment;
- residential development along the eastern side of the Tumbi Umbi catchment and in the Killarney Vale tributary catchment;
- small scale commercial/industrial operations north of Wyong Road and west of the Tumbi Umbi Creek channel.

Figures 2 and 3 show the major local roads in the Study Area. The local roads referenced in this study are:

- Beckingham Road
- Wyong Road;
- Hansens Road;
- Tumbi Road;
- Adelaide Street;
- Warratta Road;
- Playford Road;
- Rotherham Street;
- Lancaster Parade;
- The Entrance Road (Central Coast Highway).

It is noted that there are three major water control structures within the Tumbi Umbi Creek catchment, namely, two stormwater detention basins and a water quality control wetland.

The nomenclature used for the detention basins has varied over time. The basin on the Killarney Vale tributary at the Council's hockey fields has been variously identified as:

- “Bateau Bay Hockey Field Basin”
- “Playford Road Basin”
- “Killarney Upper Basin”
- “Eastern Road Basin”

The basin on the Killarney Vale tributary near Wyong Road has been variously called:

- “Killarney Vale Basin:
- “Killarney High School Basin”
- “Cornish Avenue Basin”
- “Killarney Vale Lower Basin”

For the purposes of this study, the two basins in the Killarney Vale tributary have been identified as “Playford Road Basin” and “Killarney Vale Basin”.

The primary objective of the Tumbi Umbi Creek Floodplain Risk Management Review is to determine appropriate floodplain management measures for the preparation of a cost-effective Floodplain Risk Management Plan for the study area.

The study addresses flooding caused by runoff in the Tumbi Umbi Creek and its tributaries and does not address flooding caused by elevated water levels in Tuggerah Lake independent of river flooding. Floodplain management for Tuggerah Lake flooding is to be addressed in a separate study.

## 2. HISTORICAL DEVELOPMENT OF THIS REVIEW AND PLAN

This Study and Plan have had a long development period to reach the current position.

An historical sequence of periods of activity can be identified as:

- Prior to the issue of the 1986 Floodplain Development Manual;
- Application of NSW 1986 Manual;
- Period 1995 to 2005.
- Period 2006 to 2013

Drainage construction works have also proceeded over the above periods. Some of these works have been directed towards alleviation of the then existing flood problems, while others have been constructed to allow development to proceed.

The activities within each period are described below. The descriptions have been derived from the documents provided by Wyong Shire Council and from the consultant's personal knowledge.

Prior to 1986

Intensive residential development along the foreshores of Tuggerah Lake, near the Tumbi Umbi Creek outfall, appears to have commenced in the early 1960's, with gradual conversion of "holiday cottages" to full time residential usage.

Residential, commercial and light industrial development has continued since the late 1970's to reach the current development state.

Major floods occurred in 1978 and 1981. The rainfalls recorded in these events exceeded the currently accepted design rainfalls for the design one percent AEP event. Four flood investigations were undertaken from 1978 to 1986, with the object of reducing flood impacts along Tumbi Umbi Creek and the Killarney Vale tributary. The relevant studies are summarised in the next chapter.

Period 1986 to 1995

Over this period, Wyong Shire Council undertook a series of activities to comply with the 1986 Floodplain Development Manual. These activities involved:

- development of an Interim Flood Policy, which essentially created a matrix of allowable site development scenarios against flood hydraulic categories. The development matrix was used by Wyong Shire Council as part of its Policy F5 "Development of Floodprone Land".

- revision of flood studies for Tumbi Umbi Creek, using more advanced computer systems to address identified deficiencies in the early studies;

- completion of a floodplain management study for Tumbi Umbi Creek up to "draft exhibition report" stage. The draft report was reviewed by Council staff. However, it was never placed on public exhibition or adopted by Council.

At that time, the floodplain management studies reviewed structural floodplain management options (physical works) and non-structural options (land use planning and the like). There was no desire or pressure on the part of Wyong Shire Council to change the interim flood policy that was in place.

Period 1995 to 2005

The principal floodplain management activities and issues dealt with on-going development on the Tumbi Umbi Creek and tributaries floodplain and were, in particular:

- renovations and re-building of the residential housing stock;
- in-fill development of residential land.

The relative magnitude of these activities has been deduced by inspection and comparison of available aerial photography, Council's various development approvals, and the house floor level data base.

Period 2005 to 2013

The principal floodplain management activities and issues on the Tumbi Umbi Creek and tributaries floodplain identified in the earlier studies are relatively small in magnitude compared to the flooding issues for the Tuggerah Lake foreshores, in particular the impact of postulated sea level rises.

Accordingly, the Tumbi Umbi Floodplain Management Plan has been held in draft form, awaiting completion of the Tuggerah Lake investigation work and preparation of Wyong Shire Council's 2013 revision of the LEP.

Development proposals have reportedly been assessed using the revised matrix as outlined in the 2005 draft Floodplain Management Study report.

## 3. STUDY APPROACH

The approach to this floodplain risk management study is slightly different to a normal procedure under the NSW Floodplain Risk Management Manual. This difference follows:

- the substantial work on the flood studies and floodplain management studies completed up to 1995 under the guidelines outlined by the 1986 Floodplain Development Manual;

- a draft floodplain management study was completed in July 1996, which had undergone internal review by Wyong Shire Council staff, but was not placed on public exhibition, nor subsequently formally adopted by Council. The draft floodplain management study identified:

    - five properties as liable to above building floor flooding for the design 1% AEP event and 16 properties as liable (to above building floor inundation) in a repeat of the 1981 storm event;

    - total mean annual tangible flood damages as some $96,000 (in 1996 dollars) with 78 percent of the flood damage incurred through damage to public infrastructure.

- the 1996 draft Floodplain Management Plan examined a range of structural and non-structural measures to reduce flood impacts and associated flood damages. The principal recommendations were:

    - changes to Council's Interim Flood Policy and its associated development matrix;

    - changes to the freeboard specification;

    - adoption of a dual floor level specification to account for differences between the design 1% AEP event and the 1981 flood event;

    - regular maintenance of the Killarney Vale tributary to remove siltation and vegetation (principally).

- the limited changes to the floodplain management process introduced by the 2005 Floodplain Development Manual.

It is normal practice in flood studies to use a hydrology model to identify flood flows (discharges) and a riverine hydraulic model to identify flood behaviour (flood levels, flows and flow velocities).

The flood studies used to identify design flood behaviour were:

- hydrology model: WBNM software
- riverine hydraulics model: MIKE-11 software

Both WBNM and MIKE-11 models are relatively sophisticated models, which can adequately represent flood behaviour for floodplain management through the Tumbi Umbi catchment. There have been changes to both models over the period of 1995 to 2007, which have mainly been user interfaces for the software, while the underlying theories and concepts remain unchanged.

Further, over the last four years, Wyong Shire Council has been developing a single Development Control Plan (DCP) covering their administrative area.

Two study approaches were available to complete this study and to prepare the floodplain risk management plan.

The first approach involves complete revision of the flood study using the most recent two dimensional software, followed by review of floodplain risk management options and preparation of the risk management plan. This process would take 2 to 3 years to complete.

The second approach involves building on the previous work (the flood studies and floodplain management studies) updating the work as applicable to 2010 conditions, whilst achieving compliance with the 2005 Floodplain Development Manual.

The second alternative approach above was considered the best alternative, given:

- the time required to reach completion by following the first approach;
- the financial cost of the first approach, given it is essentially re-working of existing information;
- considerable funds have already been expended getting the existing flood studies and floodplain management studies to their virtual completion stage;
- the time pressure to have the floodplain risk management plan information incorporated into Wyong Shire Council's comprehensive LEP review.;
- recent development appears to be above the 1981 flood levels (the largest flood to date);
- the limited number of existing buildings liable to above floor flooding.

Thus, the study approach used has been essentially extending the existing flood and floodplain management studies, particularly:

- developing conformance with the 2005 NSW Floodplain Development Manual;
- estimation of 0.5 percent AEP flood behaviour in the study area;
- identification of flood hydraulic categories (floodways, flood storage and flood fringe area) and flood hazard categories (high hazard and low hazard);

- updating flood damage estimates by inclusion within the building data base of buildings constructed over the period 1995 to 2008;

- updating flood damage and works cost estimates by use of the Consumer Price Index (CPI) over the period 1995 to 2010;

- introduction of the concepts of flood risk, in accordance with the 2005 Floodplain Development Manual;

- review of the works and measures proposed in the 1995 Tumbi Umbi Floodplain Management Study;

- drawing of conclusions from the current study and the experience of application of the 1995 study over the period 1995 to 2012 as a "development policy".

# 4. REVIEW PREVIOUS FLOOD STUDIES AND FLOODPLAIN MANAGEMENT STUDIES

There have been numerous investigations into flooding and floodplain management measures in Tumbi Umbi Creek and the Killarney Vale tributary since 1978.

The earlier studies proposed that a number of floodplain management works and risk management measures be undertaken along Tumbi Umbi Creek and the Killarney Vale tributary. The majority of these works have been carried out, while some other proposed works were found by later studies to be ineffective.

## 4.1 Earlier Studies

There have been a number of investigations of flooding in Tumbi Umbi Creek undertaken since the January 1978 flood. A brief summary of each of these investigations is given below.

**1. `Tumbi Umbi Stormwater Drainage Study', Willing & Partners, July 1979,** (Ref. 8)

This study investigated future drainage requirements, principally culverts at road crossings along Tumbi Creek. The study also recommended that a detention basin be constructed across Tumbi Umbi Creek 1.6 kilometres upstream of Tumbi Road. The basin was not constructed (see Ref.6).

**2. `Tumbi Umbi Creek Valley, Floodplain Management Study Vol 1: Technical Investigations', Cameron McNamara, 1983** (Ref. 9)

This study investigated the major floods that occurred in January 1978 and February 1981. RORB rainfall-runoff models of the Tumbi Umbi Creek and Killarney Vale tributary catchments were developed to provide discharge estimates for HEC-2 hydraulic models of the two creeks. These models were used to estimate 1% AEP design flood levels along the two creeks.

**3. `Tumbi Umbi Creek Valley, Floodplain Management Study Vol 2: Management Strategies', Cameron McNamara, 1983** (Ref. 10)

This report investigated possible management strategies. The study report recommended that channel improvements be carried out, the Adelaide Street culvert be replaced and the Playford Road detention basin wall be raised and that detention basins be constructed across Tumbi Umbi Creek and the Killarney Vale tributary immediately upstream of Wyong Road. The basin on Tumbi Umbi Creek was not constructed (Ref.12) but the other works have been constructed, generally as recommended.

These 1983 reports were never published and distributed as the correlation between recorded flood levels and modelled results for both the 1978 and 1981 events was not considered to be satisfactory.

**4. `Tumbi Umbi Creek Flood Study, Compendium of Data', Cameron McNamara, March 1987** (Ref. 11)

This study prepared the most reliable flood data available at that time.

**5. `Tumbi Umbi Creek Flood Study Survey Report 30130 ASOZ', Public Works Department, February 1984** (Ref. 12)

This report details the cross-section survey along the Killarney Vale tributary and ground survey of flood levels identified in the above Compendium of Data.

**6. `Tumbi Umbi Creek Flood Protection Works', Cameron McNamara, December 1987** (Ref. 13)

This report details augmentation of the Wyong Road culvert on Tumbi Umbi Creek, channel improvements downstream of Wyong Road and the proposed detention basin upstream of Wyong Road. The study concluded that the proposed detention basin was not effective in reducing flood levels and that augmentation of the Wyong Road culvert and channel improvements were effective in reducing flood levels. In general, the culvert and channel works have been completed.

**7. `Tumbi Umbi Creek Flood Study', Cameron McNamara, February 1988** (Ref.14)

This study investigated the 1978, 1981 and 1984 flood events using a CELLS hydraulic model. The study concluded that design rainfalls are under-estimated. Design rainfalls for the 1% AEP design flood were increased by 33% and adjusted 1% AEP design flood levels were determined.

**8. `Tumbi Umbi Creek Flood Study', Kinhill Engineers, February 1991** (Ref. 15)

The Kinhill report is essentially an update of the above 1988 study (by Cameron McNamara) prepared by Kinhill after their acquisition of Cameron McNamara.

**9. `Tumbi Umbi Creek Flood Study Review', Paterson Consultants, December 1994** (Ref. 6)

This report represents the most recent general flood investigations. It reviewed the earlier studies and established a calibrated MIKE-11 hydraulic model of the creek system, incorporating the various works constructed since 1978. Calibration and verification of the modelling was based on recorded data for the 1978, 1981, 1990 and 1992 flood events.

The study also formed the basis of the local investigations that had been undertaken for proposed developments at the top end of Tumbi Umbi Creek near Lancaster Avenue and "Lower Tumbi Valley Urban Release Area" (which covers the Mingara Recreational Club development and the Glengarry Retirement Village development).

**10. 'Tumbi Umbi Creek Floodplain Management Study, Exhibition Report", Paterson Consultants, December 1994** (Ref. 7)

This report undertook a floodplain management study of Tumbi Umbi Creek and the Killarney Vale tributary following the 1994 "Flood Study Review". The Floodplain Management Study was completed to "Exhibition Report" stage, but not reviewed by Council staff. The Exhibition Report was not placed on public exhibition and thus not ever received or adopted by Council.

**11. `Lower Tumbi Valley Urban Release Area, Section 94 Contributions Plan, Technical Report – Drainage', Paterson Consultants, June 1997** (Ref. 17)

This report details a draft design for:

- enlargement of the "Moss" drain;
- creation of "Mingara" drain with an associated levee;
- construction of two water quality improvement wetlands (one at the junction of the "Moss" drain and the other adjacent to the Mingara car park area.

The report also details design 1% AEP flood levels after the works. The recommended works were constructed in 2000.

## 4.2 Completed Floodplain Management Works

The earlier studies proposed a number of works be carried out along Tumbi Umbi Creek and the Killarney Vale tributary. The majority of these works have been carried out, while some other proposed works have been found by later studies to be ineffective.

The floodplain management works that have been carried out since 1978 are summarised in Table 4.1, while Figure 4 illustrates their location.

The regrading of Wyong Road (Item 13 in Table 1) has incorporated the extension and enlargement of the outlet culvert for the Killarney Vale Lower basin.

**Table 4.1**

**Tumbi Umbi Creek Flood Management and Drainage Works**

| No. * | Works | Year Constructed |
|---|---|---|
| 1 | Clearing Tumbi Umbi Creek downstream of Wyong Road | 1978 |
| 2 | Adelaide Street Oval regraded | 1982 |
| 3 | Adelaide Street culvert replaced by 2 – 3.6 x 1.2 RCBC | 1983 |
| 4 | "Moss" drain | 1985 |
| 5 | Concrete channel Warratta Road to Hinemoa Street | 1985 |
| 6 | Cornish Avenue basin wall raised | 1985 |
| 7 | Playford Road basin wall raised and floor lowered | 1986 |
| 8 | Concrete lining of channel downstream of Playford Road | 1988 |
| 9 | Wyong Road culvert enlarged to 3 – 3.3 x 3.6 RCBC | 1988 |
| 10 | Channel improvements Wyong Road to Vanessa Road | 1990 |

| No. * | Works | Year Constructed |
|---|---|---|
| 11 | Channel improvements upstream of Wyong Road | 1992 |
| 12 | Wyong Road culvert enlarged to 4 – 3.0 x 3.6 RCBC | 1993 |
| 13 | Wyong Road upgraded, Killarney Vale lower basin outlet extended | 1995 |
| 14 | Dredging at mouth of Tumbi Umbi Creek | 1995 |
| 15 | Construction of "Mingara" Channel, levee and wetland | 2000 |
| 16 | Killarney Vale – an additional 3.6 * 1.2 m RCBC at Adelaide Street | 2001 |
| 17 | Killarney Vale - widening channel by 6 m from downstream of Wyong Road (from chainage 950 m to 530 m) | 2001 |
| 18 | Killarney Vale - blocking one of the 1050 mm outlet pipes from the Wyong Road Basin (for water re-use at Mingara sports fields) | 2001 |
| 19 | Dredging of creek mouth to improve navigation access | 2007 |

Notes: * Refer to Figure 4 for location of works.

# 5. CURRENT KNOWLEDGE – FLOOD BEHAVIOUR

## 5.1 Flood Behaviour

Tumbi Umbi Creek drains into Tuggerah Lake. Tuggerah Lake is not affected by tides.

Reference 5 gives predicted flood levels in Tuggerah Lake, as given in Table.5.1 below.

**Table 5.1**

**Predicted Flood Levels – Tuggerah Lake**

| Return Period (% AEP) | Peak Level (m AHD) |
|---|---|
| 5% | 1.4 |
| 2% | 1.8 |
| 1% | 2.2 |
| PMF | 2.7 |

Tumbi Umbi Creek flood levels, given the size of the catchment, are expected to rise and fall within twelve hours, while Tuggerah Lake would rise and fall within a period of days. Thus, it is not automatic that a 1% AEP flood would occur on Tumbi Umbi Creek at the same time as the 1% AEP flood in Tuggerah Lake. It is more likely that a large flood in either Tuggerah Lake or Tumbi Umbi Creek would occur with a small or moderate flood in the other water body.

Similar situations occur on both the Lower Wyong River and Lower Ourimbah Creek although those catchments are much larger than Tumbi Umbi.

For Tumbi Umbi Creek, the "adopted" design flood combination involved a design flood occurring on Tumbi Umbi Creek, concurrent with a steady lake level in Tuggerah Lake corresponding to the 10%AEP flood in Tuggerah Lake.

Figures 5 and 6 indicate the flood levels, approximate extents of inundation and flood hazard for Wyong Shire Council's "adopted" 1% AEP flood, while Figures 7 and 8 illustrate similar information for the 0.5% AEP and Figures 9 and 10 illustrate similar information for the PMF event.

Thus, in the lower parts of Tumbi Umbi Creek, the peak flood levels are either dominated by flood flows along Tumbi Umbi Creek or flood levels from Tuggerah Lake backing up Tumbi Umbi Creek. Accordingly, flood levels have been fixed by either Tumbi Umbi Creek flooding or by Tuggerah Lake flooding. The division between Tumbi Umbi Creek flooding domination and Tuggerah Lake domination of flood levels occurs in the vicinity of Wyong Road on the Killarney Vale tributary and approximately 1 kilometre upstream of Wyong Road on Tumbi Umbi Creek itself.

The assumption of separate flooding controls is a simplification. Joint probability analysis (as part of the Lower Ourimbah Creek Floodplain Management Study) of both flooding on Ourimbah Creek and Tuggerah Lake, over the range of combinations, shows the joint probability as being some 110 millimetres higher than the levels indicated from the assumption of fixed Tuggerah Lake levels. Similar or lower flood level differences to account for joint probability of flooding in Tumbi Umbi Creek are expected. Differences of this magnitude can be accounted in the freeboard allowance used in the planning controls.

The Tumbi Umbi catchment is small and systematic records of flooding are not available. Recorded flood levels are available for various floods at two locations, as shown in Table 5.2 below, as a ranked listing.

**Table 5.2**

**Recorded Floods – Tumbi Umbi Creek (Main Tributary)**

| Rank | Flood | Peak Flood Level (m AHD) | |
|---|---|---|---|
| | | Wyong Road | Tumbi Road |
| 1 | January 1978 | 4.6 [5] | 9.5 [2] |
| 2 | February 1981 | 3.6 [1] | 9.5 [2] |
| 3 | April 1990 | 3.58 [1] | N/A [4] |
| 4 | February 1990 | 3.26 [1] | 9.43 [2] |
| 5 | May 1988 | 3.26 [1] | 9.4 [2] |
| 6 | January 1990 | N/A [4] | 9.17 [2] |
| 7 | April 1999 | 2.25 [3] | N/A [4] |
| 8 | October 2004 | 2.13 [3] | N/A [4] |
| 9 | June 2007 | 2.12 [3] | N/A [4] |
| 10 | February 1992 | 2.05 [1] | 9.08 [2] |

Notes:
1. Source: Peak level indicator MHL 11032
2. Source: Peak level indicator MHL 11034
3. Source: Automatic water level recorder
4. N/A: Not available
5. Derived from other recorded flood levels

The data in Table 5.2 has been derived from Reference 4, which in turn used various sources, namely:

- debris and flood marks after the flood event;
- resident interviews;
- a series of peak level indicators installed by NSW Public Works Department. (These devices are now defunct);
- automatic water level gauges installed by Manly Hydraulics Laboratory.

A significant local flood on the Killarney Vale tributary occurred in April 1999. Two houses (both elevated buildings with garage and laundry on the ground floor) were inundated.

Differences between hydraulic model results and recorded flood levels were investigated. Wyong Shire Council responded to the flood by:

- increasing the capacity of culverts at Adelaide Street;
- increasing the size of the channel between Adelaide Street and Wyong Road;
- blocking one outlet of the Killarney Vale detention basin.

The June 2007 event, which caused widespread flooding up to 1.65 m AHD in Tuggerah Lake, reached RL 2.12 m AHD on Tumbi Umbi Creek at Wyong Road.

There have been no flood flow measurements along Tumbi Umbi Creek or its tributaries.

The flow estimates used in the flood hazard mapping and flood studies have been derived by comparison of recorded rainfalls, floodplain and channel topography and recorded flood levels. Flow measurement of flood flows at Wyong Road would significantly improve the flood data base and should give greater confidence in the hydrologic and hydraulic modelling. The hydrologic and hydraulic models involve some assumptions (necessarily reasonable compromises) but the assumptions and compromises cannot be rationalised without further rainfall, flood level and flood flow data.

The existing provisional flood hazard category along Tumbi Umbi Creek is shown as:

- Design 1% AEP flood: Figures 5 and 6
- Design 0.5% AEP flood: Figures 7 and 8
- Design PMF flood: Figures 9 and 10

Review of the design 1% AEP flood extents (Figures 5 and 6) show that:

- flood liable properties with dwellings or commercial development are generally located north of Wyong Road. These properties were developed from the early 1960's, generally as holiday cottages and the like.

- the more recent developments (since the 1980's) in the Tumbi Umbi catchment have been planned and developed mindful of the flooding risk;

- the flood levels have been derived from the MIKE-11 hydraulic model, which uses stream cross-sections to define topography. The cross-sections were defined by ground survey.

- in assessing the flood extents, the ALS ground data in some areas has been viewed as unreliable because of the dense vegetation cover. The ALS technology relies on a light reflection off the ground surface. The reflections are distorted by dense vegetation, giving erroneous results for actual ground levels.

- flooding extents are generally confined to the valley floors;

- the flood extents increase as the magnitude of the flood increases. The flood extent changes between the 1% AEP, 0.5% AEP and PMF events. For example the PMF flood increases the lateral flood extents of the 1% AEP flood by up to 300 metres downstream of Tumbi Road and by up to 50 metres upstream of Tumbi Road.

- during a 0.5% AEP design flood and the PMF event, overtopping of Wyong Road near its intersection of Beckingham Road is expected with flooding through the industrial / commercial area north of Wyong Road. The hydraulic models used for this study were not established to investigate flooding greater than the 1% AEP event and further investigation north of Wyong Road is required to quantify local flooding impacts.

- similarly, in events larger than the design 1% AEP flood, overtopping of the private levee protecting the Mingara Club development area is likely to occur.

Comparison between the flood extents shown on Figure 5 and Figure 12 shows the impact of increasing Tuggerah Lake flood levels for the design 1% AEP flood from RL 1.1 m AHD to RL 2.2 m AHD. The figures indicate that the prevailing water levels in Tuggerah Lake at the time of the flood essentially only impact flood behaviour north of Adelaide Street, Florence Street and their extension to Bon Mace Close.

Comparison between Figures 9 and 13 present the flood extents for the PMF event, with prevailing Tuggerah Lake levels of RL 2.2 m AHD and RL 2.7 m AHD. The flood extents are dominated by the total flood discharge in the stream system, not the prevailing water levels in Tuggerah Lake.

Figure 11 illustrates the design hydrograph for the 1% AEP flood (using the 9 hour design storm from AR&R).

With respect to Figure 11, it is noted:

- the location "Tumbi Umbi Creek at Wyong Road" does not include the flow contribution flowing from west to east adjacent to Wyong Road. The peak flow from this contributor is approximately 25 cu. m/sec.

- while there is attenuation of flow downstream of Tumbi Road, there is also significant contribution from local catchment downstream of this point;

- the most rapid increases in flow occur over a period of 1 hour;

- the behaviour shown on Figure 11 also reflects the rainfall intensity pattern for the design 9 hour storm from AR&R;

- virtually the same design flood levels through Tumbi Umbi Creek for the 9 hour design storm are produced by the 1 hour design storm for the design 1% AEP event;

- the rate of rise of floods varies through the Tumbi Umbi Creek system. At Tumbi Road, the rate of rise in the design 1% AEP event is in the range 0.2 to 0.5 metres per hour. For

Tumbi Umbi Creek at Wyong Road, the rates of rise are in the order of 0.7 to 1.25 metres per hour. The difference in the rates of rise is caused by the stream topography. At Tumbi Road, the flood extent is comparatively wide compared to Tumbi Umbi Creek at Wyong Road. This topography implies greater flood storage at Tumbi Road and consequently, the rate of rise is less than occurs at Wyong Road.

- it is clear that flood levels can rise from being "within bank" to major flood levels within a period of one to two hours;

- the relatively fast rise of flood levels during an event and the short duration of the rainfall events that cause flooding implies that there is simply insufficient time available to prepare and issue effective flood warning, nor time for the local residents (many of who work at some distance from their residences) to make effective flood protection activities, should a significant rainfall event occur.

## 5.2 Adopted Flood Hazard

Figures 14 and 15 display the adopted flood hazard for the study area.

It should be noted that:

- the flood levels derived from the flood models are based on ground survey of cross-sections;

- the flood extents have been derived by interpolation of the ALS data.

In many instances along Tumbi Umbi Creek and the Killarney Vale tributary, the accuracy of the ALS data is degraded by the presence of heavy vegetation cover. Given the uncertainties of the ALS data, areas of floodway have been created on an interpretive basis. If development is proposed adjacent to the identified flood liable areas, ground survey (to AHD) will be required to define the flood extents and flood hazard to greater accuracy.

The flood extents shown on Figures 14 and 15 are very similar to the flood extents produced by Reference 14, where interpolation of the surveyed cross-sections was used. While the surveyed cross-sections recorded an offset distance and ground level, the plan position of the surveyed points was not recorded and thus, it is difficult to locate the cross-sections precisely to identify flood extents.

# 6. LAND USE PLANNING CONSIDERATIONS

## 6.1 Zoning and Planning Controls

There are four main levels of land use planning controls. As a hierarchy, they are:

1. State strategies and policies
2. Regional plans and strategies
3. Local land use strategy, and zonings under a Shire-wide Local Environment Plan
4. Local policies and specific planning controls under Development Control Plans

There are four State Environmental Planning Policies (SEPPs) directly relevant to the study area in relation to floodplain risk management. These are:

- SEPP 14 - Coastal Wetlands
- SEPP 26 - Littoral Rainforest
- SEPP 44 - Koala Habitat
- SEPP 71 - Coastal Protection

There is one designated SEPP 14 wetland within the study area, located through the flood liable area of Tumbi Umbi Creek, upstream of Tumbi Road.

Wetland areas are protected by the SEPP and require management which retains their conservation values. Any works related to flood mitigation affecting the SEPP14 wetlands would be designated development under the Environmental Planning & Assessment Act (1979) and require an environmental impact statement (EIS) prior to any works.

The SEPP14 wetland is not likely to be affected by any structural works as part of the Tumbi Umbi Floodplain Risk Management Plan.

The current zonings are defined in the Wyong LEP (2013).. the land use categories can be described in a simplified fashion as

- Type 1: Rural
- Type 2: Residential
- Type 3: Business
- Type 4: Industrial
- Type 5: Recreation
- Type 6: Environmental Protection

The simplified zoning provide an overview. Detailed enquiry of the land use zoning must be referred to Wyong LEP (2013).

Wyong Shire Council has prepared a comprehensive revision of the LEP (2013) which has been approved by Council and Gazetted by the NSW Department of Planning.

## 6.2 Wyong Shire Council LEP – 2013 and DCP – 2013

Wyong Shire Council has received formal legislative approval (Gazettal) of the Wyong Local Environmental Plan LEP – 2013 and the accompanying Development Control Plan (DCP – 2013).

The LEP – 2013 replaces the 1991 LEP and consequently replaces Council's earlier policies on floodplain development.

A short summary of the LEP – 2013, as it applies to floodplain management, is given below. The LEP – 2013 document must be considered if a detailed examination is required.

The LEP – 2013 follows the NSW standard template and creates land use zonings. For each zoning, the LEP gives:

- objectives for development;
- development that may be carried out without development consent;
- development that may be carried out only with development consent;
- development that is prohibited.

Clause 7.2 "Flood planning" and Clause 7.3 under Part 7 "Additional Local Provisions" create the concept of development of a "Flood Planning Area" (Clause 7.2) and development between the flood extent of the PMF and the "Flood Planning Area" (Clause 7.3).

Development within the Flood Planning Area requires Council (as the consent authority) to be satisfied that the development:

- is compatible with the flood hazard;
- is not likely to significantly adversely affect flood behaviour;
- incorporates appropriate measures to manage flood risk;
- is not likely to cause significant adverse environmental impact on the subject water courses;
- is not likely to result in unsustainable social and economic costs as a result of flooding.

Clause 7.3 requires the Council (as consent authority) to be satisfied that flood evacuation or continuing use of developments is available for specific development types within the PMF flood extent, but outside the extent of the Flood Planning Area.

The Development Control Plan (DCP – 2013) outlines the development requirements for development types that are permissible under the LEP – 2013. A brief summary of the DCP – 2013, as it applies to floodplain management, is given below. For specific details, the reader should consult the DCEP – 2013 document.

Chapter 3.3 "Floodplain Management" details requirements for development control for individual developments. The overall form of the DCP involves "objectives" and "requirements". Similarly, under "Floodplain Management", a series of "prescriptive controls" and "performance criteria" are provided. In principal, where a development applicant seeks a variation in the DCP requirements, documentation is

to be provided to Council demonstrating that the DCP "objectives" are met. Similarly, where a development applicant seeks a variation in the "prescriptive controls", documentation is to be provided demonstrating that the "performance criteria" are satisfied.

The "prescriptive controls" are identified by a matrix, which details the requirements for particular development categories against satisfaction of particular floodplain management issues.

In cases where a particular development type and particular floodplain management issue cannot be satisfied, the "prescriptive controls" matrix identifies the proposal as "unsuitable for development" and thus subject to "performance criteria". Appendix D of the DCP – 2013 outlines the documentation that would be required for Council to give consideration to the question whether the "performance criteria" can be met.

For Tumbi Umbi, it is proposed to sub-divide the extent of flooding in a PMF event into three categories (see Section 9.3 of this report). The "prescriptive controls" matrix proposed for Tumbi Umbi (the area covered by this report) is detailed in Appendix C of this report.

# 7. FLOOD DAMAGES

## 7.1 Overview

Damages caused by flooding can be divided into tangible damages, that can be quantified in monetary terms, and intangible damages that are difficult to quantify in monetary terms.

Tangible flood damages can be subdivided as follows:

- Direct damages - repair or replacement of buildings and contents damaged or destroyed by floodwaters; and

- Indirect damages - cost incurred in clean-up, evacuation, temporary accommodation and loss of income.

Intangible damages reflect the effect of flooding on the health and psyche of the community. These damages typically take the form of anxiety, depression, trauma and general deterioration in well-being of those affected by flooding.

The direct flood damages have been assessed using the ANUFLOOD flood damages model that was developed at the Centre for Resource and Environmental Studies at the Australian National University (Ref. 12). Whilst this software is relatively dated, it is applicable provided current (2010) data is input.

The model assesses the potential direct damage to property. The actual damages resulting from a flood may be significantly less than the estimated potential damages if sufficient warning is given to enable occupants and contents to be relocated or protection measures to be implemented.

The model does not provide estimates of indirect damages. Data collected for other studies suggests that indirect damages are typically equivalent to 15% to 20% of direct damage for residential development.

The intangible damages, that are also relevant in floodplain management, are not assessed by the ANUFLOOD model nor are they assessed in similar models.

The flood damages estimates have been prepared in several stages as the Tumbi Umbi Floodplain Risk Management Plan has moved towards completion. The stages involved:

- 1995 – 1996: Assessment of damages based on the 1996 building stock and flood damages estimates for building type and flooding depth as applicable in 1996.

- 2008 – 2009: Update of the building stock data base by inclusion of approved developments over the period 1996 to 2009. Flood damage estimates were further updated using CPI adjustments.

- 2010: The total flood damage estimates were updated from 2009 by simple CPI adjustment.

The total flood damages estimation process is outlined in the following sections.

## 7.2 Damages Model

The ANUFLOOD model uses three sets of input data as follows:

- a property database;
- a stage-damage relationship that specifies the estimated potential direct damage sustained at differing depths of flooding for different categories of properties; and
- a flood-stage-probability distribution for the study area.

A detailed flood damages estimate was undertaken in 1995 using ANUFLOOD.

The information for the property database was obtained by ground survey for all properties that were located less than 0.5 metres above the estimated 1% AEP flood level at the site.

The data collected for residential properties included location, ground level, lowest habitable floor level, high-set or low-set construction, building materials and damage class required for estimation of flood damages and other data required for floodplain management considerations (such as location, precinct, and lot size).

Similar data was collected for the commercial and light industrial properties with the inclusion of size of the property as damage estimates are based on floor area.

A full description of the residential and commercial/light industrial property databases was provided to Wyong Shire Council for insertion into their flood liable property data base for the surrounds of Tuggerah Lake and particular tributaries to Tuggerah Lake.

There have been further developments in the Tumbi Umbi catchment since the 1995 surveys. Such developments were identified by review of the Building Applications (BAs), Development Applications (DAs) and Construction Certificates (CCs) issued by Wyong Shire Council over the period 1996 to 2009. The lower limit for examination of recent developments was set at a construction cost of $50,000. Ground survey of levels for recent development confirmed:

- there is very little replacement of buildings existing in 1995 in the study area;
- the new developments have floor levels above the PMF level. This follows, given the areas sub-divided are above the PMF limit.

Because of the variation in flood levels along the main creek and the northern tributary, the study area was divided into eight (8) “flood damage precincts” for the purposes of flood damage estimation. These precincts correspond to regions where the difference between the 1% and 20% AEP design floods is relatively uniform. This enables the surveyed ground and floor level data to be adjusted to allow for the flood slope along the creek. The location of each flood damage precinct is shown on Figures 16 and 17.

A reference point was allocated for each flood damage precinct and a flood stage-probability distribution for each reference point was determined from the Flood Study (Reference 6) hydraulic model results. The flood stage - probabilities adopted for the damages estimation are presented in Table 7.1. The floor levels for all buildings within each flood damage precinct were adjusted to allow for the flood slope between the reference point and the building site.

**Table 7.1**

**Design Flood Levels Adopted for Damage Assessment**

| **Tributary** | **Killarney Vale** | | | **Tumbi Umbi** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Flood Damage Precinct** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Reference Location** | **D/S Playford Road Basin** | **U/S Killarney Vale Basin** | **D/S Wyong Road** | **Creek Entrance** | **D/S Wyong Road** | **U/S Wyong Road** | **U/S Tumbi Road** | **D/S Pat Morley Oval** |
| **AEP (%)** | **Flood Level (m AHD)** | | | | | | | |
| 20 | 8.20 | 2.65 | 1.82 | 1.29 | 1.98 | 3.14 | 9.52 | 18.76 |
| 5 | 8.41 | 3.00 | 1.90 | 1.40 | 2.28 | 3.61 | 9.70 | 18.84 |
| 1 | 8.50 | 3.44 | 2.04 | 1.56 | 2.72 | 4.40 | 9.85 | 18.95 |
| 0.01 | 9.10 | 4.56 | 3.18 | 2.32 | 5.05 | 6.02 | 10.38 | 19.40 |

The flood damage versus inundation data used in the 1996 study was based on Nyngan and Inverell floods up-dated by Consumer Price Index (CPI) to 1996 dollars. For this study, the 1996 dollar values have been updated to 2010 values again by CPI values.

The above approach provides flood damage estimates that are lower than the OEH guidelines, "Floodplain Management Guideline No. 4, Residential Flood Damage Calculation", (Reference 4). Nonetheless, the approach is valid in giving a lower limit of estimate of flood damages, while the Floodplain Management Plan is viewed as unlikely to recommend structural works, where reduction of flood damages represents major decision criteria.

The adopted flood damage versus inundation values are summarized in Table 7.2.

There has not been recent major flooding along Tumbi Umbi Creek and thus the 1996 Floodplain Management Study used generalized damage data from the April 1990 flood in Nyngan and the February 1991 flood in Inverell. The data collected included potential direct damage to buildings and contents, external property damages (including vehicles) and indirect damage estimates for evacuation, temporary accommodation, clean-up and loss of income.

The April 1999 flood on Tumbi Umbi Creek was not examined in detail, given that the flood damage was attributable to the contents of a single dwelling which is not viewed as representative over the wider sample required over a community to produce reliable changes (if any) to the standardised flood damage curves.

**Table 7.2**

**Potential Direct Damages**

| Depth of Flooding (m) | Residential Structural and Contents ($) | Commercial / Light Industrial ($/sq. m) |
|---|---|---|
| 0 | 5,000 | 30 |
| 0.5 | 28,400 | 270 |
| 1.0 | 39,200 | 440 |
| 1.5 | 41,700 | 550 |
| 2.0 | 45,500 | 610 |

It is emphasized that the ANUFLOOD model assesses "direct" flood damages to the structure and contents of buildings which are inundated by floodwaters. The model does not assess damages to the grounds ie gardens, pools, storage sheds, and removal of debris, etc, but accounts for above ground flooding (but not inundation above floor levels) by allocation of a lump sum damage figure to each property inundated.

The data collected at Nyngan and Inverell included the indirect costs associated with flooding comprising:

- clean up: $3,600/property
- evacuation, temporary accommodation and loss of wages: $760/household/day
- loss of trade: $4,450/day

For short duration floods, the indirect damages above are equivalent to 20% of potential direct damages for residential and commercial/light industrial properties for a typical depth of flooding of 0.5 metres. The indirect damages for Inverell were estimated to be 20% of potential direct damages for residential properties and 16 to 24% of potential direct damages for commercial and light industrial properties.

Given this information, indirect flood damages have been assumed to be equivalent to 20% of potential direct damages for residential, commercial and light industrial properties.

Potential direct damages represent the damages that would occur during a flood if no action is taken to reduce damages. In general, residents can be expected to take some action to reduce flood damages. Such action would include the following:

- placing moveable items on tables;
- moving contents to upper floor levels;
- use of sandbags to seal doorways; and
- removal of vehicles to higher ground.

The above actions enable residents to reduce the actual damages suffered in a flood event. The savings in flood damages that can be achieved is dependent on a number of factors, including:

- flood warning lead times;
- flood awareness and preparedness;
- availability of upper level floors; and
- access conditions and evacuation considerations.

Considerable reduction in damages can be achieved with adequate warning and appropriate response.

The relatively short response time of the Tumbi Umbi Creek catchment prevents the preparation and broadcasting of effective flood warnings for the bulk of the study area. Effective flood warnings can be provided to residents in areas where flooding is caused by high levels in Tuggerah Lake.

The flood awareness of the community is perceived to be low, with only a small number of residents having prior experience of flooding.

Accordingly, no reduction in potential damages is expected from flood warning or community response to flood warning.

Thus, direct damages estimates have been assumed to be equal to the potential direct damages to buildings and contents.

The original work on flood damages in ANUFLOOD was based on collection of resident interviews following a major flood in Lismore in 1974. The data has been updated and additions made by various government agencies and consulting companies principally using data from floods that occurred in Inverell, Nyngan, Forbes and Sydney. It has also been updated on the basis of CPI adjustments for annual inflation. In 2004, DIPNR (Ref.4) released, in draft, guidelines for the estimation of residential flood damages, which incorporated considerable volumes of data based on insurance claims. The 2004 work has been extended and has been recently published as a spreadsheet in 2011 and reissued in 2013. The most recent work (DIPNR 2004 and OEH 2013) have based inflation as described by increases in average weekly earnings as opposed to CPI changes.

For the purposes of the current study, the flood data used has been the updated ANUFLOOD data for comparison against the 2004 DIPNR as these were the most current data sets available at the time of assessment of flood damages (2009). In this study it has not been sought to update the flood damages to 2013 dollar values on the basis that:

- the earlier floodplain management studies have not indicated that any structural works will prove cost-effective;
- the current study foresees no change in that recommendation;
- there is not a single "correct answer" with respect to flood damages; and
- the flood damage estimates are of somewhat academic interest in providing a measure of flood damages in Tumbi Umbi Creek versus Wyong Shire wide view of flood damage potential;

Table 7.3 below gives comparative figures used in this study (based on direct damage plus 20% indirect damages plus clean-up costs) versus the DIPNR Guidelines (total damage). Table 7.3 also illustrates that the damages figures adopted in this study represent 70 percent of the damage potential derived from the DIPNR guidelines.

**Table 7.3**

**Comparison of Flood Damage Estimates**

| Depth of Flooding above Floor Level (m) | ANUFLOOD (This Study) ($)(2010) | DIPNR ($) |
|---|---|---|
| 0.0 | 9,600 | 7,477 |
| 0.5 | 37,680 | 52,975 |
| 1.0 | 50,640 | 73,785 |
| 1.5 | 53,640 | 74,596 |
| 2.0 | 58,200 | 84,406 |

The DIPNR and OEH guidelines on residential damage highlight:

- there is not a single "correct answer" with respect to flood damages;
- insurance paid out appears to be considerably higher than actual damage;
- consideration of insurance paid out as a measure of damage is higher than damage restoration costs;
- the damage costs used in this study (based on recorded damages at Nyngan and Inverell) are about 70 percent of the flood damages based on insurance paid out, and thus represent a lower bound of damages.

## 7.3 Residential Properties

The 1996 analysis of the floor levels data reveals that there are only four (4) houses within the study area that have the main floor located below the 1% AEP design flood level for local creek flooding. In total, 60 houses had floor levels that have less than 0.5m freeboard to the design 1% AEP flood level

Nine (9) elevated houses had floor levels of the laundry and garage areas below the 1% AEP design flood level.

Review of the Building Application and Construction Certificates issued over the period 1996 to 2008 show 20 new residences and one infill of a lower ground floor level in the areas in or adjacent to the design 1% AEP flood extent. Site inspection of the new dwellings shows:

- all new dwellings were above the design 1% AEP flood levels;
- all dwellings except one were above the design 1% AEP flood level plus 0.5 m freeboard;

- twelve of the 20 new dwellings were at or above the PMF flood levels.

Accordingly, incorporation of the new dwellings into the 1996 house data base does not impact flood damages.

It is clear that the pattern of developments over the period 1996 to 2010 is limited by the small land holding sizes and lack of vacant blocks. Thus, Tumbi Umbi has not seen the sub-division of larger blocks into small blocks (as has occurred on the Lower Wyong River) or replacement of existing buildings on relatively large lots (as has occurred on Ourimbah Creek).

Table 7.4 below gives the comparison between house floor levels and design 1% AEP flood levels for the eight precincts adopted for flood damage assessment. From Table 7.4 it will be noted that the majority (85 percent) of dwellings with floor levels below the 1% AEP flood level and an appropriate freeboard (0.5 m) are located on Tumbi Umbi Creek near its entrance to Tuggerah Lake and on the Killarney Vale tributary downstream of Wyong Road.

**Table 7.4**

**Distribution of Residential Floor Levels**

| Floor Level | Total Number of Houses Below Flood Level | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Precinct | | | | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Total** |
| 1% AEP – 0.25 m | - | - | - | - | - | - | - | - | - |
| 1% AEP | - | - | 4 | - | - | - | - | - | 4 |
| 1% AEP + 0.25 m | - | - | 14 | 8 | - | - | - | - | 22 |
| 1% AEP+ 0.5 m | 2 | - | 29 | 22 | 4 | - | 3 | - | 60 |
| 1% AEP + 0.75 m | 12 | ND | 41 | 38 | 10 | - | 16 | - | 117 |
| 1% AEP + 1.0 m | 24 | ND | 49 | 48 | 33 | 3 | 41 | - | 198 |

Note: ND = Not Determined

The estimated potential direct flood damages to residential properties for a range of flood probabilities are shown in Table 7.5. The data presented in Table 7.5 shows that the bulk of the flood damages is sustained in Flood Damage Precincts 3, 4 and 5 which are located between Wyong Road and Tuggerah Lake. This area is also prone to flooding from Tuggerah Lake.

The number of houses inundated by Tuggerah Lake flooding, independent of runoff in Tumbi Umbi Creek, is summarised in Table 7.6. The Tuggerah Lake flood level probability distribution was determined in the 1994 Tuggerah Lakes Flood Study (Ref. 5).

The data presented in Table 7.6 shows that more houses are flooded and greater flood damage is caused in this area (Flood Damage Precincts 3, 4 and 5) by Tuggerah Lake flooding than by flooding in Tumbi Umbi Creek.

**Table 7.5**

**Potential Direct Flood Damages - Residential Properties (Tumbi Umbi Creek catchment flood)**

| AEP (%) | Potential Direct Damages ($) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Flood Damage Precinct | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| | D/S Playford Road Basin | U/S Killarney Vale Basin | D/S Wyong Road | Creek Entrance | D/S Wyong Road | U/S Wyong Road | U/S Tumbi Road | D/S Pat Morley Oval | |
| 20 | - | - | 5,900 | - | - | - | - | - | 5,900 |
| 10 | - | - | 7,700 | - | - | - | - | - | 7,700 |
| 5 | - | - | 9,700 | - | - | - | - | - | 9,700 |
| 2 | - | - | 22,000 | - | - | - | - | - | 22,000 |
| 1 | - | - | 36,000 | - | - | - | - | - | 36,000 |
| 0.01 | 485,800 | ND | 1.67 M | 845,500 | 3.34 M | 226,200 | 89,600 | - | 6.66 M |
| Mean Annual Damages | 2,400 | ND | 10,300 | 4,100 | 16,500 | 1,100 | 400 | 0 | 34,729 |

Note: ND = Not Determined

**Table 7.6**

**Tuggerah Lake Flooding - Lower Tumbi Umbi Creek**

| AEP % | Lake Level | Houses Flooded | Potential Direct Damages ($) |
|---|---|---|---|
| 20% | 1.36 | - | 68 |
| 10% | 1.62 | | 7,640 |
| 5% | 1.80 | 4 | 44,000 |
| 2% | 2.05 | 24 | 448,400 |
| 1% | 2.23 | 35 | 597,100 |
| 0.01% | 2.70 | 102 | 2.20 M |
| Mean Annual Damages | | | 28,135 |

The estimated mean annual damages for the area between Wyong Road and Tuggerah Lake caused by lake flooding is marginally greater than the damages caused by creek flooding for the full study area. Thus, flooding caused by elevated lake levels poses a greater problem than does local creek flooding

## 7.4 Commercial and Light Industrial Properties

There is an area of commercial/light industrial development immediately downstream of Wyong Road and west of Tumbi Creek Road. This area has been filled to a minimum level of RL 4.0 m AHD. Thus, all commercial/light industrial properties in this area are 1.5 metres or more above the 1% AEP design flood level.

This area may be subject to inundation in the PMF event, which is anticipated to overtop Wyong Road. However, the flood models were not established to model this behaviour and thus, additional investigation is required in this area.

## 7.5 Public Utilities

The land within the study area that is inundated in the 1% AEP design flood extents extends over a total area of some 125 hectares. Public utility works that are located within the inundated area include:

- roads;
- parklands;
- undeveloped wetland areas; and
- underground water, sewerage, power and telephone services.

Public utility damages comprise the replacement or repair of assets that suffer damage as a result of inundation and the costs of clean-up of debris deposited by floods as well as disposal of clean-up material from private property. Public utility services encompass all public sector assets excluding buildings, which are included in the commercial properties damages assessment.

Analysis of public utility damages for floods at Nyngan, Inverell, Grafton (2006), and Kempsey (2006) indicates that public utility damages are of the order of $7,800 to $9,250 per hectare of inundated land

Public utility damages have been assessed at $7,800 per hectare of inundated land excluding the wetland areas. The wetland areas extend over some 90 hectares or 60% of the land inundated in the 1% AEP design flood. The estimated damages to public utilities for a range of flood probabilities are presented in Table 7.7.

**Table 7.7**

**Public Utilities Damages**

| AEP (%) | Damages ($) |
|---|---|
| 20 | 250,500 |
| 5 | 384,000 |
| 1 | 576,800 |
| 0.01 | 1,199,200 |
| Mean Annual | 75.594 |

## 7.6 Total Tangible Flood Damages

The total mean annual tangible flood damages for the study area comprises:

| | | |
|---|---|---|
| - | direct damages to residential properties (Table 7.5) | $ 34,729 |
| - | indirect damages to residential and commercial/light industrial properties (20% of direct damages) | $ 6,946 |
| - | public utility damages (Table 7.7) | $ 75,594 |
| - | Total | $116,269 |

The estimated mean annual indirect damages to residential and commercial/light industrial properties has been assessed at 20% of the direct damages.

It is noted that about 65% of the total tangible flood damages is estimated to be sustained by public utilities.

The potential damage to residential properties between flooding from Tumbi Umbi Creek and flooding from elevated water levels in Tuggerah Lake is similar.

The relatively high public utilities damages component is a reflection of the small number of properties affected by creek flooding rather than the damages sustained by roads, utility services, parkland and the costs of post-flood clean-up and disposal of debris.

It is estimated that almost 50% of the damages suffered by public utilities is sustained by roads with clean-up and disposal of debris from parklands, roadways and private property accounting for 15% - 25% of the public utilities damages.

# 8. FLOODPLAIN MANAGEMENT ISSUES

## 8.1 Overview

The Floodplain Development Manual lists a number of structural and non-structural flood mitigation measures that can reduce the impact of floods.

Structural flood mitigation measures reduce the impact of flooding by modifying flood behaviour ie. the extent, depth and velocity of floodwaters and frequency of flooding. These measures include:

- flood mitigation dams;
- levees;
- bypass floodways;
- channel improvements; and
- detention basins.

Flood mitigation dams and detention basins perform essentially the same function, though on vastly different scales. The former is applicable for large rivers and catchments, whereas, the latter is most suitable for small streams that respond quickly to rainfall and/or stormwater flooding

Levees are an effective means to protect development from flooding in frequent to moderately rare events. The height of the levee is determined by economic factors and site conditions in addition to flood behaviour. Therefore, in general, levees do not provide protection against all floods.

Issues to be considered in the levee proposals include:

- probability of overtopping and failure;
- consequences of overtopping or failure;
- drainage of land within the levee; and
- adverse impacts at other locations.

A bypass floodway would provide an additional outlet or flowpath for floodwaters. Construction of bypass floodways is limited by the topography of the area, environmental considerations and the availability of land. (the bulk of which would probably require acquisition of existing residential development). There is minimal opportunity to construct any by-pass floodways in the Tumbi Umbi catchment.

Channel improvements increase the capacity of a stream to discharge floodwaters. The effect of channel improvements is to reduce the overbank flow and, hence, depth of flooding. Channel improvements are unlikely to have a significant effect in areas where flooding is dominated by Tuggerah Lake levels or where there is extensive overbank flow.

Factors to be considered in the assessment of channel improvements include:

- impacts on ecology of the stream;
- visual impacts; and
- maintenance requirements.

Non-structural measures reduce the impact of flooding on existing development and reduce the risk of damage caused by flooding for future development. These measures include:

- floodproofing of buildings;
- land use controls;
- building and development controls;
- voluntary purchase;
- public education; and
- flood warning and disaster planning.

Flood-proofing of buildings and voluntary purchase of flood-liable properties can reduce the impact of floods on existing development, while land use planning controls and building and development controls are applied in order to minimize the impact of floods on future development within the flood-liable area.

Flood warning and disaster planning enable people and possessions to move out of the way of an approaching flood. In general, the flood warning available for small catchments is inadequate for flood-affected persons to initiate evacuation procedures.

Public education raises the level of awareness of flooding issues so that residents will accept and act on flood warnings and adopt appropriate safeguards in the design of new building construction.

## 8.2 Applications to Tumbi Umbi Creek

The measures outlined in the Floodplain Development Manual are broad scale generic options and have been briefly noted above.

The urban development in the Tumbi Umbi catchment has intensified from the early 1960's. Consequently, floodplain management measures have been applied within the catchment, particularly after severe storms in 1978 and 1981, together with further urbanisation of the Tumbi catchment.

Two detention basins have been constructed in the Killarney Vale tributary. These basins have been modified since construction to change their performance (namely, to reduce flood discharges along the Killarney Vale Tributary).

Channel works have been constructed:

- along the Killarney Vale tributary (to reduce flood levels);

- parallel to Wyong Road and parallel to Beckingham Road to enable development of the Mingara Club Complex, the Glengarry Retirement Village and residential development near the Beckingham Road / Wyong Road intersection.

A levee was constructed as part of the drainage works and channel works at the Mingara Club.

Land use and planning controls have been applied to urban release areas that preceded urban development within the catchment. These urban release areas have not increased flood damages and indicate the

success of land use planning controls to promote development consistent with the flood liability of particular areas.

The unpublished 1996 draft Tumbi Umbi Floodplain Management Study examined the opportunities and constraints for measures involving:

- an additional detention basin upstream of Wyong Road on Tumbi Umbi Creek;
- a flood warning system;
- channel improvements along the Killarney Vale tributary;
- house raising;
- voluntary purchase of flood liable buildings.

The 1996 Tumbi Umbi Floodplain Management Study briefly considered options for levees and creation of an additional outlet to Tuggerah Lake to provide some protection against flooding for existing rainfall.

The levee option was rejected, principally on the basis that there was not sufficient open space to construct levees and such levees would not protect against Tuggerah Lake flooding (the principal source of flood damage in Tumbi Umbi Creek).

The foreshores of Tuggerah Lake are heavily urbanised and the topography of the foreshore area in the vicinity of Tumbi Umbi Creek is not favourable to providing either a wide floodway or a shorter route to enable a reduction in flood levels. Further, the bypass option would not reduce Tuggerah Lake flooding. The same conclusion was drawn for this study.

The conclusions drawn from the 1996 floodplain management study on the above options and the 2010 review were:

***Additional Detention Basin, upstream of Wyong Road – Not Recommended***

The hydraulic modelling showed a large basin would reduce flood levels along Tumbi Umbi Creek by 30 to 100 millimetres. Only three houses from 19 flood liable houses downstream of Wyong Road received benefits from the works. The works cost in 1996 was $500,000 and the benefit-cost ration (at 4 percent discount rate) was 0.06.

Whilst the works costs and benefits from the works have increased since 1996, the benefit-cost ratio in 2009 would be similar. If the benefits are doubled by using higher flood damages cost, the benefit cost ratio at 0.12 would remain unattractive. The number of houses benefitting is small and remains unchanged since 1996.

***House Raising – Not Recommended***

House raising of vulnerable properties is an effective means of reducing flood damages to residential properties, by raising habitable floor levels above flood level. However, such raising is not cost effective for slab-on-ground or brick veneer forms of construction.

The 1996 data showed that there are 22 houses with floor levels less than 0.25 metres above the estimated 1% AEP design flood level. Only one of these houses is suitable for raising. Thus, house-raising was not considered to be an effective option for generally reducing flood damages in the study area.

The benefit-cost ratio of the house raising program was assessed in 1996 as 0.12. The current benefit-cost ratio for the work would be less than 0.1, given building cost increases over the period 1996 to 2010 would be greater than the increases in flood damages (flood damages representing the benefits).

***Voluntary Purchase – Not Recommended***

The 1996 Tumbi Umbi Floodplain Management Study considered a voluntary purchase program as an alternative means of reducing residential flood damages. These houses may then be demolished or relocated to flood-free land and the site redeveloped above flood level. The high cost of this option generally restricts its viability to small localised areas of residential development located in high hazard floodways where no alternative solution is practicable. There are four (4) houses with floor levels located below the estimated 1% AEP flood level for creek flooding. Whilst voluntary purchase of these flood-liable properties will reduce the damages caused by creek flooding, there are 26 other houses in the immediate area that are more at risk to flooding from Tuggerah Lake. Given the large numbers of residences liable to flooding, the potential for re-development, on the individual purchase cost, a voluntary purchase in Tumbi Umbi Creek is not viewed as a viable option.

***Channel Improvements – Maintenance Recommended***

Channel improvements were considered in the 1996 Floodplain Management Study along the Killarney Vale tributary. The 1996 Floodplain Management Study summarized:

- channel improvements downstream of Adelaide Street would not produce a significant reduction in flood levels because the area is dominated by Tuggerah Lake;

- channel clearing along the Killarney Vale tributary between Wyong Road and Adelaide Street.

The hydraulic model results show that flood levels along this reach of the creek can be lowered by 70 millimetres with regular clearing of the creek channel. This would result in two of the four houses that are located slightly below the 1% AEP flood level not being flooded in the 1% AEP design flood. There would be no reduction in the number of houses flooded in a repeat of the 1981 event; however the depth of flooding would be reduced by approximately 70 mm.

There are a small number of relatively sparsely located houses that are less than 0.5 metres above the estimated 1% AEP design flood level.

Wyong Shire Council responded to the 1999 flood by:

- widening the Killarney Vale tributary channel by 6 metres;
- amplifying the Adelaide Street culverts;
- raising the wall height of the Killarney Vale basin and reducing its outlet capacity.

Nonetheless, without a regular maintenance routine, siltation and aquatic vegetation growth will continue and could create a repetition of the 1999 flood.

The 1999 flood event highlighted the importance of maintaining the section of the Killarney Vale tributary between Wyong Road and Adelaide Street to ensure no siltation or growth of aquatic vegetation in the channel. The recorded flood levels display a greater than expected flood slope, indicating siltation of the channel after the cross-section survey was taken and effects of significant vegetation growth in the channel (principally *Typha*, "Cumbingi")

## 8.3 Summary of Floodplain Risk Management Works Measures

The unpublished 1996 Floodplain Management Study presented a comparison matrix for the various works options considered. The passage of time (from 1996 to 2010) has not essentially changed the works comparison.

Analysis of the practical floodplain risk management measures is presented as a comparison matrix in Table 8.1 that shows the relative performance of each of the options against the evaluation criteria category. The relative performance is ranked from 1 for the highest. Equal weightings have been attached to each of the four criteria in order to assess the ranked order of the options.

**Table 8.1**

**Summary Comparison of Floodplain Risk Management Options**

| Criteria Category | Options | | | | |
|---|---|---|---|---|---|
| | **"Status Quo"** | **Detention Basin** | **House Raising** | **Voluntary Purchase** | **Channel Clearing** |
| Effectiveness | 5 | 3 | 4 | 1 | 2 |
| Economics | 2 | 5 | 3 | 4 | 1 |
| Social Impacts | 3 | 5 | 2 | 4 | 1 |
| Environment | 1 | 5 | 4 | 2 | 3 |
| Overall | 11 | 18 | 13 | 11 | 7 |
| Ranking | 4 | 5 | 3 | 2 | 1 |

The results presented in the summary comparison indicate that channel clearing is the superior option. The "Status Quo" option and voluntary purchase options are marginally superior to the house raising option, while the detention basin option is clearly inferior to the other options.

# 9. DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

## 9.1 Plan Objectives

The objectives of this floodplain risk management plan, broadly, are:

- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property;
- to reduce private and public losses resulting from floods;
- to recognise the benefits flowing from use, occupation and development of flood prone land, cognisant of the first two objectives above.

The framework of the Floodplain Risk Management Plan is set by the NSW Government's Flood Prone Land Policy as enunciated through the NSW Government's "Floodplain Development Manual", (2005), (Reference. 2).

The primary responsibility for management of floodplain risk rests with local government (that is, local councils) with financial and technical assistance from the State Government. Historically, the Federal Government has also provided funds for selected projects.

Wyong Shire Council has undertaken floodplain risk management studies on a waterway by waterway basis over the past 30 years. This Floodplain Risk Management Plan is intended:

- to apply a "continuous improvement" process to Wyong Shire Council's current practice;
- to facilitate integration so that floodplain risk management is consistent across the boundaries of the various waterways;
- to develop a set of floodplain risk management measures that are consistent with Wyong Shire Council's planning documents, understandable by the public, and easier for Wyong Shire Council staff to apply in the development control process.

## 9.2 Current Issues Summary

A number of flood studies and floodplain management studies have been undertaken on Tumbi Umbi Creek and the Killarney Vale tributary to Tumbi Umbi Creek over the past 30 years.

Drainage works and levee works have been constructed notably in response to severe storms and flooding in 1978, 1981 and 1999 and to enable development (notably the Mingara Club development) to proceed.

The most recent floodplain risk management study (1996 unpublished), recommended physical works be limited to regular clearing and maintenance of the Killarney Vale tributary. Given the nature and magnitude of development on the floodplain at that time (1996) and changes to the floodplain in the

intervening period to this study (2010), there are no valid considerations to change the 1996 recommendation.

The Tumbi Umbi Creek Floodplain Risk Management Study Review has identified four current (in 2013 ) floodplain risk management issues.

The identified current issues related to:

- land use zoning and planning;
- development of better understanding of flood behaviour;
- public information and education;
- operations and maintenance.

The most recent developments in the study catchment have been based on land use planning cognisant of the flood risk. Clearly, the resulting development patterns indicate the effectiveness of land use planning to limit the growths of flood liable properties and flood damages.

The components of this Plan address these current issues.

## 9.3 Land Use Zoning and Planning

An overview of Wyong Shire Council's current land use zonings from a floodplain risk management perspective shows that the current zonings are adequate to achieve the aims of the NSW Floodplain Development Manual. However, a significant proviso is that:

- rezoning to more flood risk liable uses does not occur; and

- special exemptions are not granted, so that developments which would be prohibited under the present zonings are allowed to proceed with re-zoning being undertaken.

In the area between Wyong Road and Tuggerah Lake, there are a number of dwellings with lower floor levels that are potentially flood liable from Tumbi Umbi Creek and tributaries. These dwellings, together with many others, are also flood liable from elevated water levels in Tuggerah Lake. The use of planning controls will enable a gradual change in floor levels to provide better flood protection, as renewal of the building stock occurs over time.

During the preparation of this Floodplain Risk Management Plan and its antecedents, the NSW Government has changed the focus of land use planning and has required local government to regularly up-date their Local Environmental Plans (LEPs).

Wyong Shire Council has adopted DCP 2013 (Chapter 3.3) that effectively moves away from the earlier floodplain development policies and creates a matrix assessment process. The proposed matrix for Tumbi Umbi appears in Appendix C of this report.

The proposed prescriptive matrix divides the flood liable area in the study area into four flood planning areas.

The recommended Flood Planning Level for Tumbi Umbi is the design 1% AEP flood level plus 0.5 metres freeboard.

The four flood planning areas within the prescriptive matrix (see Appendix C) comprise:

Flood Planning Area 1, which covers the area between the inundation extent of the PMF and the extent of application of Flood Planning Level;

Flood Planning Area 2, which covers the areas between the extent of application of the Flood Planning Levels and the extent of inundation of design 1% AEP flood.

Flood Planning Area 3, which covers the area between the extent of inundation of the design 1% AEP flood and any "High Hazard" areas. Thus Planning Area 3 covers the categories of "Flood Fringe" and "Low Hazard Flood Storage"

Flood Planning Area 4, which covers those floodway areas which are "High Hazard" and thus considered “unsuitable for development” categories of most land uses excepting “agriculture and recreation” and “permissible earthworks”.

Flood Planning Area 1 is principally directed to providing flooding related controls to critical infrastructure and emergency infrastructure so that they are sited above the Flood Planning Level and offering flood protection against the PMF.

### 9.4 Development of Better Understanding of Flood Behaviour

The flood study work, to date, has been undertaken progressively as various flood risk management works and measures have been completed. There are, however, a number of issues that have arisen as part of the latest Floodplain Development Manual’s emphasis on development of an understanding of the behaviour of the PMF event.

Specific areas requiring further investigation relate to:

- rainfall patterns;
- potential flooding of industrial/commercial areas in events larger than the design 1% AEP flood event;
- potential for overtopping of the Playford Road detention basin.

The “Tumbi Umbi Creek Flood Study Review” (Reference 6) indicated that the rainfall recorded in 1978 and 1981 exceeded the design 1% AEP rainfall. While such occurrences are theoretically possible, an alternative view is that the design rainfalls may be too low for the particular topography and size of the Tumbi Umbi catchment.

The detention basins on the Killarney Vale tributary were designed using the design rainfall temporal patterns from Australian Rainfall and Runoff (Ref. 3). However, the 1999 flood rainfall followed a totally different pattern, which accentuated the impact of prior filling of the Killarney Vale basin before the arrival of the flood peak.

Australian Rainfall and Runoff is currently (2013) being reviewed, including the design rainfall data. On completion of the rainfall revisions, Wyong Shire Council should examine the implications of any changes in design rainfall patterns and consider whether it would be prudent to move from the design 1% AEP event to a repeat of the 1978 or 1981 events for setting of floor levels.

The area immediately downstream of the basin wall at the Playford Road detention basin is an area of concern. The basin floor is approximately at RL 10.5 m AHD, while the basin wall crest is at approximately RL 12.0 m AHD. However, immediately downstream of the basin wall, the ground levels are at approximately RL 9.4 m AHD, while each of the building blocks abutting the basin wall is occupied by residential dwellings. The potential for overtopping of the Playford Road basin should be checked to ensure significant flood damage is not created by overtopping.

## 9.5 Public Information and Education

Two mechanisms are proposed to improve flood awareness and flood preparedness in the Tumbi Umbi Creek catchment.

The two mechanisms are:

- use of Wyong Shire Council's GIS system with external GIS viewers to indicate that, where a property is within the PMF flood extent, it will be subject to Wyong Shire Council's policies regarding development of floodprone land. Other GIS based data could also be displayed with further information relating to:
    - design flood levels at the site;
    - approximate ground level data at the site;
    - flood hazard and hydraulic categories for Wyong Shire Council's adopted Flood Planning Levels;
    - freeboard requirements.
- use of area specific brochures to indicate flood liability and to provide information such that individual land owners can form their own individual flood plans and evacuation routes.

Assistance from technical staff will be required to prepare the area specific flood information from the available flood studies.

The rapid response of the Tumbi Umbi catchment and associated rapid rise of floodwaters indicates that there is simply insufficient warning time available to operate an effective flood warning system or for the local residents to rely on the SES to assist in flood evacuations. Accordingly, residents will need to rely on their own flood planning and response actions. The public information program should be directed to informing and assisting residents develop their own flood response plans.

## 9.6 Operations and Maintenance

Over the past 40 years, Wyong Shire Council has installed various works and measures to assist in floodplain risk management and to assist the general development within the Study catchment area.

Wyong Shire Council relies on a number of open drains to provide trunk drainage functions, notably:

- the Killarney Vale tributary;
- "Moss drain beside Wyong Road;
- "Mingara" drain, which joins "Moss" drain near the intersection of Wyong Road and Beckingham Road.

Excessive vegetation growth in these drains will reduce the capacity of such drains to achieve their desired intent (conveyance of floodwater and to reduce overbank flooding). On-going active vegetation management is required to ensure that the drainage capacity is not reduced by vegetation growth.

The above maintenance activities are an essential part of the successful operation of an integrated floodplain risk management process and plan.

It should be appreciated that the floodplain management works and measures do not operate regularly on a day to day basis, but rarely, when floods occur. Thus, maintenance must be undertaken to ensure the smooth operation of these works and measures on the rare occasions (during floods) when their operation is required.

Specific attention needs to be made to the Killarney Vale tributary, which has a number of elevated houses with low ground floors in the proximity. The 1999 flood showed the impact of siltation and vegetation growth in this particular section.

It is appreciated that the above maintenance activities are a small part of Wyong Shire Council's operations and the works are generally not in the public view. The temptation to delete the maintenance work to satisfy budgetary constraints or public perceptions should be strongly resisted, since the floodplain risk management process relies on successful operation of these components.

## 9.7 The Floodplain Risk Management Plan

This section outlines the recommended Floodplain Risk Management Plan. The section has been prepared on the format of "Floodplain Risk Management Issue" and "Response", drawn from Sections 9.3 to 9.8 inclusive.

Table 9.1 identifies "Management Issue Categories", "Response" together with a priority ranking, project duration, and projected cost.

1. Floodplain Risk Management Issue

   Public information and education on flood risk within the study area is limited and can be improved, given current knowledge of flood and flood behaviour.

Response

Wyong Shire Council's GIS system can be developed to indicate if subject property is flood liable in the PMF event and thus development is required to be in accordance with Wyong Shire Council floodplain risk management policies.

The area for application for the PMF event is indicated by:

- Figures 9 and 10 of this report, or
- Flood Planning Area 1, 2, 3 and 4 in the 2013 revision of the Wyong Shire LEP.

Other information can be developed for dissemination using the GIS system, such as predicted flood levels, existing house floor levels and flood hazard categories. This data may or may not be available from Wyong Shire Council, subject to the property location.

Current flood knowledge can be developed to provide specific flood risk information on an area by area basis, as opposed to the historic trend of developing generalized flooding information and brochures. Such site specific information would allow individual occupiers to set up their own flood plans for flood level monitoring, evacuation and flood preparedness.

2. Floodplain Risk Management Issue

The April 1999 flood event demonstrated the need to maintain the Killarney Vale tributary in a "clean" condition (that is, free of siltation and aquatic vegetation) thus ensuring its flood conveyance capacity. The creek system requires a regular inspection of the creek system and maintenance clearing as required.

Response

Formalise inspection, maintenance and reporting requirements within Wyong Shire Council through an appropriate department to ensure the inspection and maintenance activities are undertaken.

3. Floodplain Risk Management Issue

Further technical investigations are required to confirm and review three areas of uncertainty, principally:

- the flood hazard in the commercial and industrial area, should flood water overtop Wyong Road near its intersection with Beckingham Road. This investigation will need to be undertaken using a two-dimensional floodplain hydraulic model.

- review of the flood hazard immediately downstream of the Playford Road detention basin, should the basin wall be overtopped. In this area, existing residential development abuts the downstream and lower side of the basin wall;

- review the revised rainfall intensities and design temporal patterns in the revised (yet to be released) version of Australian Rainfall and Runoff, given the inconsistencies in the return period of the 1978 and 1981 storm events against the current (1987) version of Australian Rainfall and Runoff.

The lack of any high flow measurements in Tumbi Umbi Creek remains a significant impediment to resolving the inconsistencies between the catchment hydrology and river models in the study area.

Response

Undertake the required technical investigations in the priority listing as funds permit, preferably using a two-dimensional flood model.

Actively pursue NSW government agencies to undertake some high flow measurements along Tumbi Umbi Creek when floods occur, or alternatively, undertake a trial program to confirm if such measurements can be effectively undertaken using Wyong Shire Council's in-house resources.

Table 9.1 below indicates the appropriate priority and projected cost of each response above.

**Table 9.1**

**Tumbi Umbi Creek Floodplain Risk Management Plan**

| Risk Management Issue | Response | Priority | Duration | Projected Cost |
|---|---|---|---|---|
| 1. Public Information and Education | 1. Include flood risk notation on Section 149 Certificates | High | 2 months (and on-going) | - |
| | 2. Update flood mapping and put on website | High | 6 months | - |
| 2. Inspection and maintenance of existing waterways, in particular the Killarney Vale tributary | Review inspection and maintenance procedures | High | On-going | $30,000 per annum |
| 3. Development of Flood Knowledge | 1. Review flood hazard immediately downstream of Playford Road detention basin | High | 6 months | $30,000 |
| | 2. Flood Study | Moderate | 6 months | $60,000 |

## REFERENCES


1. `Floodplain Management Manual' NSW Government, Dec. 1986.

2. "Floodplain Development Manual", New South Wales Government, April 2005

3. "Australian Rainfall and Runoff, A Guide to Flood Estimation", Institution of Engineers Australia, 1987

4. "Floodplain Management Guideline No. 4, Residential Flood Damage Calculation," DIPNR, 2004

5. "Tuggerah Lakes Flood Study", Lawson and Treloar Pty Ltd, (Sept. 1994)

6. "Tumbi Umbi Flood Study Review", Paterson Consultants Pty Ltd, December 1994

7. "Tumbi Umbi Creek Floodplain Management Study – Exhibition Report" Paterson Consultants Pty Ltd, September 1996

8 ."Tumbi Umbi Creek Stormwater Drainage Study", Willing & Partners, July 1979.

9. "Tumbi Umbi Creek Floodplain Management Study Vol. 1: Technical Investigations", Cameron McNamara, 1983.

10. "Tumbi Umbi Creek Floodplain Management Study Vol. 2: Management Strategies", Cameron McNamara, 1983.

11. "Tumbi Umbi Creek Flood Study, Compendium of Data", Cameron McNamara, 1987.

12. "Tumbi Umbi Creek Flood Study, Survey Report 30130 ASOZ", New South Wales Public Works, Feb. 1988.

13. "Tumbi Umbi Creek Flood Protection Works", Cameron McNamara, Dec. 1987.

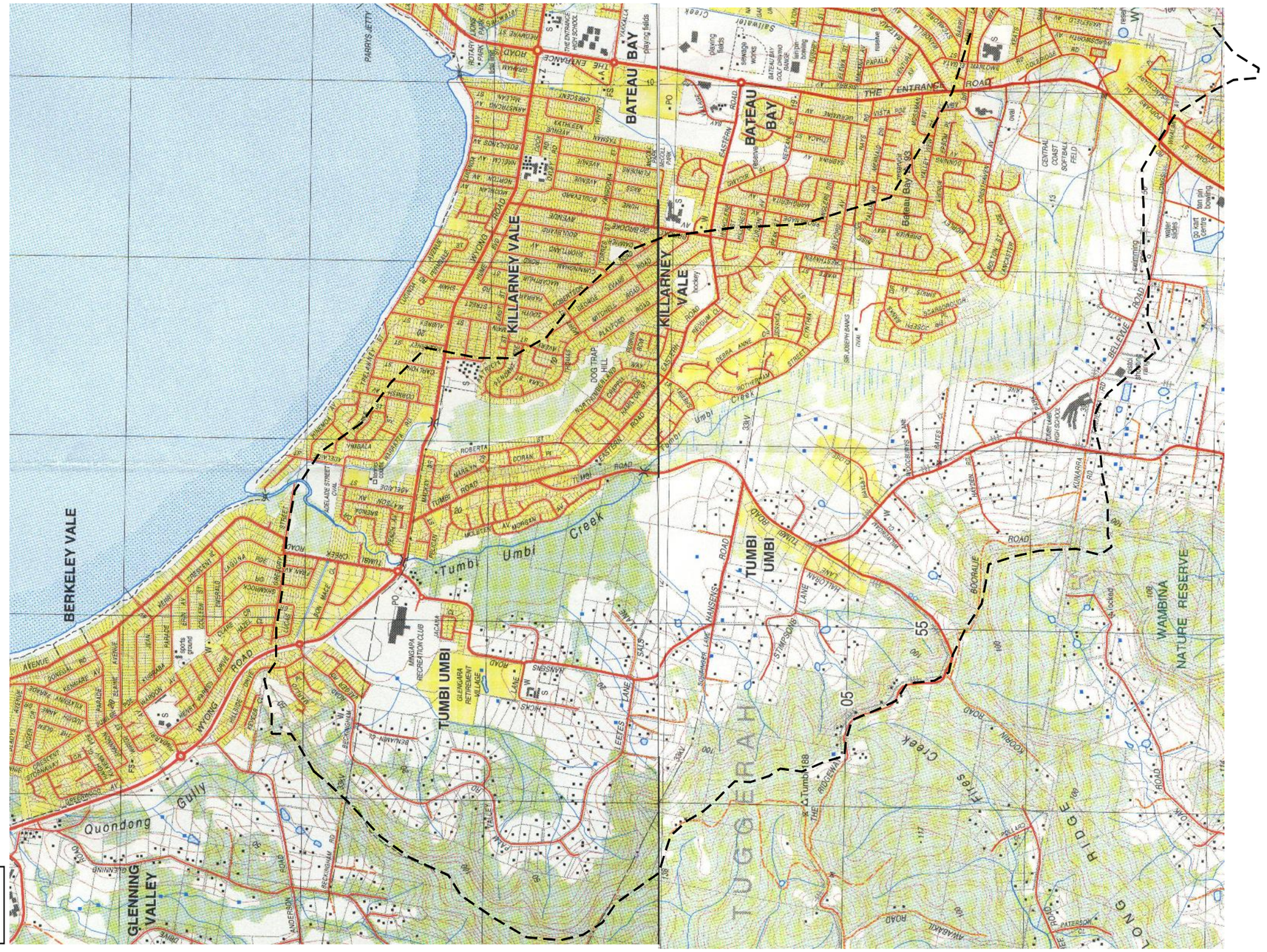
14. "Tumbi Umbi Creek Flood Study", Cameron McNamara, Feb. 1988.

15. "Tumbi Umbi Creek Flood Study", Kinhill Engineers, Feb. 1991.

16. "ANUFLOOD Programmer's Guide and User's Manual" Centre for Resource and Environmental Studies, 1987.

17. "Lower Tumbi Valley – Urban Release Area, Section 94 Contributions Plan, Technical Report – Drainage", Paterson Consultants Pty Ltd, June 1997.

# FIGURES




**Legend**
Catchment Boundary

**Base map: 1:25000 topographic maps, "Wyong" & "Gosford"**

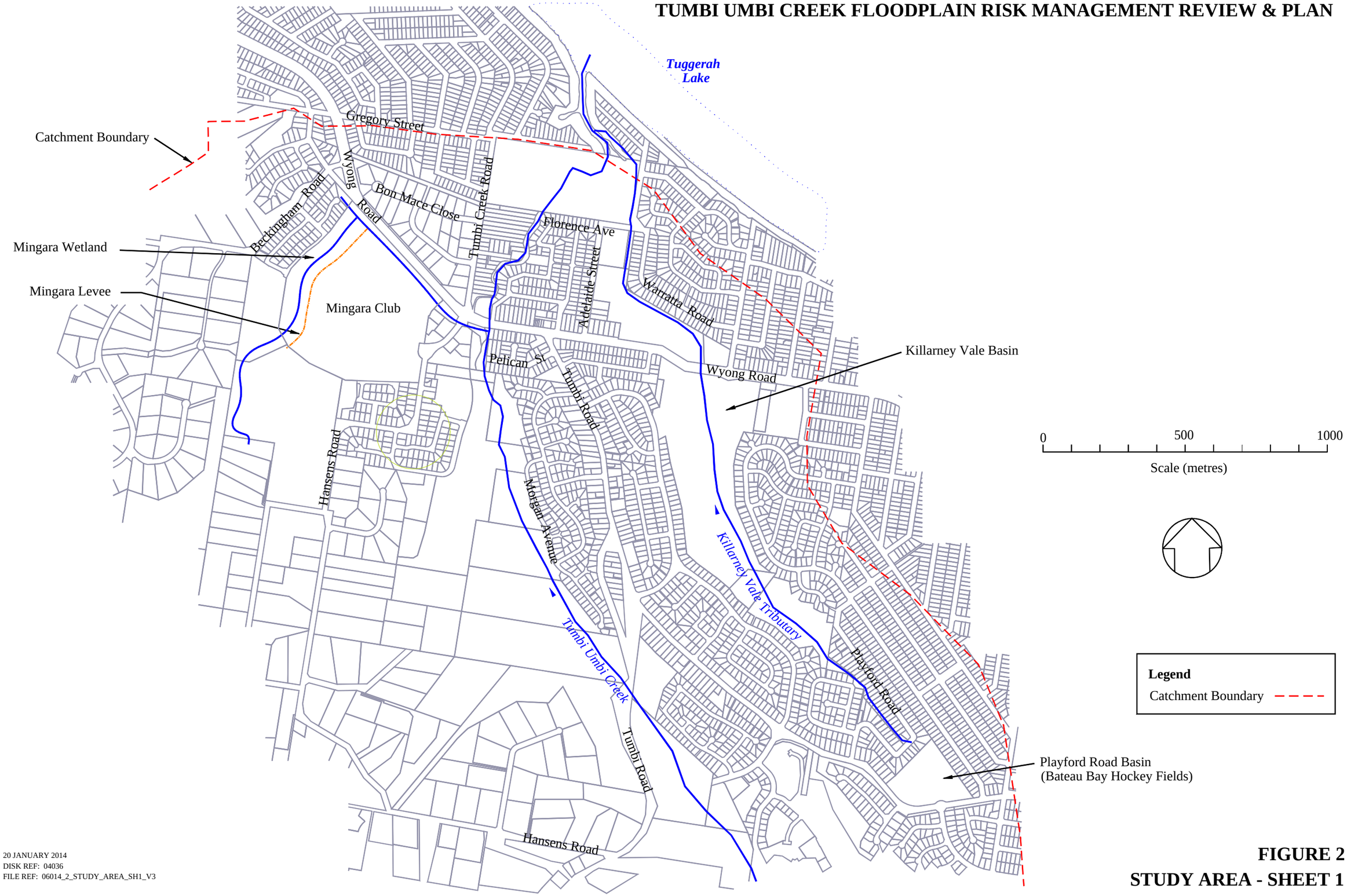
**0** **1000**
**Scale ( m)**

16 JAN 2009
DISC REF: 04036
FILE REF: 04036_1_STUDY_LOCALITY_V2

**FIGURE 1**
**STUDY LOCALITY**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**

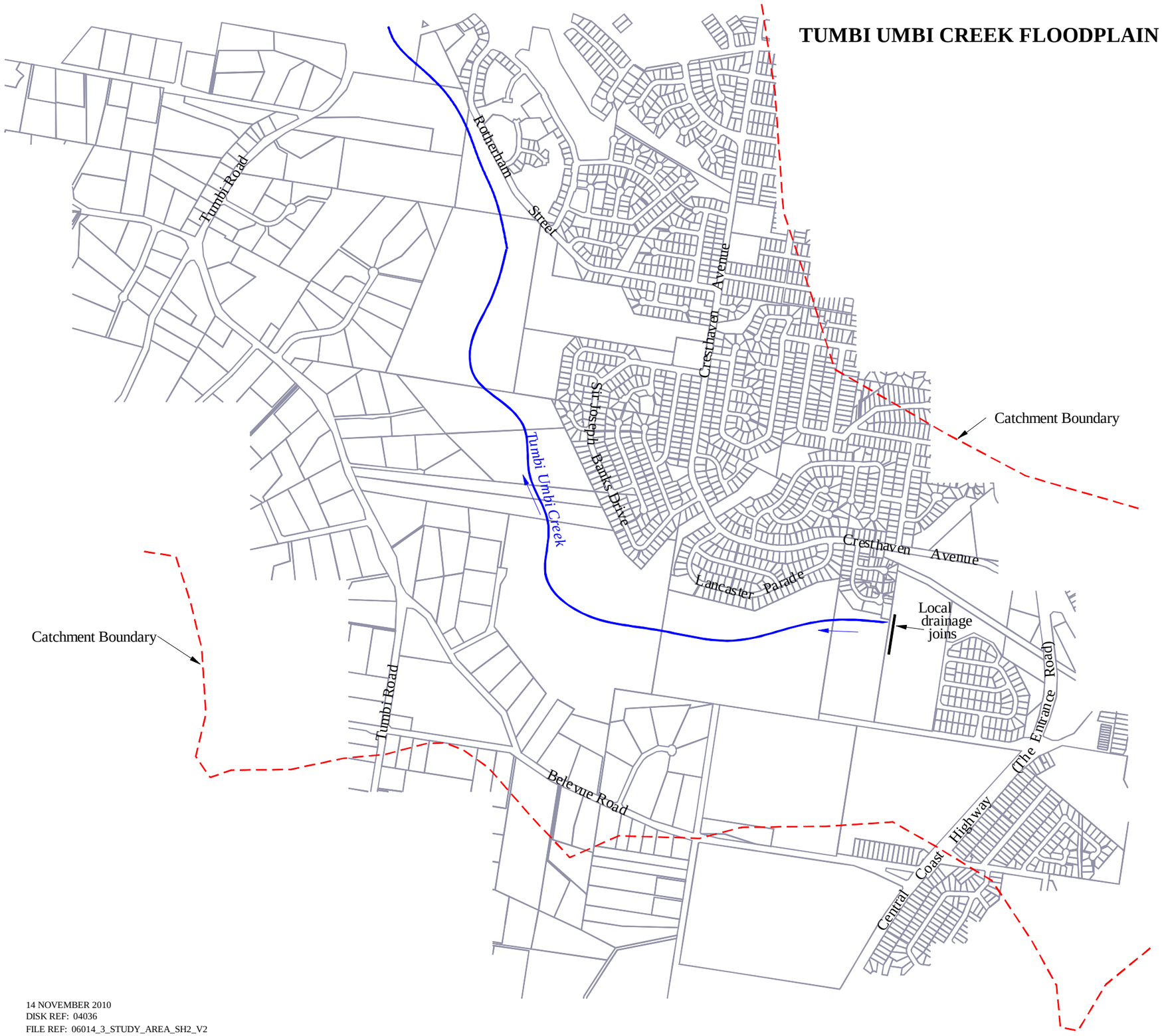



20 JANUARY 2014
DISK REF: 04036
FILE REF: 06014_2_STUDY_AREA_SH1_V3

**FIGURE 2**
**STUDY AREA - SHEET 1**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**




0 500 1000

Scale (metres)

**Legend**

Catchment Boundary

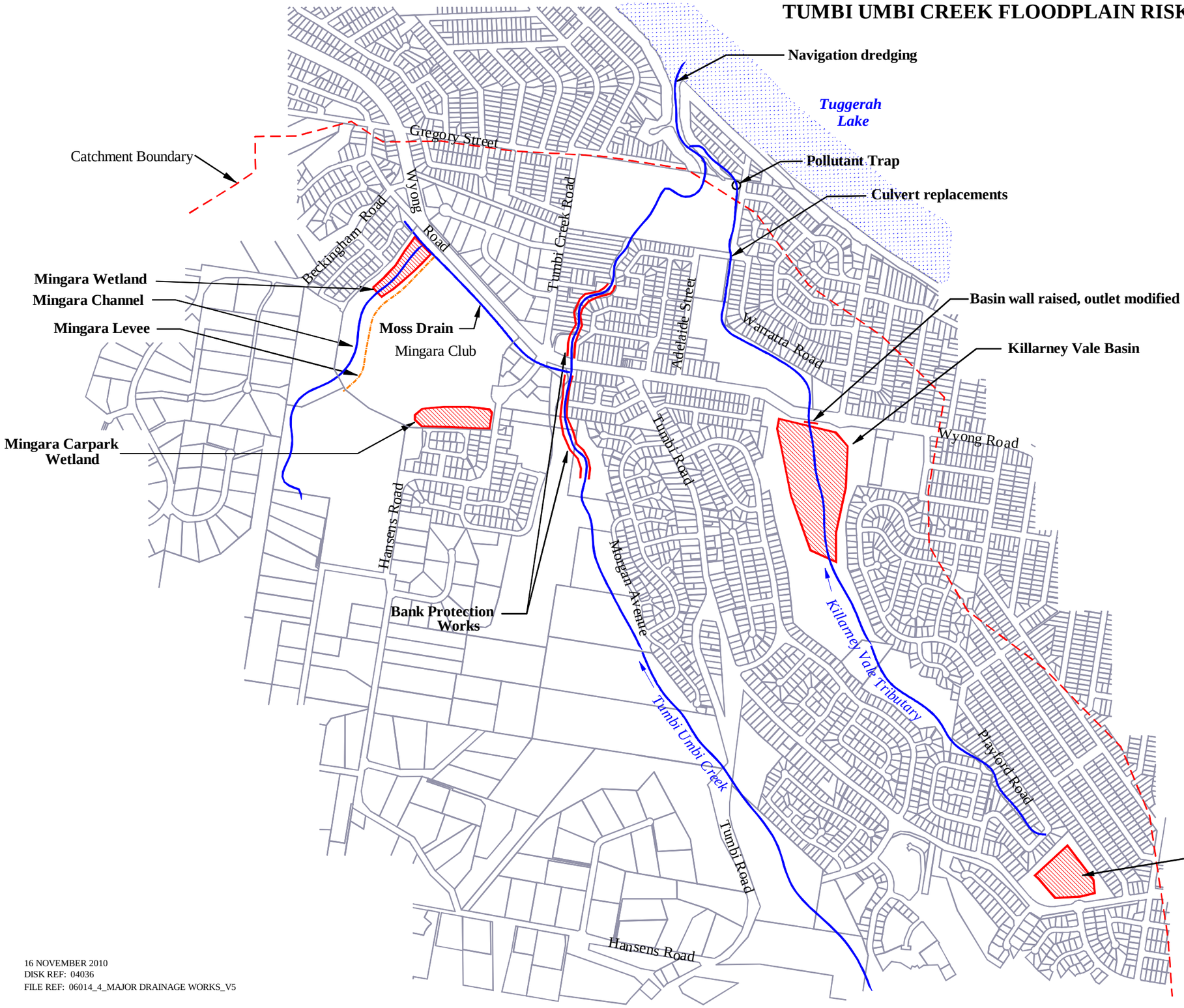
14 NOVEMBER 2010
DISK REF: 04036
FILE REF: 06014_3_STUDY_AREA_SH2_V2

**FIGURE 3**

**STUDY AREA - SHEET 2**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**




0 500 1000

Scale (metres)

**Legend**

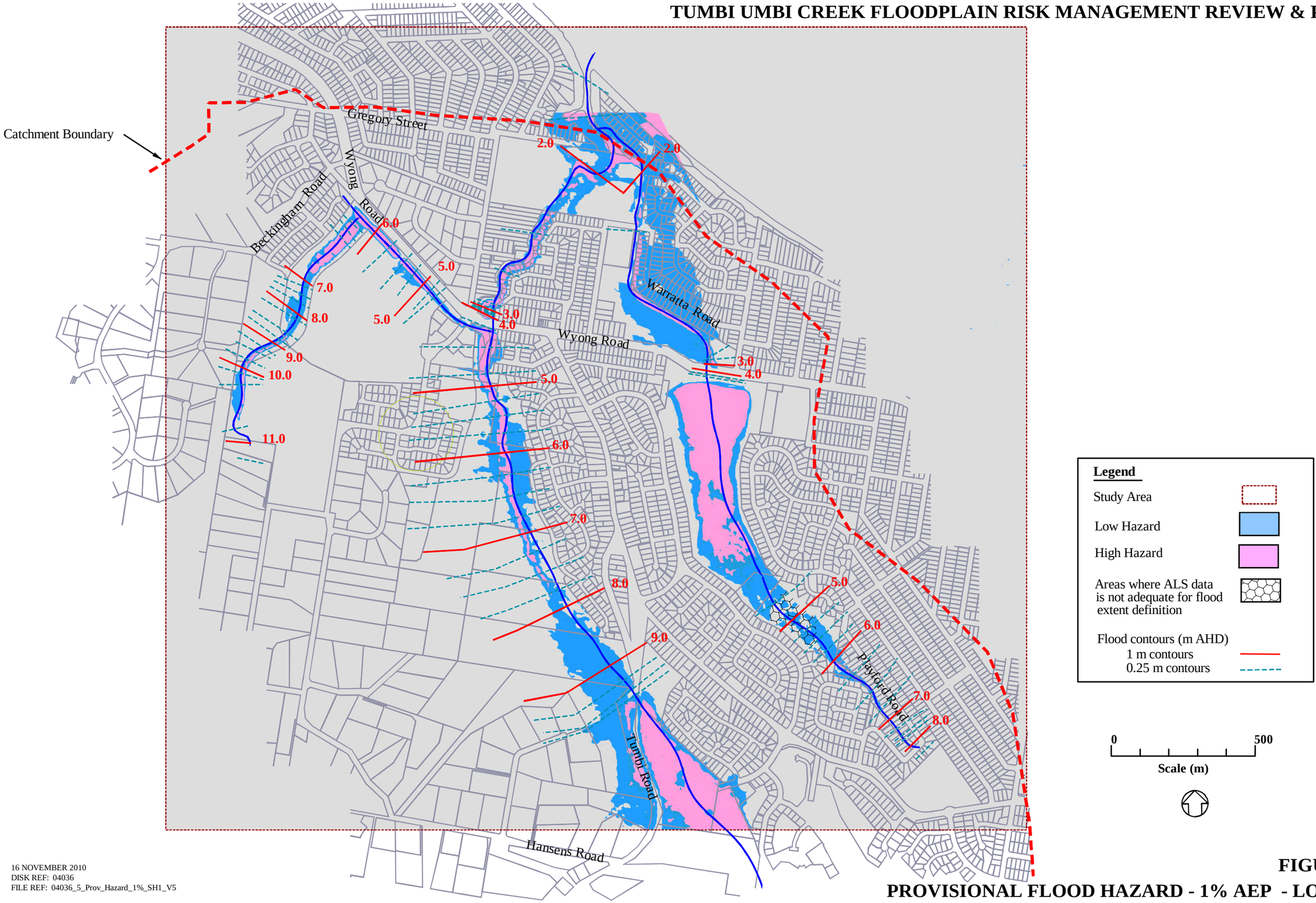
Catchment Boundary

16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 06014_4_MAJOR DRAINAGE WORKS_V5

**FIGURE 4**
**MAJOR DRAINAGE WORKS**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**



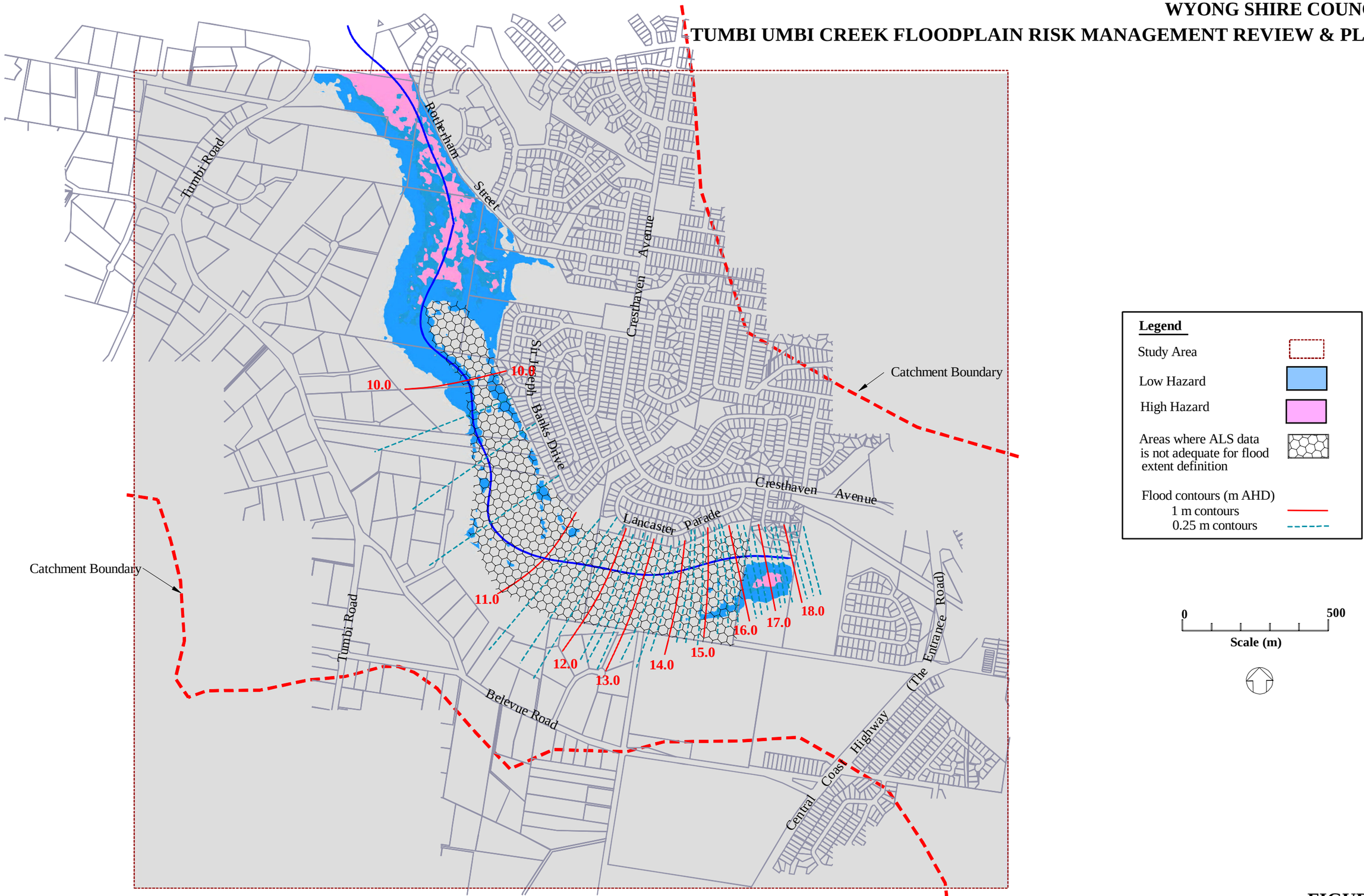

16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_5_Prov_Hazard_1%_SH1_V5

**FIGURE 5**

**PROVISIONAL FLOOD HAZARD - 1% AEP - LOWER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**



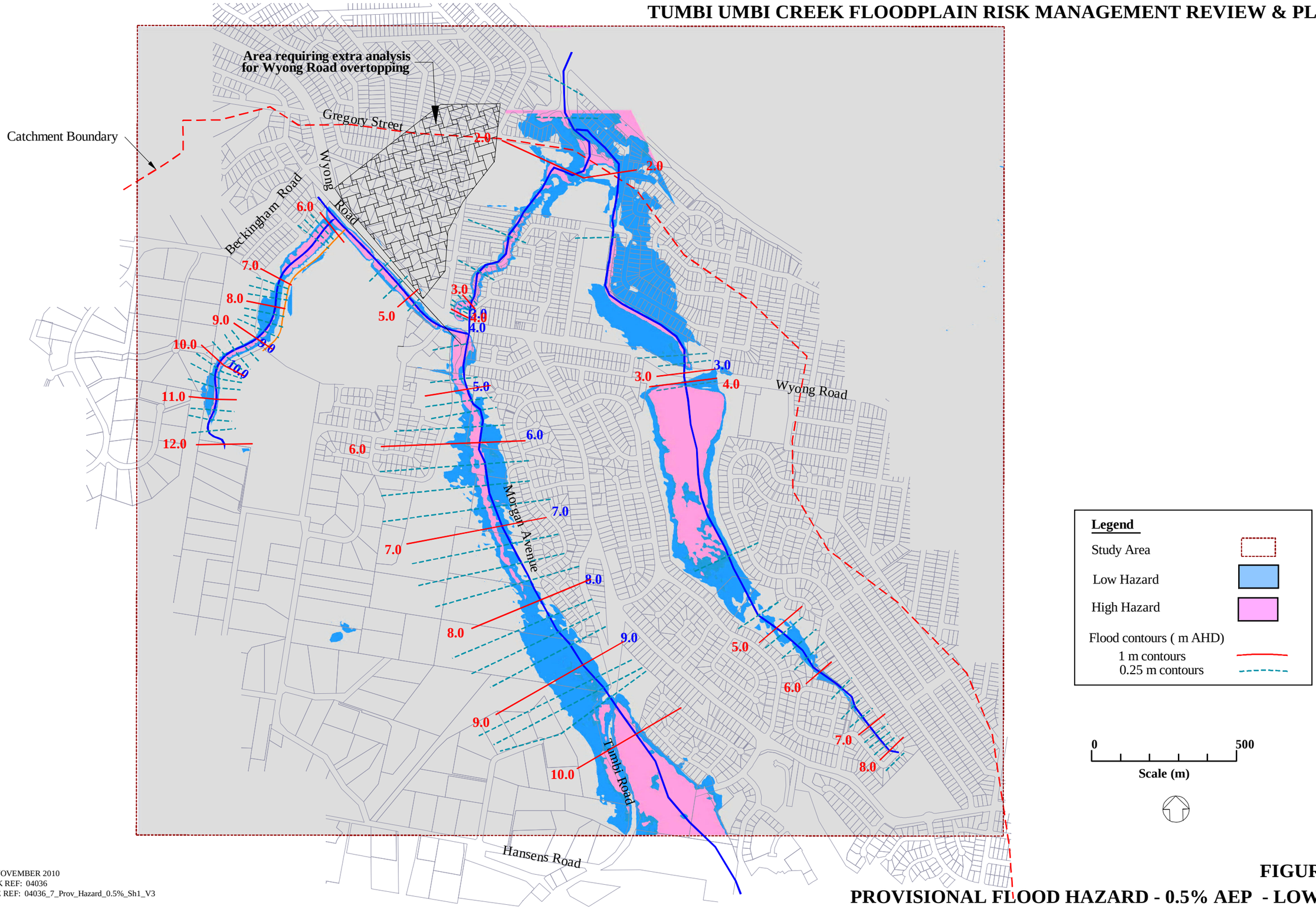

16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 06014_6_PROV_FLOOD_HAZARD_SH2_V5

**FIGURE 6**

**PROVISIONAL FLOOD HAZARD - 1% AEP - UPPER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**

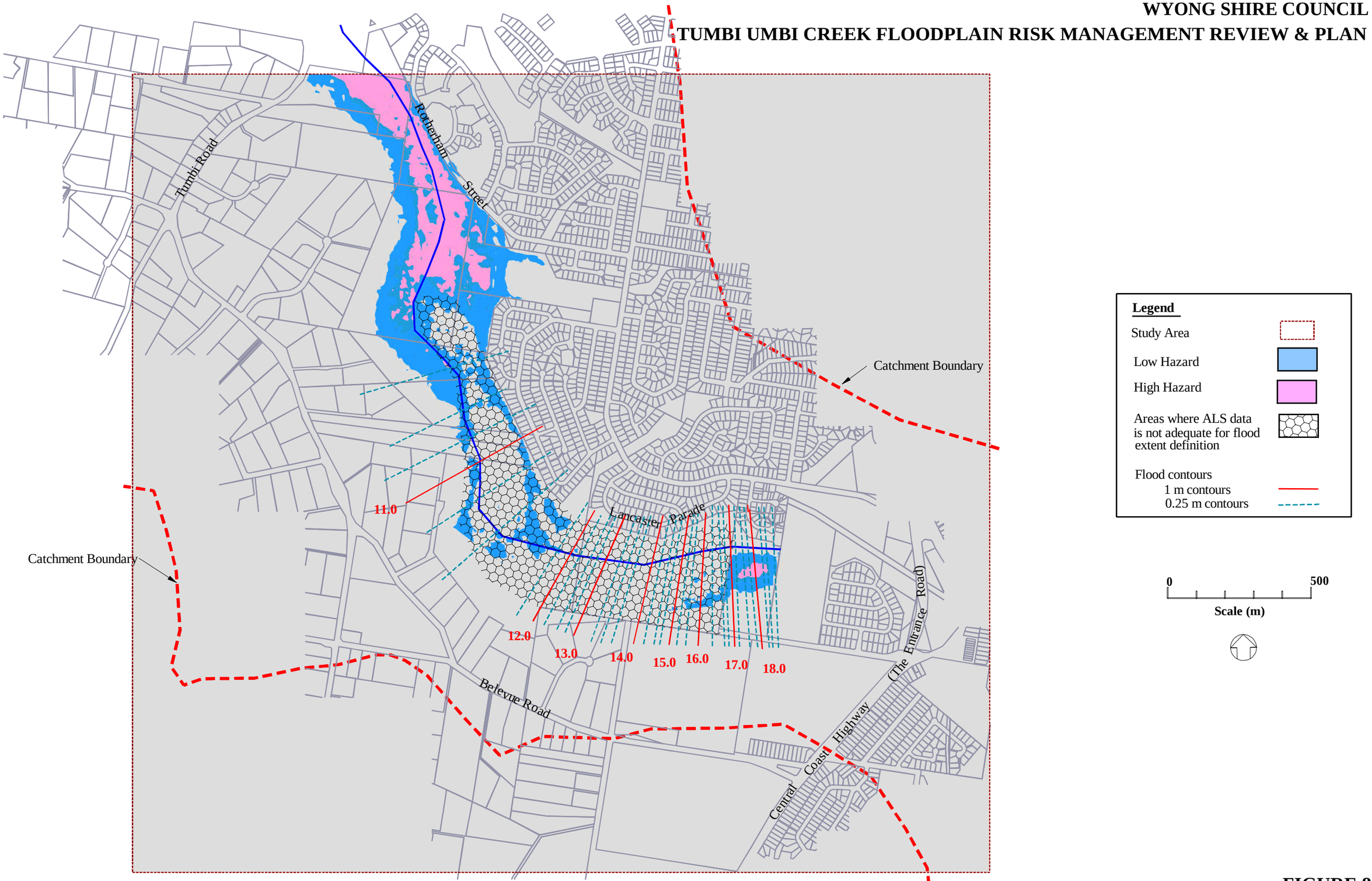



18 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_7_Prov_Hazard_0.5%_Sh1_V3

**FIGURE 7**

**PROVISIONAL FLOOD HAZARD - 0.5% AEP - LOWER**

# WYONG SHIRE COUNCIL
# TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN

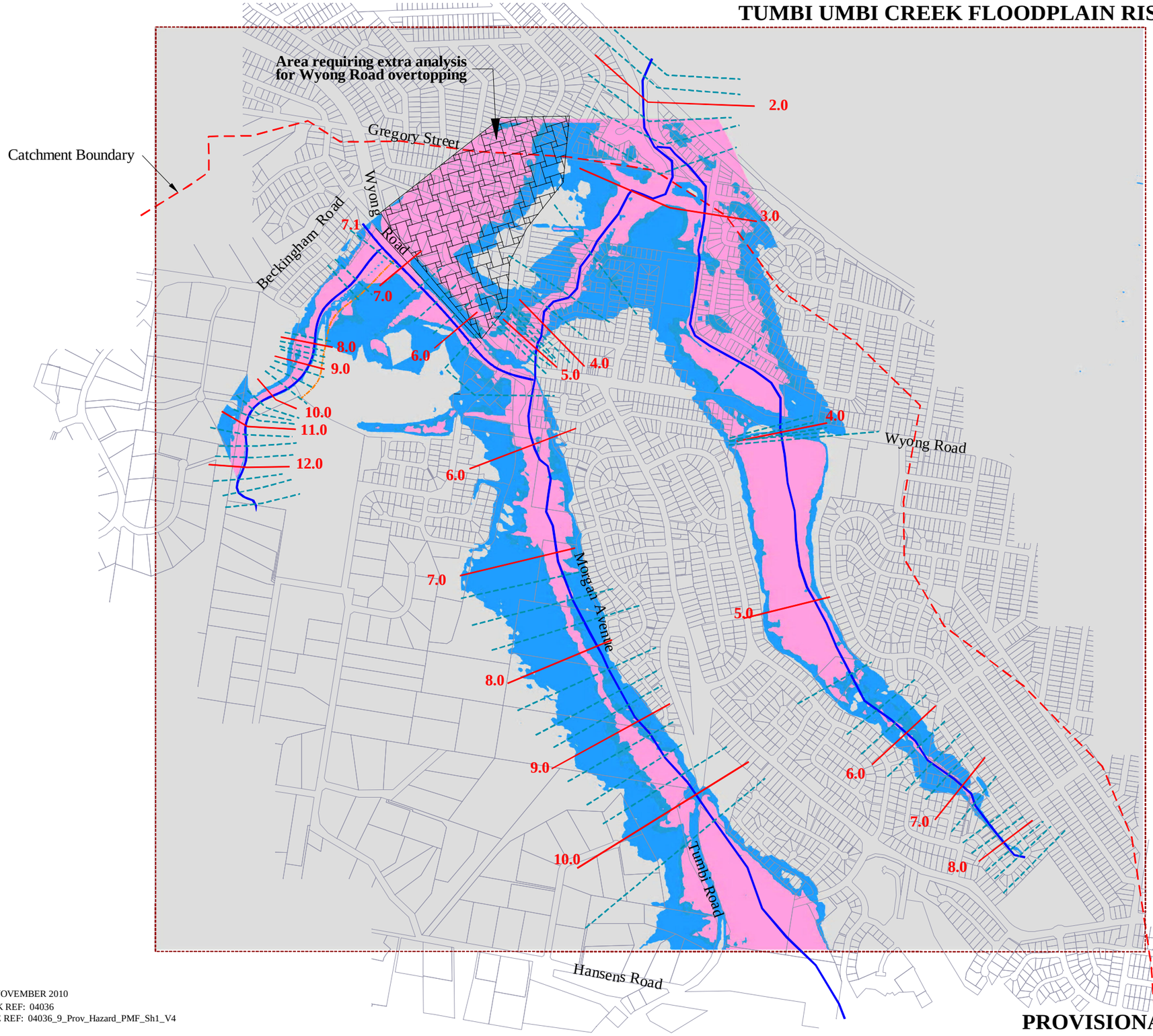



16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_8_PROV_HAZARD_0.5% AEP_SH2_V4

**FIGURE 8**
**PROVISIONAL FLOOD HAZARD - 0.5% AEP - UPPER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**



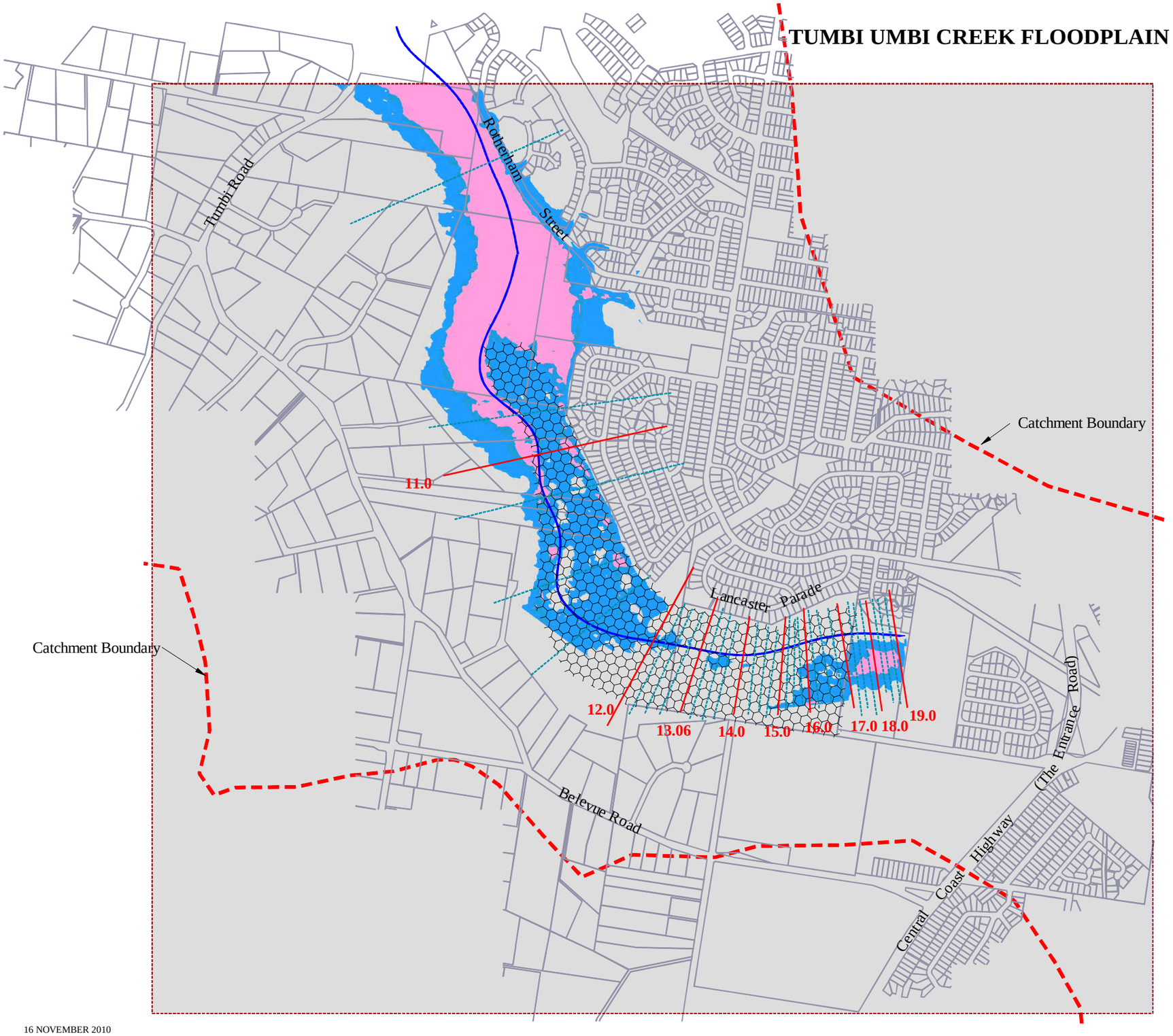

19 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_9_Prov_Hazard_PMF_Sh1_V4

**FIGURE 9**

**PROVISIONAL FLOOD HAZARD - PMF - LOWER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**




**Legend**

- Study Area
- Low Hazard
- High Hazard
- Areas where ALS data is not adequate for flood extent definition
- Flood contours
  - 1 m contours
  - 0.25 m contours

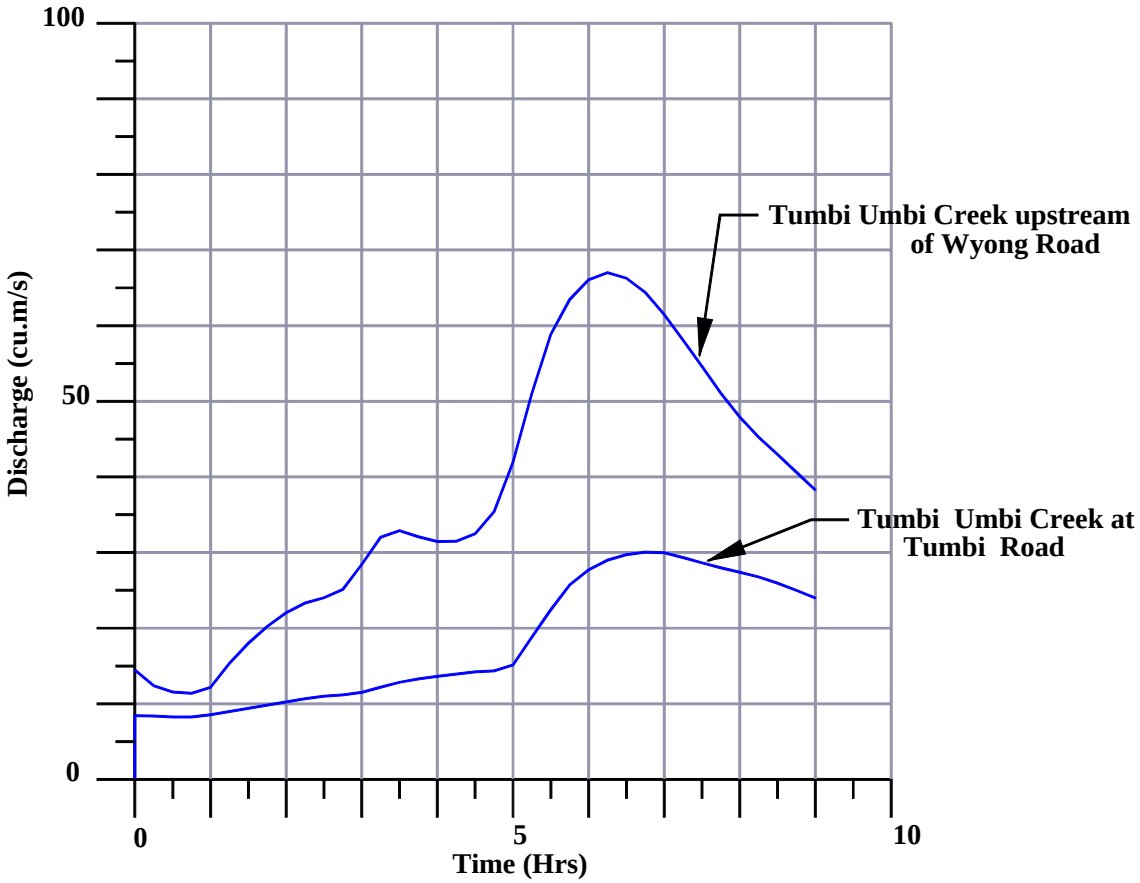
0 500

Scale (m)

16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_10_PROV_HAZARD_PMF_SH2_V4

**FIGURE 10**

**PROVISIONAL FLOOD HAZARD - PMF - UPPER**

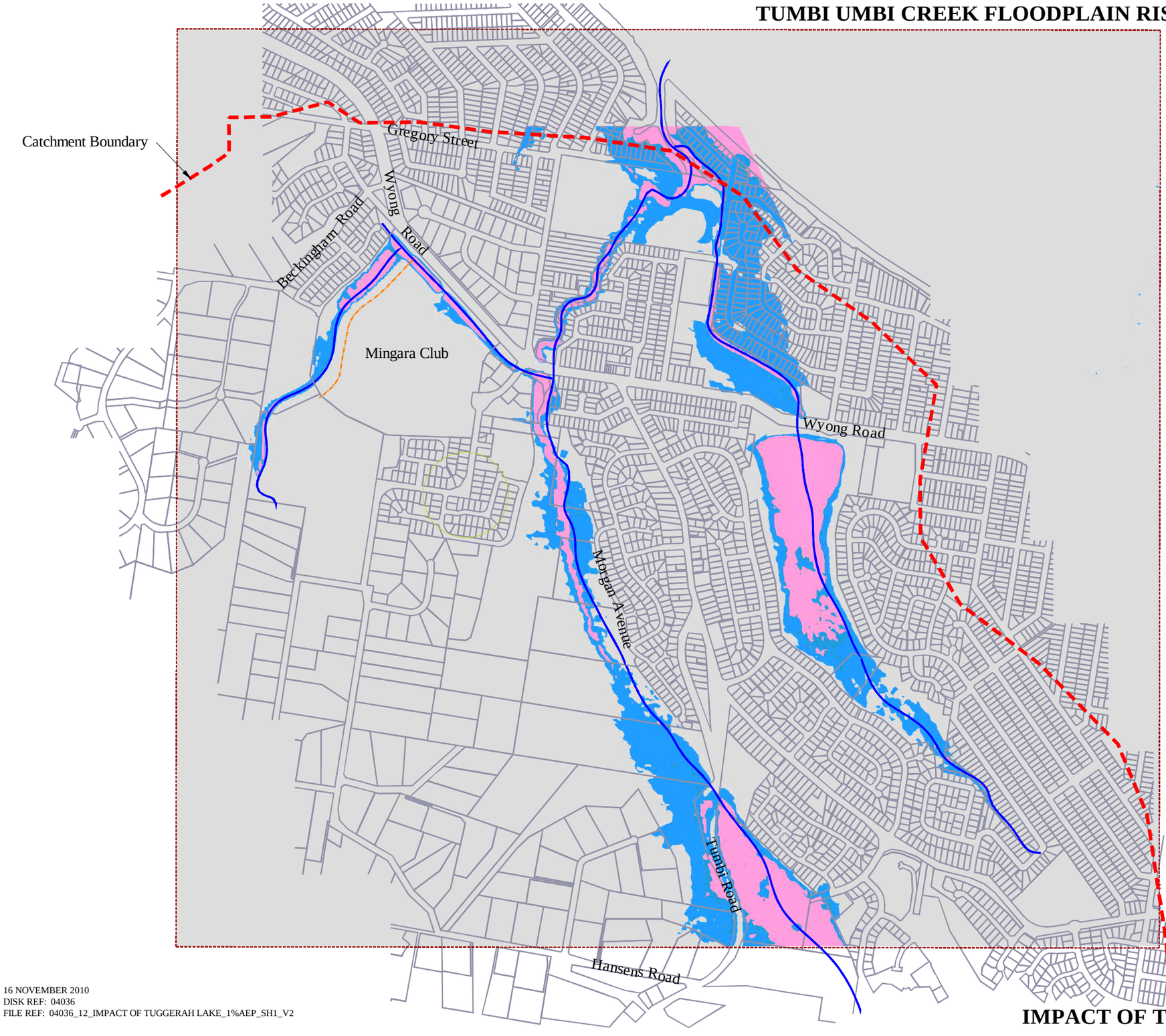



16 JANUARY 2014
DISK REF: 04036
FILE REF: 04036_11_FLOOD HYDROGRAPH_1%_V3

**FIGURE 11**
**DESIGN FLOOD HYDROGRAPH - 1% AEP**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**




**Legend**

Study Area

Low Hazard

High Hazard

0 500

Scale (m)

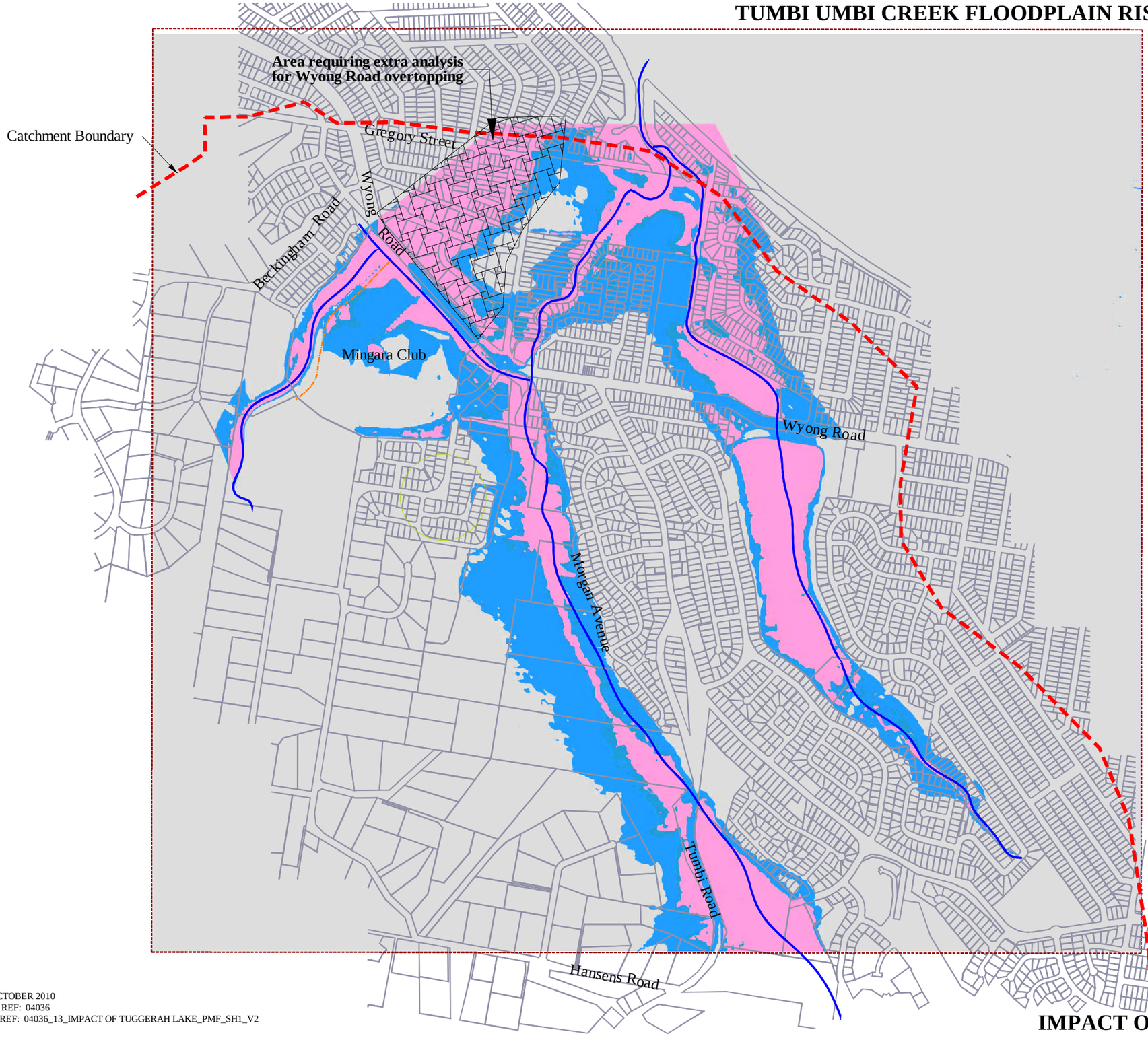
16 NOVEMBER 2010
DISK REF: 04036
FILE REF: 04036_12_IMPACT OF TUGGERAH LAKE_1%AEP_SH1_V2

**FIGURE 12**

**IMPACT OF TUGGERAH LAKE - 1% AEP - LOWER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**



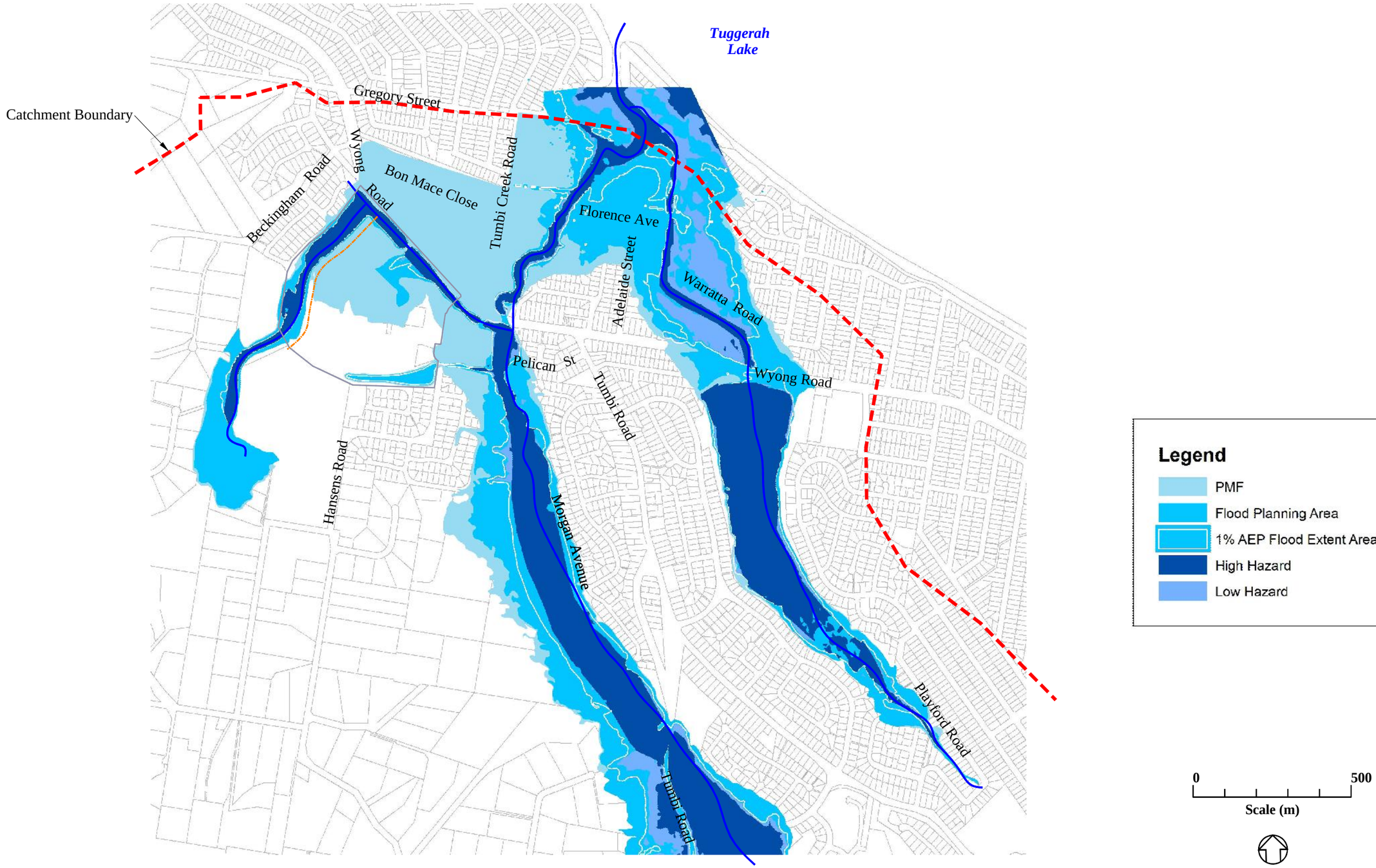

18 OCTOBER 2010
DISK REF: 04036
FILE REF: 04036_13_IMPACT OF TUGGERAH LAKE_PMF_SH1_V2

**FIGURE 13**

**IMPACT OF TUGGERAH LAKE - PMF - LOWER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**

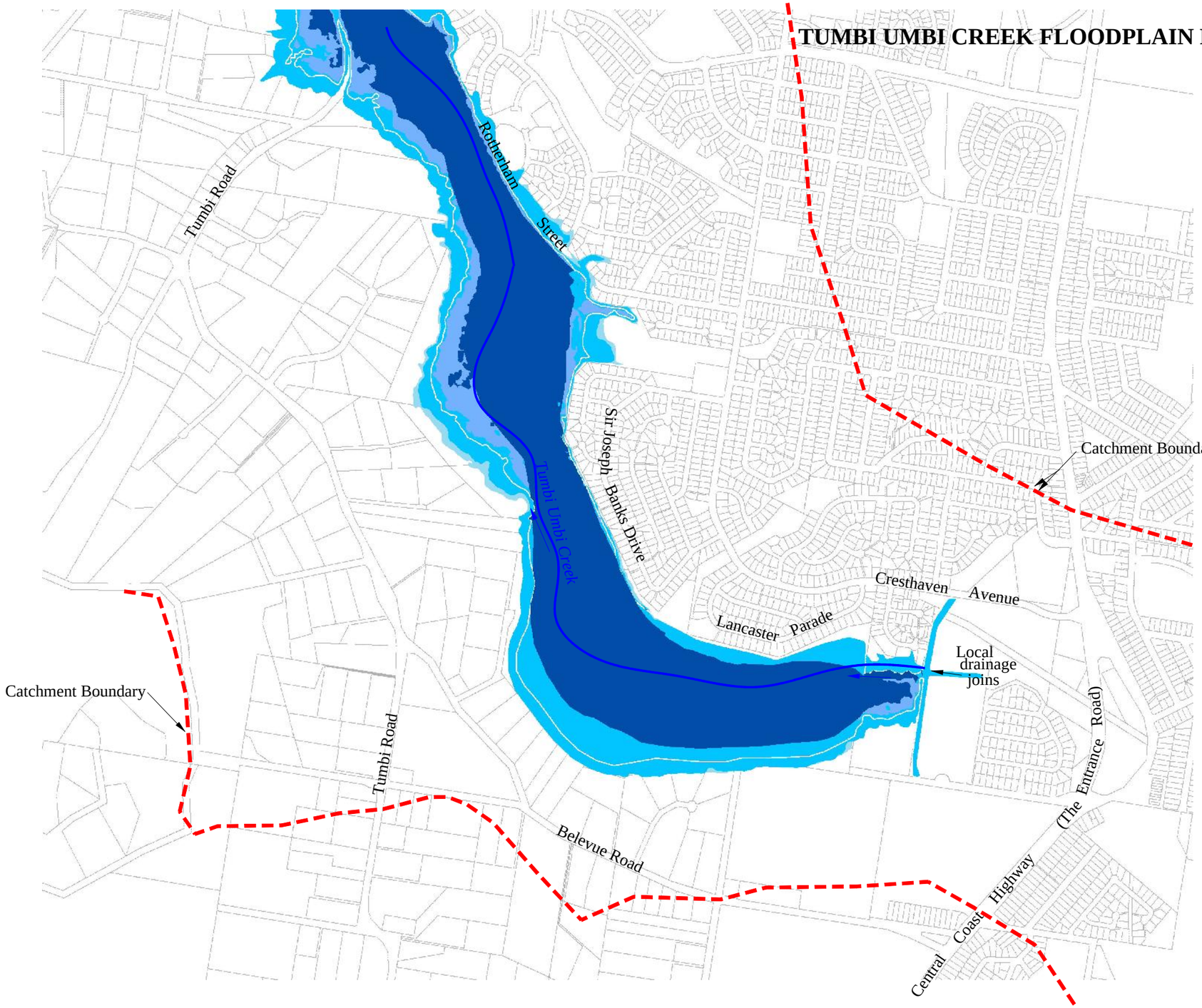



30 May 2014
DISK REF: 04036
FILE REF: 04036_14_ADOPTED FLOOD HAZARD_1%_SH1_V5

**FIGURE 14**
**ADOPTED FLOOD HAZARD - 1% AEP - LOWER**

**WYONG SHIRE COUNCIL**

**TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN**




**Legend**

- PMF
- Flood Planning Area
- 1% AEP Flood Extent Area
- High Hazard
- Low Hazard

0 500

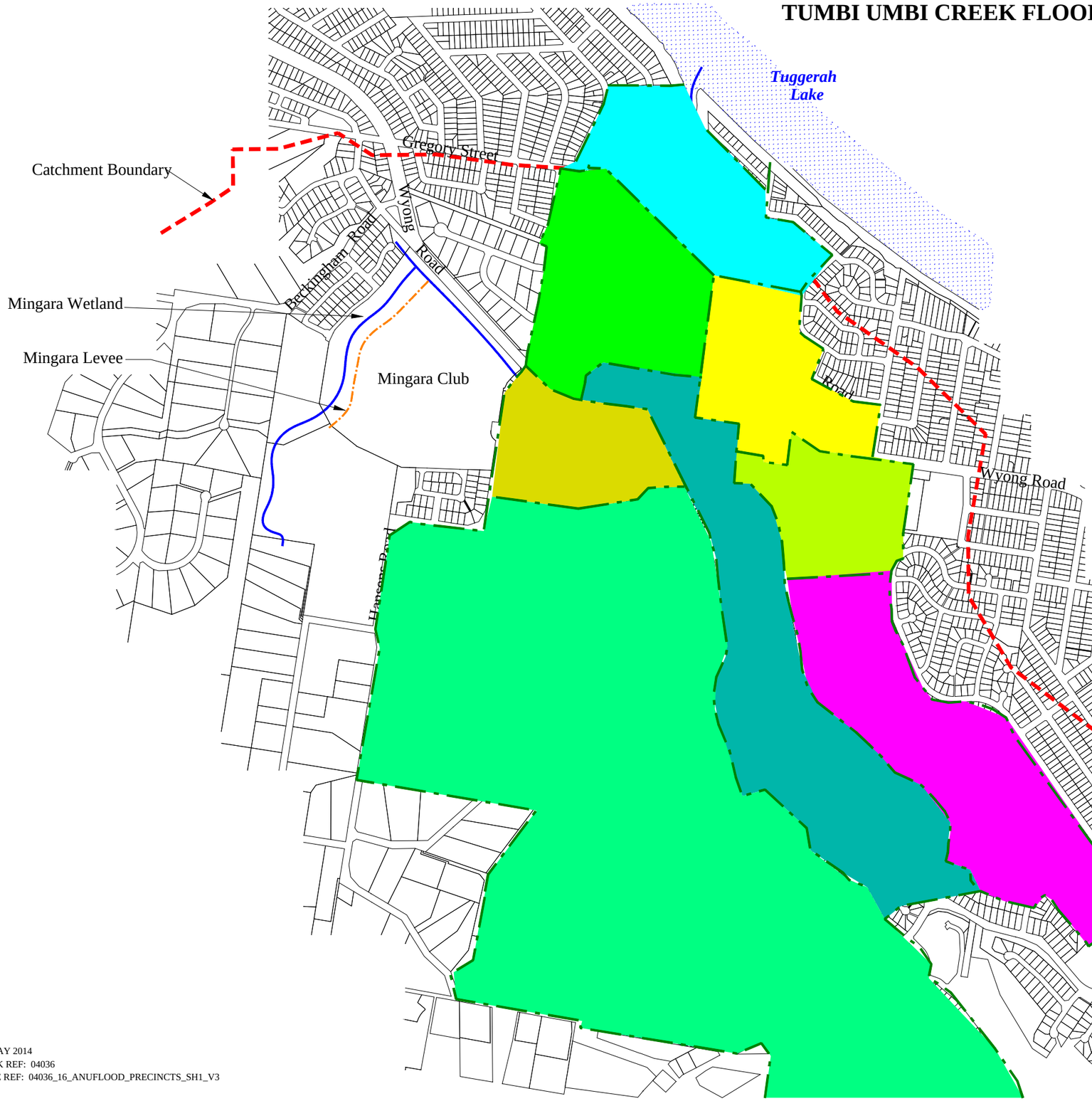
**Scale (m)**

30 May 2014
DISK REF: 04036
FILE REF: 04036_15_ADOPTED_HAZARD_1%_SHT2_V5

**FIGURE 15**

**ADOPTED FLOOD HAZARD - 1% AEP - UPPER**

# WYONG SHIRE COUNCIL
# TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN




**Legend**

Catchment Boundary

Anuflood Precinct Boundary

Anuflood Precinct Indicator 2

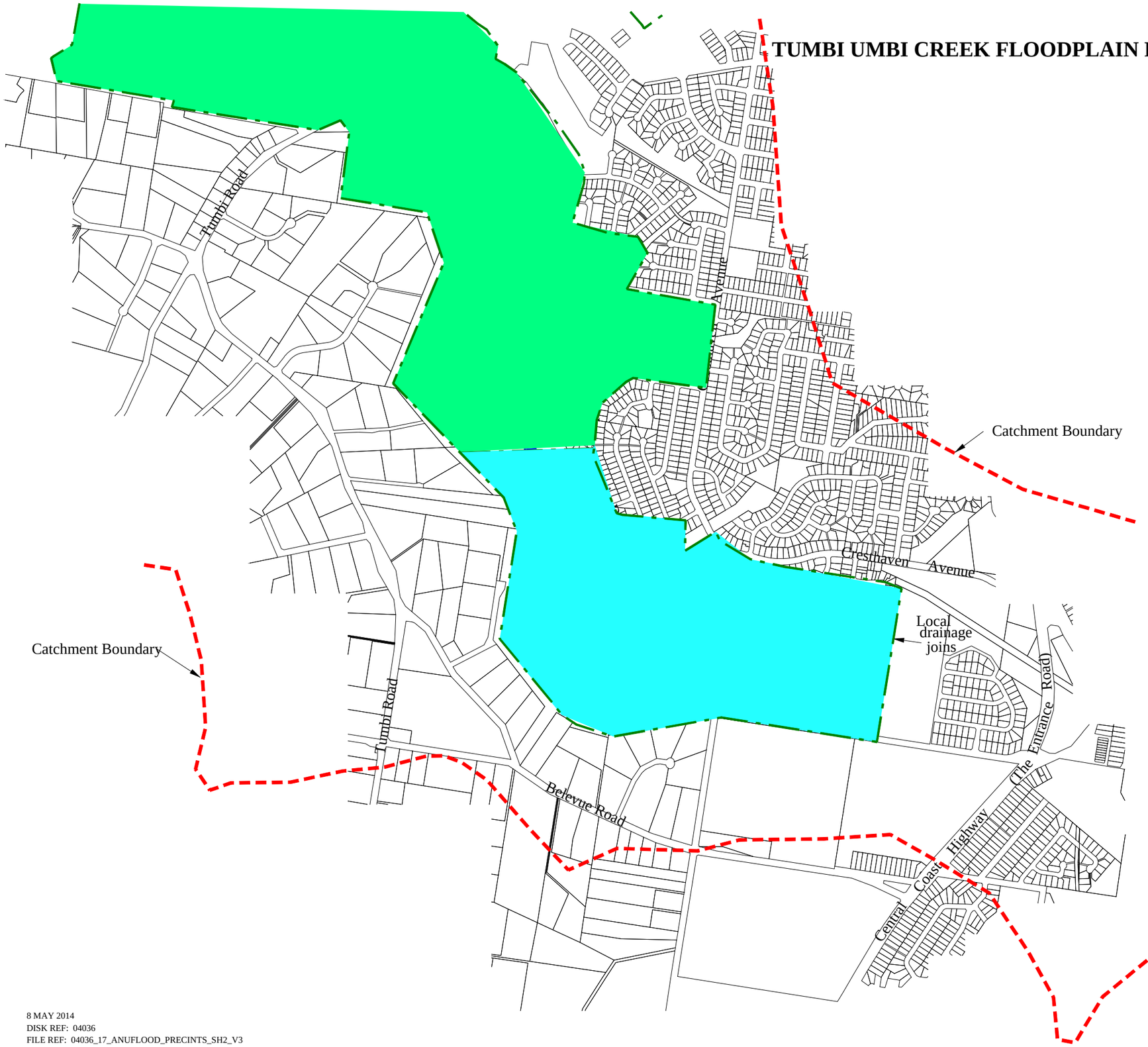
0 500 1000

Scale (metres)

8 MAY 2014
DISK REF: 04036
FILE REF: 04036_16_ANUFLOOD_PRECINCTS_SH1_V3

**FIGURE 16**
**ANUFLOOD PRECINCTS - SHEET 1**

# WYONG SHIRE COUNCIL
# TUMBI UMBI CREEK FLOODPLAIN RISK MANAGEMENT REVIEW & PLAN




**Legend**

Catchment Boundary

Anuflood Precinct Boundary

Anuflood Precinct Indicator 8

0 500 1000

Scale (metres)

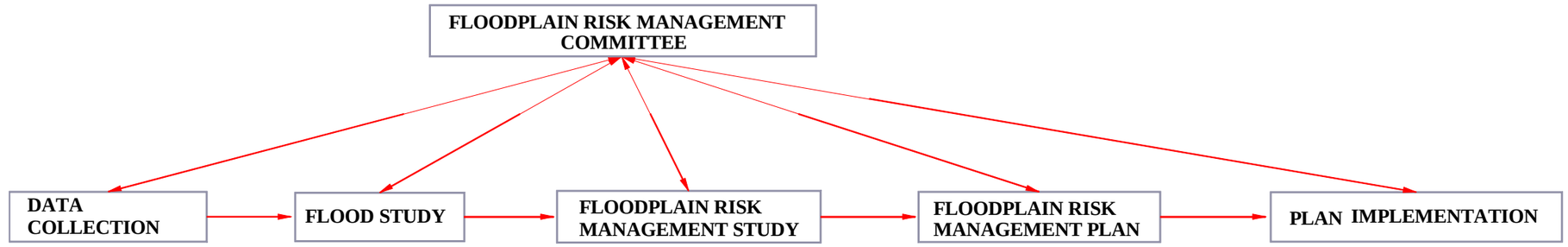
8 MAY 2014
DISK REF: 04036
FILE REF: 04036_17_ANUFLOOD_PRECINTS_SH2_V3

## FIGURE 17
## ANUFLOOD PRECINCTS - SHEET 2

# APPENDICES

# APPENDIX A

## FLOODPLAIN MANAGEMENT PROCESS




**FLOODPLAIN RISK MANAGEMENT PROCESS**

19 NOVEMBER 2010
DISC REF: 04036
FILE REF: 04036_A1_FLOODPLAIN_MANAGEMENT_PROCESS

**FIGURE A1**
**FLOODPLAIN RISK MANAGEMENT PROCESS**

# APPENDIX B

## EXTRACT FROM GLOSSARY
## FLOODPLAIN DEVELOPMENT MANUAL (Reference 2)

| | |
|---|---|
| | 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. |
| **flood fringe areas** | the remaining area of flood prone land after floodway and flood storage areas have been defined. |
| **flood liable land** | is synonymous with flood prone land (ie) land susceptible to flooding by the PMF event. Note that the term flood liable land covers the whole floodplain, not just that part below the FPL (see flood planning area). |
| **flood mitigation standard** | the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding. |
| **floodplain** | area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land. |
| **floodplain risk management options** | the measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options. |
| **floodplain risk management plan** | a management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives. |
| **flood plan (local)** | A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES. |
| **flood planning area** | the area of land below the FPL and thus subject to flood related development controls. The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 Manual. |
| **flood planning levels (FPLs)** | are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "standard flood event" in the 1986 manual. |
| **flood proofing** | a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages. |
| **flood prone land** | land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land. |
| **flood readiness** | Readiness is an ability to react within the effective warning time. |
| **flood risk** | potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. |

existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

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

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

**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. (See Section K5). Freeboard is included in the flood planning level.

**habitable room** — in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.

in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

**hazard** — a source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L.

**hydraulics** — term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

**hydrograph** — a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

**hydrology** — term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

**local overland flooding** — inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

# APPENDIX C

## PROPOSED PRESCRIPTIVE CONTROLS MATRIX – TUMBI UMBI

**Proposed Development Control Matrix in Draft DCP**

| Proposed Land use | Precinct 1 Above FPL to PMF | Precinct 2 Up to FPL | Precinct 3 Flood Storage and Flow Paths | Precinct 4 High Hazard |
|---|---|---|---|---|
| Single Dwelling Houses | | 1 | 1, 4, 6, 7 | |
| Agriculture & Recreation | | 1 | 1, 4, 6, 7 | |
| Sheds / Garages / ancillary Residential | | 1 | 1, 4, 7 | |
| Commercial and Industrial Uses | | 1, 5 | | |
| Medium to High Density Residential | | | | |
| Critical or Sensitive Facilities | 2 | | | |
| Land Subdivision | 3 | 3, 5 | | |
| Tourist Development | | 1, 5 | | |
| Caravan parks - short-term sites | | 5 | 4, 5 | |
| Permissible Earthworks | | 8 | | |

Flood related development controls do not apply

Flood related development controls apply (refer to numbered prescriptive controls)

Land use will not be supported unless a performance based assessment is provided and is deemed satisfactory by Council

1 = Joint report by a professional engineer who specialises in floodplain management and a professional engineer who specialises in civil engineering to certify that the development provides:

(a) Minimum Habitable Floor Levels = 1% AEP flood level plus 500mm freeboard (*Flood Planning Level*)

(b) Minimum Non-Habitable Floor Levels = 5% AEP flood level

(c) Minimum level requirements for electrical fittings, internal sewer fixtures, and external overflow gully risers apply as per Building Code of Australia

(d) Minimum levels of open car parking spaces, carports and driveways = 5% AEP flood level

(e) Mine subsidence allowance to be added to levels (a), (b), (c) & (d) above, if applicable.

(f) Low flood hazard access and egress for pedestrians during a 1% AEP flood to an appropriate area of refuge located above the Flood Planning Level.

(g) Low flood hazard emergency vehicle road access (Ambulance, SES, RFS) during a 1% AEP flood event.

(h) All structural components that can withstand the forces of floodwater, debris and buoyancy up to the flood planning level.

(i) Building materials and surface finishes at or below the flood planning level are all capable of withstanding prolonged immersion in water.

(j) Negligible flood affectation elsewhere in the floodplain for a full range of flood events up to the 1% AEP flood event, having regard to: a) loss of flood storage, b) changes in flood levels, flows and velocities upstream, downstream and adjacent to the site, c) cumulative impact of multiple development in the vicinity.

(k) Consideration of the impacts of climate change.

2 = Joint report by a professional engineer who specialises in floodplain management and a professional engineer who specialises in civil engineering to certify that the development provides:

(a) Minimum floor levels = PMF level plus 500mm freeboard plus mine subsidence allowance, if applicable.

(b) Low flood hazard access and egress for pedestrians during a PMF flood to an appropriate area of refuge located above the PMF.

(c) Low flood hazard emergency vehicle road access (Ambulance, SES, RFS) during a PMF flood event.

(d) Consideration of the impacts of climate change.

3 = Joint report by a professional engineer who specialises in floodplain management and a professional engineer who specialises in civil engineering to certify that the development provides:

(a) Minimum height of building footprints, open car parking areas, driveways and new public roads = 5% AEP flood level plus mine subsidence allowance, if applicable

(b) Low flood hazard access and egress for pedestrians during a 1% AEP flood to an appropriate area of refuge located above the Flood Planning Level.

(c) Low flood hazard emergency vehicle road access (Ambulance, SES, RFS) during a 1% AEP flood event.

(d) Risk assessment of flood hazard during a PMF flood event; including consideration of changes to flood behaviour, and location of floodways, to ensure that the consequences of the increased flood hazard are acceptable and manageable.

(e) Negligible flood affectation elsewhere in the floodplain for a full range of flood events up to the PMF, having regard to: a) loss of flood storage, b) changes in flood levels, flows and velocities upstream, downstream and adjacent to the site, c) cumulative impact of multiple development in the vicinity.

(f) Consideration of the impacts of climate change.

4 = No filling allowable apart from area of building footprint, open car parking areas and driveway

5 = Joint report by a professional engineer who specialises in floodplain management and a professional engineer who specialises in civil engineering to include:

(a) An Evacuation Plan demonstrating that permanent, failsafe, and maintenance free measures are incorporated in to the development to ensure the timely and safe evacuation of people from the development in a 1% AEP Flood event, without significant cost or risk added to emergency services personnel. Signage of the plan must be prominently displayed around the development.

6 = Maximum site coverage 50%. No concession for building heights.

7 = Maximum size of ancillary structure is $50m^2$. Appropriate signage on a minimum of one prominent internal or external wall indicating flood hazard of the area. Sign to be a minimum size 600mm x 600mm.

8 = Report by a professional engineer who specialises in floodplain management to certify that the development provides: Negligible flood affectation elsewhere in the floodplain for a full range of flood events up to the 1% AEP flood event, having regard to: a) loss of flood storage, b) changes in flood levels, flows and velocities upstream, downstream and adjacent to the site, c) cumulative impact of multiple development in the vicinity.