Tabourie Lake FRMSP

Floodplain Risk Management Study

NA49913170

Prepared for
Shoalhaven City Council

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Executive Summary

Shoalhaven City Council have commissioned Cardno to undertake a Floodplain Risk Management Study and Plan for the Lake Tabourie Township and its surrounds.

The Tabourie Lake Broadwater is fed primarily by Lucy Kings Creek and Munno Creek. These tributaries are the primary source for the Tabourie Creek. The major tributary of Branderee Creek merges with Tabourie Creek and almost doubles the contributing catchment area from 21 to 40 km2. Lemon Tree Creek (or Lemon Tree Creek) completes the major creek contributions entering upstream of the Tabourie Creek outlet to the Tasman Sea.

The Lake Tabourie Township is the only significant community in the study area. The majority of residences within the township straddle Lemon Tree Creek. The only access to this portion of the township is via Centre Road. On the northern side of Tabourie Creek at the outlet to the Tasman Sea is the Lake Tabourie Tourist Park. The only access into the Lake Tabourie Tourist Park is via Caravan Park Entrance Road. These roads are critical access routes for the village.

An assessment was undertaken on the number of properties to be affected by flooding under different frequency storm events, as well as an estimate of the appropriate economic damage for each event. The following table summarises these results.

Table i Flood Affected Properties and Damages under Existing Conditions

Flood Event	Properties with over floor flooding *	Properties with Over ground flooding *	Flood Damage ($)
50% AEP	0	0	0
20% AEP	2	21	560,653
5% AEP	12	60	1,951,980
2% AEP	41	120	4,946,099
1% AEP	42	121	5,535,211
PMF	176	194	27,468,424
Average Annual Damage			**593,441**

* Not including caravans

Options to reduce or manage the effects of flooding in the catchment were investigated, and recommendations to manage the risks of flooding were developed. A number potential options for the management of flooding were identified using the merits-based approach advocated in the NSW State Government’s Floodplain Development Manual (NSW Government, 2005), and in consultation with the community, Council and state agency stakeholders.

These options included:

- Flood modification measures
- Property modification measures
- Emergency response measures

All potential options were assessed using a triple bottom (technical, economic, environmental and social). Hydraulic modelling of some of the flood modification options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure.

The assessment found, of the all the options investigated (including flood, property and emergency measures), the top three identified by the multi-criteria analysis were:

1. EM 1 Information transfer to SES
2. P 2 Building and development controls
3. EM 6 Local Evacuation Centre

Of the structural options assessed, excluding the road raising options for emergency access only, the top three options identified by the multi-criteria analysis were:

1. FM 2.5a Local levee and road raising combination with 1% AEP protection
2. FM 1.1 Princes Highway Levee
3. FM 2.4 Bridge & Centre Street road raising with levee construction

The ranking of the options is proposed to be used as the basis for prioritising the components of the Floodplain Risk Management Plan. It must be emphasised that the scoring is not “absolute” and the proposed scoring and weighting should be reviewed in light of any additional future information.

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* Figures are included in the body of the report. All other figures are included at the end of the report.

Glossary

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

Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Overland flow	The term overland flow is used interchangeably in this report with "flooding".

Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
ARI	Average Recurrence Intervals
BoM	Bureau of Meteorology
DCP	Development Control Plan
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
IFD	Intensity Frequency Duration
km	Kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
m	Metre
m^2	Square metre
m^3	Cubic Metre
mAHD	Metres to Australian Height Datum
mm	Millimetre
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment & Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service

1 Introduction

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Tabourie Lake catchment. The study has been undertaken to define the existing flooding behaviour and associated hazards of the study area, and to investigate possible mitigation options to reduce flood damage and risk. The tasks required to fulfil this objective were undertaken alongside community consultation to ensure that community concerns were identified and, where possible, incorporated into the study.

This report provides a review of the existing flooding issues, the current emergency response, education and planning arrangements to reduce flood risk and details the economic flood damages assessment undertaken as part of this study. Details are also provided of the investigations undertaken into potential flood mitigation options. The findings of this report will be incorporated into the Floodplain Risk Management Plan.

1.1 Study Context

The NSW Floodplain Management process progresses through 6 steps in an iterative process:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of the Overland Flow / Floodplain Risk Management Plan

This document addresses Stage 4 of the process.

1.2 Study Objectives

The overall objective of this study is to develop a Floodplain Risk Management Study where management issues are assessed, management options are investigated, and recommendations are made and a Floodplain Flood Risk Management Plan developed detailing how flood prone land within the study area is to be managed.

The specific objectives of this stage of the study (the Floodplain Risk Management Study) are:

- To identify and describe the various potential flood problems and specific future flooding issues;
- To review the flood provisions in Council’s existing environmental planning policies and instruments;
- To identify and assess potential management measures for existing developed areas;
- To assess the benefits and cost of the potential management measures; and
- To identify modifications required to current policies in the light of investigations.

2 Catchment Description

Tabourie Lake is located on the NSW South Coast, south of Ulladulla. Tabourie Lake is fed primarily by Lucy Kings Creek and Munno Creek. These tributaries are the primary source of flow for Tabourie Creek. The major tributary of Branderee Creek merges with Tabourie Creek and almost doubles the contributing catchment area from 21 to 40 km^2. Lemon Tree Creek (also known as Lemon Tree Creek) completes the major creek contributions entering upstream of the Tabourie Creek outlet to the Tasman Sea. For the purposes of this study, Tabourie Lake is considered to start upstream of the Princes Highway Bridge. Downstream of the bridge, the water course is referred to as Tabourie Creek.

The Lake Tabourie Township is the only significant community in the study area. The majority of residences within the township straddle Lemon Tree Creek. The only access to this portion of the township is via Centre Road. On the northern side of Tabourie Creek at the outlet to the Tasman Sea is the Lake Tabourie Tourist Park. The only access into the Lake Tabourie Tourist Park is via Caravan Park Entrance Road. These roads are critical access routes for the local community and visitors to the area.

The study area for the Tabourie Lake Floodplain Risk Management Study and Plan covers the township of Tabourie Lake Village and its immediate surrounds. The study area is focused on the developed regions of the catchment area, as these regions are the most at risk during flood events. The Tabourie Lake catchment area and the study area are shown in **Figure 2-1**. Key features of the study area are shown in **Figure 2-2**.

Land uses within the catchment are predominately forested with some pastureland on the alluvial flats. The Lake Tabourie Township is the only large developed area in the catchment. The majority of the Township is zoned ‘Village’ with smaller areas zoned as ‘Low Density Residential’ and ‘Rural Landscape’.

Lake Tabourie Village is low lying at approximately 2m AHD and as a result low level persistent flooding is common. Tabourie Lake study area has experienced major flooding in the past due to a number of contributing factors. At the downstream end of the catchment the entrance (i.e. where Tabourie Creek discharges into the ocean) has the capacity to close which can lead to water levels rising through the floodplain. Also, high antecedent lake conditions coupled with large rainfall events have cause major flooding in the past. Historical flood events have occurred in 1971, 1975 and 1988. In addition, an ocean driven event, were flooding occurred due to elevated ocean levels rather than catchment flooding, occurred in 1974.

During peak holiday periods the population can swell from its base of 600 permanent residents by a factor of five, to 3,000. The nature of the transient, short term population can lead to a poor understanding of the risk of flooding in the township, particularly during these peak tourist periods.

Appropriate management of the Lake Tabourie Creek entrance is a critical component of this investigation, a balance between risk minimisation and maintaining the natural operation of this opening has been explored in detail. The impact of sea level rise and climate change on this catchment has also formed a critical component of the investigation due to the low lying nature of the Village and proximity to the Tasman Sea.

3 Available Data

3.1 Previous Reports and Studies

A number of previous studies have been conducted concerning the Tabourie Lake region. These studies have been reviewed as part of this study and relevant information incorporated.

Previous studies are summarised in **Table 3-1**.

Table 3-1 Summary of Previous Studies and Reports

Study / Report	Description
Tabourie Lake Entrance Management Policy & Review of Environmental Factors (Final Draft) (Peter Spurway & Associates Pty Ltd, 2005)	This Entrance Management Policy describes: ▪ The procedures to be followed by Shoalhaven City Council for artificial openings of Tabourie Lake entrance; ▪ The conditions that should be satisfied prior to an artificial opening; ▪ The responses that may be requested of state agencies in response to artificial or natural opening events; and, ▪ A course of actions to approach more natural entrance behaviour. The report notes that entrance behaviour has significant impacts on water quality in the Tabourie Lake and Tabourie Creek, recreation in the lake / creek and the ecology of the lake system and adjacent wetlands. The report recommended that: ▪ The current (at the time of writing) opening level of 1.17m be retained; ▪ Implementation of the policy be conditional on preserving the habitat of threatened resident and migratory birds; ▪ Connection of the lake front properties to the Tabourie Sewerage Scheme be made a priority to improve water quality; and, ▪ Gauge plates be installed at the Princes Highway and Lemon Tree Creek bridges, with lake measurements to relate to the gauges. Further discussion on entrance management is provided in the following sections: ▪ **Section 5.3** – The impact of climate change on entrance management ▪ **Section 12.2.3** – Alternative trigger levels possible with structural mitigation options
Caravan Parks Flood Safety Study (Bewsher Consulting, 2008)	The study was undertaken to: ▪ Assess the flood risk of, and prepare emergency plans for, 30 caravan parks in the Shoalhaven LGA; and, ▪ Prepare a revised flood risk management policy for caravan parks and manufactured homes estates in the Shoalhaven LGA. The Tabourie Lake caravan park was noted as being flood affected, but an emergency response plan was not prepared for the site as part of this study. A draft policy was prepared for Council which was to be applied to all caravan parks within the LGA. This policy includes the following performance criteria: ▪ No increase in risk to life; ▪ Safe evacuation of both residents and mobile homes; ▪ No impacts on adjacent sites; ▪ Redevelopment of high risk zones where possible; and, ▪ Long term sites should have no greater risk than allowed for residential developments; short term sites may adopt a higher risk.

<table>
<tr><th>Study / Report</th><th>Description</th></tr>
<tr><td>Tabourie Lake Flood Study (BMT WBM, 2010)</td><td>The flood study developed a RAFTS hydrological model and a TUFLOW hydraulic model to define the flooding behaviour in the study area. The models were calibrated to historical events from 1971, 1975 and 1988.

The flood study assessed the 20%, 5%, 2% and 1% AEP events, and the PMF event. The design events were run for both catchment and ocean flooding. It was observed that for major events the peak levels from catchment flooding and ocean flooding were broadly similar.

The flooding behaviour within the study area was found to be somewhat sensitive to the berm conditions adopted. This sensitivity was most pronounced in smaller flood events. In larger flood events, where the entrance is quickly overtopped, entrance conditions had a smaller influence on peak flood levels. These differences were largely restricted to the creek and overbank areas. Entrance conditions had a relatively minor influence over flooding that occurred on developed land. Council have a policy of manually opening the berm if a flood event is expected in order to manage flood levels with Tabourie Lake. For the flood study modelling, it was conservatively assumed that this manual opening did not occur, and the berm was assumed to be complete at the start of the storm event. The TUFLOW model allowed the berm to break open and erode once overtopping began.

Roads throughout the study area were found to be overtopped by flooding in multiple locations in the 5% AEP event.

The study also found that flooding within the site was particularly sensitive to sea level rise associated with climate change.</td></tr>
<tr><td>Evacuation Plan: Lake Tabourie Tourist Park (MacDonald International, 2010)</td><td>The Evacuation Plan was prepared to:
▪ Assist in protecting residents and guests of the Lake Tabourie Tourist Park from the potential dangers arising from flooding;
▪ Ensure that a planned and co-ordinated approach is taken to evacuation;
▪ Reduce the negative consequences of flooding on the local area; and,
▪ Identify potential evacuation centre locations.

The investigations found that out of the 497 sites in the park, 324 (65%) are affected in the 1% AEP event.

The evacuation plan proposes that:
▪ Assembly take place outside reception;
▪ Evacuation is to take place along Caravan Park Entrance Road to the Pacific Highway;
▪ People are to evacuate to the Ulladulla Civic Centre; and,
▪ Mobile Caravans are to evacuate to the roadside of the Pacific Highway north of the Caravan Park Entrance Road.

The plan estimated that the warning time available would be three hours.</td></tr>
</table>

Study / Report	Description
Tabourie Lake Revised Estuary Management Plan (Shoalhaven City Council, 2012)	The plan examines a range of factors that affect the Tabourie Lake estuary and proposes a series of actions to ensure the estuary is appropriately managed. The factors include: ▪ Water quality; ▪ Terrestrial and aquatic ecosystems; ▪ Access and recreation; ▪ Climate change adaption; and, ▪ Cultural heritage. Flooding is not specifically discussed. However, the report makes mention of the Tabourie Lakes flood study, and notes that the Floodplain Risk Management Study and Plan will assess entrance management with respect to flood behavior.

3.2 Survey Information

3.2.1 Terrain

Terrain information for the study was provided through a Digital Elevation Model (DEM) created as part of the Flood Study (BMT WBM, 2010). The DEM was constructed from:

- Bathymetric survey of Tabourie Creek and Tabourie Lake (from 1993);
- Photogrammetric survey of the township (from 2005);
- Topographic survey of the caravan park (from 2007);
- Topographic survey of the lake entrance (from 2008); and
- 10m contours of the wider catchment from the Geoscience Australia topographic map sheets.

The survey was assessed during the site visit (15 August 2013) to ensure it accurately represents the study area.

It has been assumed that the bathymetry and the entrance survey is representative of the current conditions.

The terrain elevation is shown in **Figure 3-1**.

3.2.2 Structures

The TUFLOW model constructed for the flood study contained detailed information on the three major bridges and crossings within the study area, namely:

- The Princes Highway over Tabourie Creek;
- The Centre Road bridge over Lemon Tree Creek; and
- The culverts under the Pacific Highway on a tributary of Lemon Tree Creek.

The data was confirmed through comparison with Council GIS data, and during the site visit.

3.2.3 Additional Survey

A detailed property survey was undertaken for all properties within the PMF extent, in order to assess flood damages for the study area and investigate the likely benefits of potential flood mitigation options. The following property data was collected:

- Floor and ground levels;
- Property details (number of stories, construction method, size, habitable stories); and
- Estimates of size and value of commercial premises.

3.3 GIS Data

The following Geographic Information System (GIS) data was provided by Council as part of the study:

- Cadastre;
- Aerial;
- DEM;
- Council drainage assets;
- Acid Sulphate Soil regions; and,
- Zonings.

3.4 Site Inspection

A site inspection was conducted on 15 August 2013. During the site inspection, key hydraulic features were investigated across the study area, as well as identifying opportunities for flood risk mitigation options.

3.5 Previous Modelling

The flood study undertaken in 2010 (BMT WBM, 2010) developed hydrological and hydraulic models to assess the flood behaviour of the study area. Hydrological modelling was undertaken using the RAFTS software package, and the hydraulics using the TUFLOW software package.

The hydraulic model was updated to a Delft3D model as part of this study. The model development and validation were discussed in the *Delft3D Model Verification Report* (Cardno, 2014), which is attached in **Appendix A**.

4 Consultation

Community consultation is to be undertaken in three key phases over the course of the project:

- Resident Survey;
- Community Workshops; and
- Public Exhibition of Draft Flood Study.

4.1 Community Information Brochure / Questionnaire

4.1.1 Purpose and Scope

The community information brochure and questionnaire was intended to provide a tool to inform the community that a FRMS was being undertaken, as well as the context and the purpose of the FRMS. It was also intended that the brochure and questionnaire would provide an opportunity to understand the community impacted by the study, their experience with flooding, their key concerns relating to flooding of the local area and any suggestions for way to manage flood risk that could be investigated further as part of the FRMS.

An information brochure and questionnaire were distributed to those properties owners within the Tabourie Lake Township in August 2013. The brochure and questionnaire are attached in **Appendix B**.

The brochure and questionnaire were delivered to approximately 420 property owners within the catchment area. Approximately 200 of these properties are within the PMF flood extent. A summary was also advertised in the local newspaper, informing residents of the study and advising that the survey was being undertaken.

From the distribution, 144 responses were received, representing a return of approximately 34% of direct distribution. This return rate is significantly higher than the typical 10% return rate normally experienced for these types of mail-outs.

The survey was conducted outside of peak holiday times, and was mailed to property owners, so the survey does not take into account the flooding knowledge and experiences of the visitors and tourists that visit the region during holiday periods.

A summary of the findings of the resident survey are presented below.

4.1.2 Summary of Findings

4.1.2.1 Years at Address

Residents were asked to provide details regarding the length of time that they had lived at their current address. The majority of respondents were owner occupiers (94% / 135) who either lived in Tabourie Lake or used the property for regular holiday accommodation. The remainder of the properties were tenanted, businesses, or other uses.

Of the 144 respondents, 67% (96) have been at their address for over 10 years and 35% (51) have lived at their address for over 20 years. The median time of residence was 15 Years. An overview of the periods of residency is provided in **Figure 4-1**.

This information is useful in understanding the responses provided to subsequent questions and provide a better general understanding of the community.

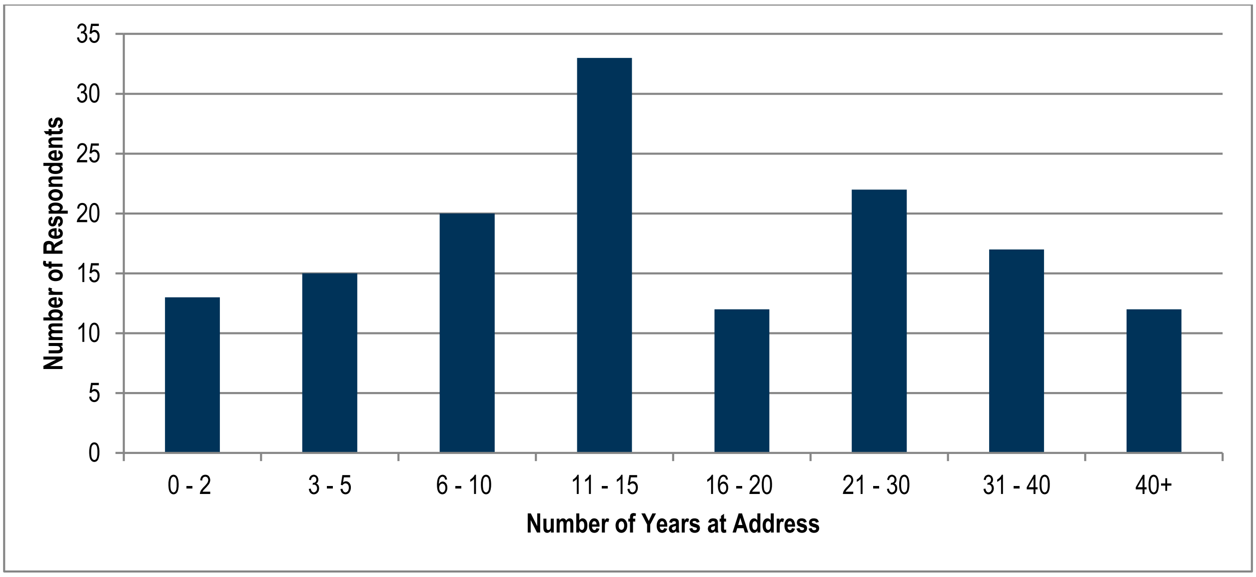

Figure 4-1 Years respondents have spent at current address

4.1.2.2 Community Flood Experiences and Expectations

Residents were asked about their previous flooding experiences, as well as what they expected future flooding conditions to be like. Responses to these questions are shown in **Figure 4-2** and **Figure 4-3** respectively.

The results show that 34% (49) of respondents have experienced flooding in the past with the majority of these being cases of over ground flooding (i.e. flooding of the property gardens and / or yard). Only 2% (3) of respondents reported having experienced over floor flooding. No previous flooding experiences were reported by 35% (9) of the respondents. Given that the last significant flood in Tabourie Lake occurred in 1991, these numbers are not unexpected, as only 30% of the respondents would have resided in Tabourie Lake at this time.

The results for the expected future flooding risk are very similar. There was a slight increase in the expected rate of over ground flooding. This suggests that respondents are basing their assumptions of future flooding risk on previous experience. Given the period of time since the last major flood event, this results in the community underappreciating the flooding risks within the catchment. Shown in **Figure 4-4** is a comparison between the expectation of future flooding, and the actual property impacts arising from a 1% AEP flood event. While the responses would be dependent on the location of the property, the results suggest that residents may be over estimating the number of properties that will be unaffected by flooding, and underestimating the number of properties that will be affected by over floor flooding.

This information is useful in understanding the community's expectation of floodplain management, their likely response in the event of a flood and will assist Council and SES in the development of appropriate flood education programs.

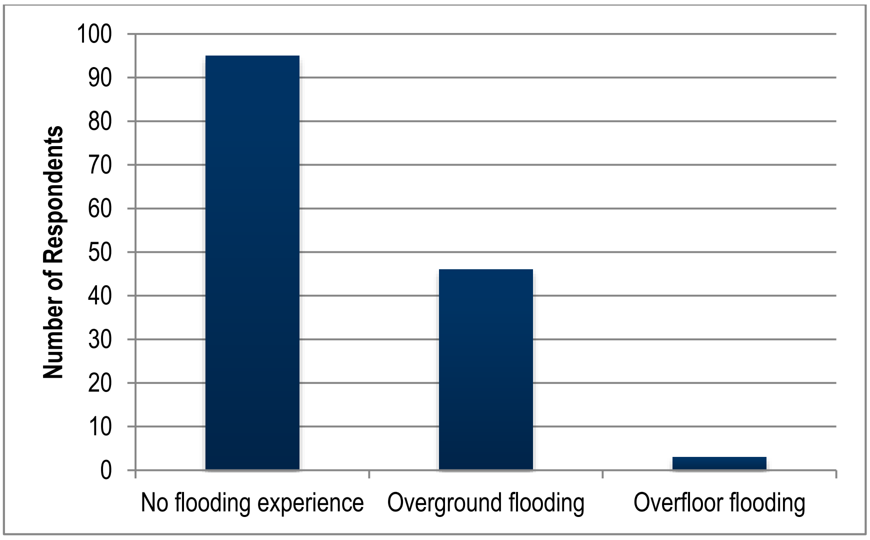

Figure 4-2 Historic Flooding Experiences

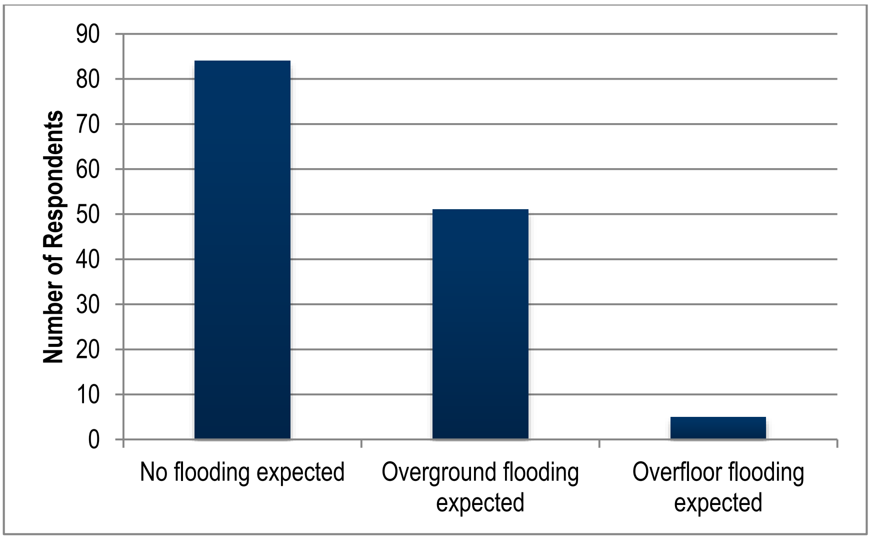

Figure 4-3 Expected Future Flooding Experience

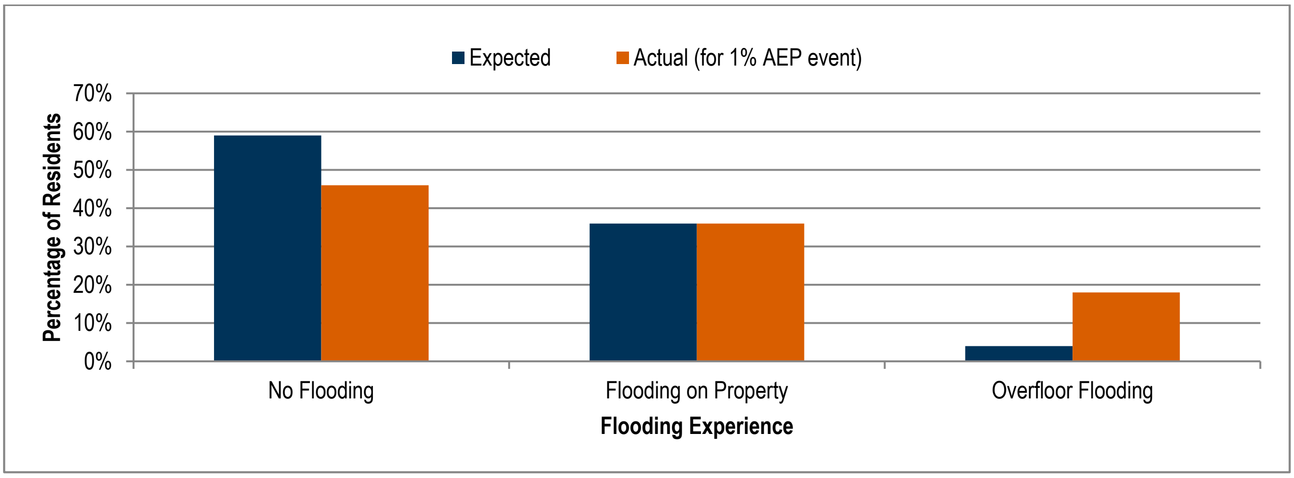

Figure 4-4 Comparison Between Expected and Actual Flood Affectation in Future Events

4.1.2.3 Community Preferred Flood Mitigation Options

The questionnaire asked respondents to give a ranking of 1 – 5 to a variety of potential flood mitigation and management options, with five being the more preferred and one not being preferred. By taking an average of the marks given to each option, the options were ranked based on resident preference. The ranking is shown in **Figure 4-5**.

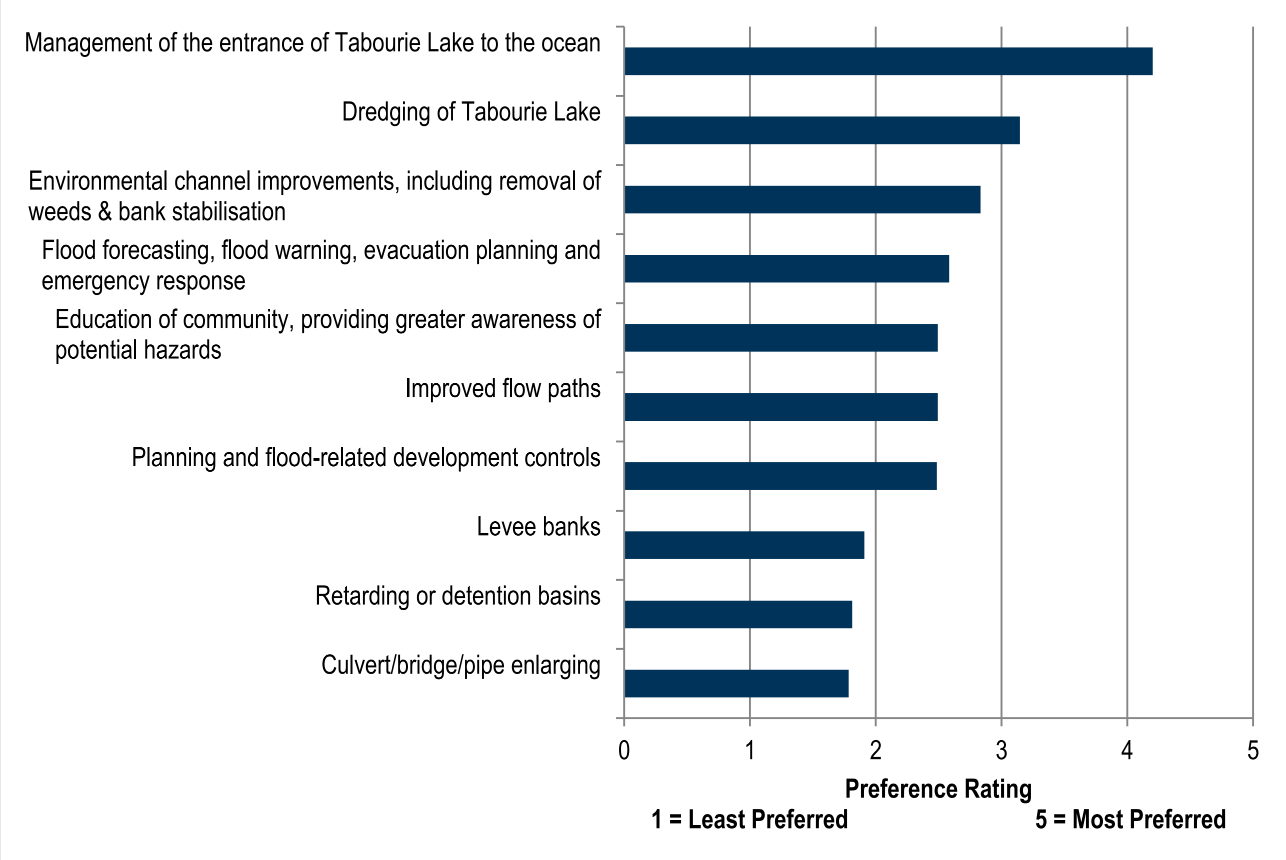

Figure 4-5 Community Preferred Flood Mitigation Options

The most popular option was management of the entrance, which is likely reflective of the communities strong engagement with entrance management. Dredging of Tabourie Lake was also popular, as were channel improvements, flood warning systems and community education. The structural options, retarding / detention basins diversions and levee banks, were the least preferred.

This information has been used to direct the development of flood mitigation options for assessment in the study and has also been incorporated into the multi-criteria matrix assessment, which aims to rank each of the options (**Section 14**).

4.1.2.4 Community Preferred Communication Avenue

Ongoing communication with the community is an important part of the study. To ensure the community is effectively engaged throughout the remainder of the study, residents were asked to provide details of the best method for passing on flood study related information to them. The results are shown in **Figure 4-6**.

The most popular method of communication by a large margin was mail outs. Community meetings, Council emails and information days were the next most popular, however support for other communication methods were generally similar. It is noted that these responses may contain some bias, as the data was gathered from a mail out survey; however, these results will assist with community engagement for the remainder of this study.

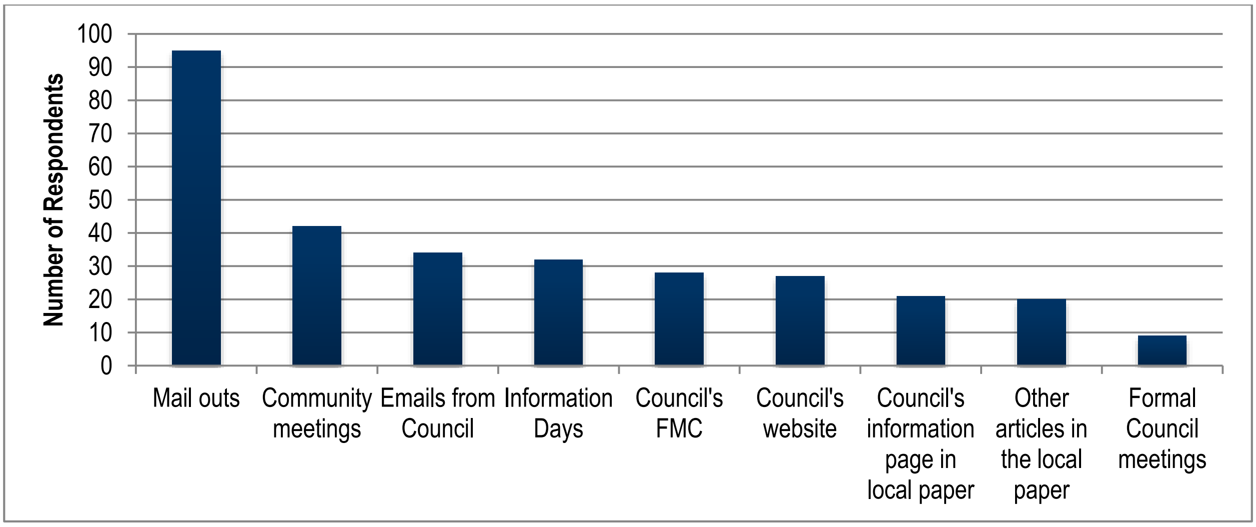

Figure 4-6 Preferred Communication Method

4.2 Community Workshops

As part of the Floodplain Risk Management Study and Plan, two community workshops were held to present the status of the study and any associated findings to residents, and to provide an opportunity for the community to offer their comments and feedback on the findings and any other concerns or issues relating to flooding and the study.

The first workshop was held at the Rural Fire Service building in Lake Tabourie on Wednesday, 30 October 2013. The workshop was undertaken to introduce the study to the community, and to hold a preliminary discussion on potential mitigation strategies.

Key comments and feedback that was provided by the community during the workshop included:

- Debris in Lemon Tree Creek poses a blockage hazard during flood events;
- Tabourie Lake and the associated creeks have experienced increased sedimentation – the effect of dredging the lake and creeks should be investigated; and,
- Entrance management is an important topic, with a number of alternative views on the subject.

The second workshop was also held at the Rural Fire Service building in Lake Tabourie on Monday, 7 July 2014. The workshop was undertaken to present to the community the results of flood mitigation option assessment and the benefit-cost analysis. The process of incorporating community opinion in the multi-criteria assessment was also discussed to ensure that the ranking appropriately reflected community sentiment.

Key comments and feedback from the second community workshop included:

- Residents were interested in how the options would both affect the opening of the entrance, and if they would support alternative opening schedules.
- There was a discussion on the various flooding mechanisms of the catchment, and how individual options were capable of protecting the community from each flooding mechanism.

4.3 Public Exhibition

The third and final workshop was held during the public exhibition period at the Rural Fire Service building in Lake Tabourie on Wednesday, 10 February 2016. The workshop was undertaken to present to the community the outcomes and recommendations from the study, and to give the community an opportunity to comment to the recommended options and the scoring used in the multi-criteria assessment, to ensure that the ranked options appropriately accounted for community sentiment.

Key comments and feedback from the second community workshop included:

- Residents were generally opposed to levee banks due to impacts on aesthetics and waterway access, as well as concerns around water ponding behind the levee during flood events. The exception was the Lyra Road levee that had the support of nearby residents.
- There was a discussion on the entrance trigger level, and how sea level rise is expected to affect the entrance. It was discussed how levee options can also allow the entrance to build higher before opening, but the community largely felt that this was not worth the compromise on aesthetics and water access.
- Community requested further information on how potential options were taken forward. There was concern that options that the community did not support would be forced upon them if included in the Plan. It was discussed that Plan did not place any binding obligation on Council, and that any structural options that were pursued would be accompanied by further consultation to ensure that the outcomes fit the communities requirements. It was also discussed that a key outcome of the Floodplain Risk Management process is the definition of community flooding risks, and that the Plan puts forward a range of options that were found to assist in addressing these risks. Both the community and Council are then able to engage in discussions about which options are best suited for implementation in the township.

5 Catchment Flood Behaviour

5.1 Model Scenarios

Summarised in **Table 5-1** and **Table 5-2** are the design runs undertaken as part of the study. Critical durations were taken from the Flood Study.

Peak flood extents for the design events are shown in **Figure 5-1**.

Hydraulic categories for the 1% AEP and the PMF events are shown in **Figure 5-2** and **Figure 5-3**.

An envelope approach was taken in order to assess both catchment and ocean events. Independent models were run for catchment events and for ocean events, with the peak flood behaviour taken from both models for mapping and assessments.

Peak flood levels at the Tabourie Creek gauge for the design events are reported in

Table 5-1 Design Flood Event Scenarios

Event	Scenarios	Rainfall	Ocean Boundary
20% AEP	Catchment	20% AEP 9 hr duration	0.60 (regular neap tide)
	Ocean	20% AEP 9 hr duration	1.89 (20% AEP)
5% AEP	Catchment	5% AEP 9 hr duration	0.60 (regular neap tide)
	Ocean	20% AEP 9 hr duration	2.25 (5% AEP)
2% AEP	Catchment	2% AEP 9 hr duration	0.60 (regular neap tide)
	Ocean	20% AEP 9 hr duration	2.45 (2% AEP)
1% AEP	Catchment	1% AEP 9 hr duration	0.60 (regular neap tide)
	Ocean	20% AEP 9 hr duration	2.51 (1% AEP)
	SLR 2050	1% AEP 9 hr duration	1% AEP + 0.23m
	SLR 2100	1% AEP 9 hr duration	1% AEP 0.36m
PMF	Catchment & Ocean	PMF 6 hr duration	2.60 (0.5%AEP)

Table 5-2 Design Flood Rainfall Parameters

Event	Critical Duration	Average rainfall intensity for catchment flood events	Peak flood level at Tabourie Creek gauge
20% AEP	9 hour	15.0 mm / hour	2.0
5% AEP	9 hour	20.8 mm / hour	2.36
2% AEP	9 hour	25.2 mm / hour	2.62
1% AEP	9 hour	28.6 mm / hour	2.66
PMF	6 hour	107.0 mm / hour	4.25

5.2 Existing Behaviour

5.2.1 Properties with Over floor Flooding

A detailed assessment of the flood damages and over floor flooding was undertaken as part of this study. The number of properties that are likely to experience over floor flooding in various design flood events are shown in **Table 5-3**. Single storey dwellings have been highlighted in the table, as these properties have limited opportunity for vertical evacuation and the residents are therefore potentially at greater risk. It is noted that almost all flood affected residential properties are single storey.

Table 5-3 Properties with Over floor Flooding

Flood Event (AEP)	Residential Properties		Commercial Properties
	Single Storey	Total Residential	
50% AEP	0	0	0
20% AEP	2	2	0
5% AEP	12	12	0
2% AEP	38	41	0
1% AEP	39	42	0
PMF	139	175	1

5.2.2 Flood Hazard

5.2.2.1 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters (Figure L2, NSW Government, 2005). The Floodplain Development Manual (2005) defines two categories for provisional hazard - High and Low.

- High hazard – possible danger to personal safety, evacuation by trucks difficult, able-bodied adults would have difficulty in wading to safety, potential for significant structural damage to buildings; and
- Low hazard – should it be necessary, a truck could be used to evacuate people and their possessions, able-bodied adults would have little difficulty in wading to safety.

The methodology for determining provisional hazard categories, from the Flood Plain Development Manual, is shown in **Figure 5-4**.

The provisional flood hazard was defined as part of the Flood Study. Provisional flood hazard mapping was prepared for the 5, 20 and 100 Year ARI and PMF events.

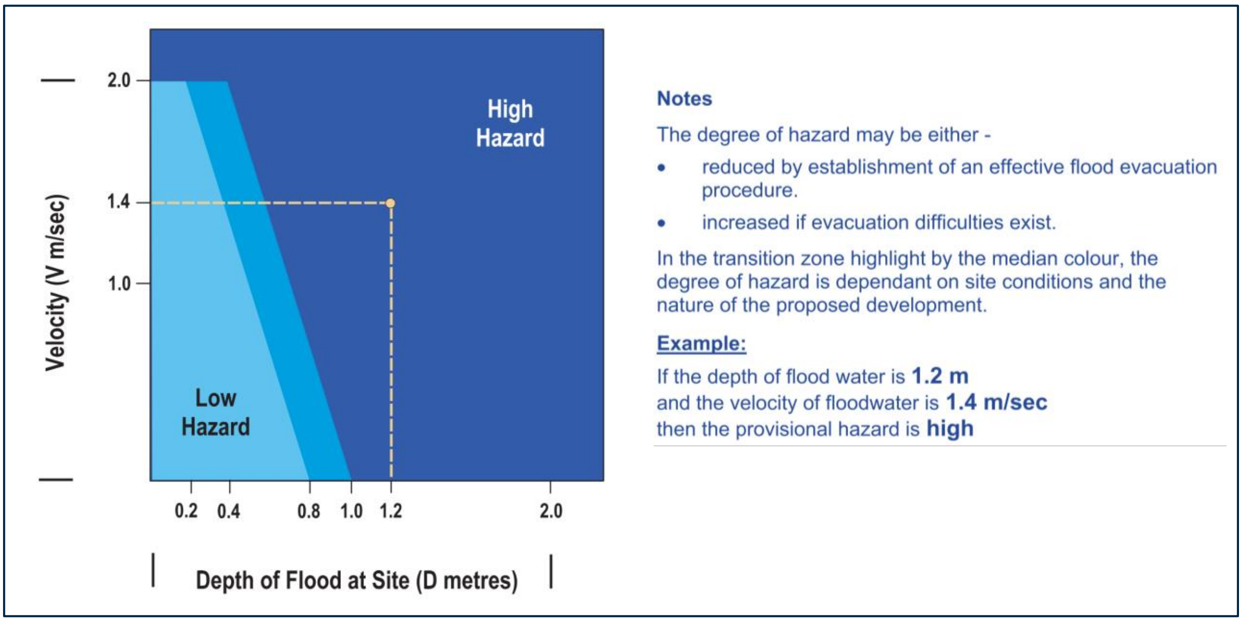

Figure 5-4 Provisional Hazard Categories (from Appendix L of the Floodplain Development Manual)

5.2.2.2 True Flood Hazard

Provisional flood hazard categorisation based around the hydraulic parameters, does not consider a range of other factors that influence the "true" flood hazard. In addition to water depth and velocity, other factors contributing to the true flood hazard include the:

- Size of the flood;
- Effective warning time;
- Flood readiness;
- Rate of rise of floodwaters;
- Duration of flooding;
- Ease of evacuation; and,
- Effective flood access.

In the Tabourie Lake catchment many of the above factors are not applicable in terms of affecting hazard identification. Many of the above factors are not applicable in terms of affecting the hazard mapping. However, consideration of the above listed factors is an important process to identify the particular issues which may result in hazardous conditions for specific locations or the entire study area.

Size of Flood

The size of a flood and the damage it causes varies from one event to another. For the purposes of this study, flood hazard has been mapped for the PMF event and the 1% AEP event. True hazard has also been assessed for these events.

Council's DCP (2014) identifies specific controls that relate to proposed development within the high hazard extent. For planning purposes the high hazard extent refer to the 1% AEP high hazard extent.

Effective Warning Time

The effective warning time is the actual time available prior to a flood during which people may undertake appropriate mitigation actions (such as lift or transport belongings and/or evacuation). The effective warning time is always less than the total warning time available to emergency service agencies. This is related to the time needed to pass the flood warning to people located in the floodplain and for them to begin effective property protection and/or evacuation procedures.

The critical storm duration for the study area is the 9 hour event. As such, the peak of the flow occurs at various locations within the catchment within 7 to 10 hours from the start of the rainfall. This has been considered in the review of emergency response arrangements in **Section 10**.

As critical durations are fairly homogenous throughout the catchment and consequently no area within the catchment is any more at risk than another. As such, no changes to the hazard mapping have been recommended as an outcome of effective warning time.

Flood Readiness

Flood readiness or preparedness can greatly influence the time taken by flood-affected residents and visitors to respond in an efficient pattern to flood warnings. In communities with a high degree of flood readiness, the response to flood warnings is prompt, efficient and effective.

Flood readiness is generally influenced by the time elapsed since the area last experienced severe flooding. Major flood events last occurred in the study area in 1988 and 1975. Based on the responses from the resident survey (refer **Section 4**) approximately 20% of respondents were living in the study area at the time of the 1988 flood event.

The lake system is relatively dynamic, with nature and manual openings of the entrance occurring relatively frequently. Consequently, many residents are aware of how the entrance affects creek and lake levels, and how flood behaviour may change as a result of entrance conditions.

However, in comparing resident responses to the community about the expected risks of future flooding, and the actual flood impacts from a 1% AEP, it was found that residents are significantly underrepresenting the risks of over floor flooding within the township (refer **Section 4.1.2.2**) . This is likely due to the long period since a major flood event occurred.

Based on the available information it is assumed that flood awareness across the study area is likely to be relatively consistent. No particular part of the catchment appears to have more flood awareness than another. As a result, the provisional high hazard extents are not recommended to be altered as a result of flood readiness.

Rate of Rise of Floodwaters.

The rate of rise of floodwater affects the magnitude of the consequences of a flood event. Situations where floodwaters rise rapidly are potentially far more dangerous and cause more damage than situations where flood levels increase slowly. The rate of rise of floodwaters is affected by catchment and floodplain characteristics.

A rate of rise of 0.5 m/hr has been adopted as indicative of hazardous conditions. There are no conclusive guidelines on this parameter. As such this value has been selected arbitrarily to provide an indication of locations where waters can reach hazardous depths in a relatively short period of time.

It is important to note that if an area has a rate of rise greater than 0.5 m/hr this does not automatically result in the area being categorised as high hazard. For instance, if the rate of rise is very high but flood depths only reach 0.2 m, this is not considered to pose any greater hazard than slowly rising waters. Therefore, peak flood depths were considered in conjunction with the rate of rise in identifying hazardous areas.

A flood depth of 0.5 m was selected as the trigger depth for high hazard where the rate of rise was equal to or greater than 0.5 m/hr. A 0.5 m flood depth is well within the range of available information as to when vehicles become unstable even with no flow velocity (NSW Government, 2005).

In the study area, there are no properties with flow behaviour within these constraints for the 1% AEP event which are not already selected by the provisional high hazard criteria (**Section 5.2.5**).

Depth and Velocity of Flood Waters

Depth and velocity are used to determine the provisional flood hazard, using purely hydraulic considerations (Appendix L; NSW Government, 2005). The Floodplain Development Manual (NSW Government, 2005) defines two categories for provisional hazard – high and low.

The provisional hazard mapping for the PMF and 1% AEP events were undertaken in line with the methodology set out in the Floodplain Development Manual (NSW Government, 2005), and has been used as the base to determine true flood hazard.

Duration of Flooding

The duration of flooding or length of time a community, town or single dwelling is cut off by floodwaters can have a significant impact on the costs and disruption associated with flooding. Flooding durations are generally less than a couple of hours, even in the longer duration events. Those properties affected by longer periods of inundation are already selected by the provisional high hazard criteria.

Ease of Evacuation

The levels of damage and disruption caused by a flood are also influenced by the difficulty of evacuating flood-affected people and property. Evacuation may be difficult because of a number of factors, including:

- The number of people requiring assistance;
- Mobility of people;
- Time of day; and
- Lack of suitable evacuation equipment.

Based ABS data (refer Section 7.1) 70% of residents are between 10 and 70 years old, while 14% are less than 10 and 16% are over 70 years old. This suggests that the majority of residents will be relatively mobile and would require minimal assistance during a flood event.

The childcare centre is a high risk site with respect to evacuation as there are likely to be a large number of young children who will require assistance, and a limited number of adults to assist them.

Evacuation is a key issue with regards to flood risk and hazard within the LGA. This issue has been reviewed in more detail in **Section 10**. However, the provisional hazard mapping is not recommended to be modified as an outcome of evacuation issues in the study area.

Effective Flood Access

The availability of effective access routes to or from flood affected areas can directly influence personal safety and potential damage reduction measures. Effective access implies that there is an exit route available that remains trafficable for sufficient time to evacuate people and possessions.

The availability of effective access routes from flood prone areas can directly influence personal danger and potential damage reduction measures. Effective access means an exit route that remains trafficable for sufficient time to evacuate people and possessions.

Flood access issues vary across the catchment. For the purposes of this assessment properties were identified as being in one of these flood access categories:

- Site is flooded and evacuation required through a high hazard flooded roadway,
- Site is flooded and evacuation is required through a flooded roadway,
- Site is flood free, however all road access is impeded by floodwaters.

To consolidate these categories and determine the implication of flood access issues on hazard mapping, criteria were set to establish effective flood access. It was determined that effective access is a road which is flooded by less than 0.3m of water. For the purposes of this assessment 0.3m is the threshold depth at which vehicles become unstable, even at very low velocities. Areas that are cut off due to floodwaters have been identified on the true hazard maps. It is not recommended that these areas be classified as high hazard as the development controls that apply to high hazard properties would not all be relevant to these properties. However, it is suggested that Council consider the access issues associated with these properties when considering any development applications for increase in development density (e.g. subdivision or dual occupancy).

5.2.2.3 Outcome of Hazard Assessment

The provisional hazard mapping for the 1% AEP and PMF events was review against factors for True Hazard. Several key issues were identified relating to flood hazard and risk as a result of this review. However, these issues have been dealt with as part of the review of emergency response arrangements, existing planning provisions and the development of flood mitigation measures. It was not considered appropriate or necessary to modify the provisional hazard mapping for these issues. As such, the provisional hazard mapping is no longer considered provisional.

True hazard maps for the 1% AEP and PMF events are shown in **Figure 5-5** and **Figure 5-6**.

5.2.3 Flood Emergency Response Planning Classification of Communities

Flood emergency response classification provides an indication of the relative vulnerability of the community and provides the SES with valuable information in managing emergency responses to flood events.

The classifications are shown in **Figure 5-7**.

The classification has been undertaken in accordance with the floodplain risk management guideline 'Flood Emergency Response Planning Classification of Communities' (DECC 2007).

The Flood Emergency Response Planning Classifications within the study area are:

- Low Flood Island – region is first surrounded, and then impacted by flooding in the PMF.
- High Trapped Perimeter – region is not inundated by the PMF but access may be restricted.
- Overland Escape Route – region and access impacted by PMF. People can escape rising flood waters by moving overland to higher ground.
- Rising Road Access – regions where access roads rise steadily to flood free ground and allow egress as flood waters rise.
- Indirectly Affected Areas – regions that are outside the flood limit that retain access.

Local evacuation or vertical refuge should be considered for properties within areas identified as low flood islands. This is discussed further in **Section 12.4.6**.

5.3 Predicted Future Flood Behaviour due to Climate Change Impacts

5.3.1 Effects of Climate Change within Lake Tabourie

Current advice from the NSW Government is for Council's to conduct their own investigations into possible changes resulting from climate change, and to adopt their own sea level rise projections. Shoalhaven City Council, in conjunction with Eurobodalla Council, commissioned the South Coast Regional Sea Level Rise Policy and Planning Framework assessment (Whitehead & Associates, 2014) to assess and recommend sea level rise projects for the Shoalhaven and Eurobodalla LGAs.

Council elected to adopt part of this report, and selected sea level rise projections (with respect to current levels) of:

- 100mm for 2030;
- 230mm for 2050; and,
- 360mm for 2100.

Climate change may also have an impact on the significant wave height during storm events, which has the potential to further increase flood levels in coastal catchments. The likelihood of changes to the significant wave height, and the resulting changes, are still uncertain. Data provided in *Projected Changes in Climatological Forcing for Coastal Erosion in NSW* (CSIRO, 2007), suggest that a 10% increase to significant wave height by 2050 and a 30% increase by 2100 would be suitable for assessments. Due to the uncertainty surrounding this issue, changes to significant wave heights were excluded from the climate change runs and were instead examined separately through a sensitivity assessment.

The changes to the hydraulic model to assess the climate change scenarios and wave height sensitivity scenarios are summarised in **Table 5-4**. Note that the sea level rise increases have been applied to current sea levels.

Table 5-4 Modelled Climate Change Scenarios

Scenario	Increase in Downstream Water Level *	Increase in Significant Wave Height
2050 Climate Change Scenario	230 mm	-
2100 Climate Change Scenario	360 mm	-
2050 Climate Change Sensitivity Assessment	230 mm	10% (0.71m)
2100 Climate Change Sensitivity Assessment	360 mm	30% (2.13m)

* Increases applied to current ocean levels

5.3.2 Results of Climate Change Modelling

The results of the climate change assessment are shown in **Figure 5-8** and **Figure 5-9** for the 2050 and 2100 scenarios respectively, and the results of associated property flooding are summarised in **Table 5-5**.

True hazard and hydraulic categories for the 1% AEP event under 2050 and 2100 are shown in **Figure 5-10** to **Figure 5-13**.

Peak flood extents for the PMF under 2050 and 2100 scenarios are shown in **Figure 5-14** and **Figure 5-15**.

The results show that flooding increases are relatively consistent across all affected properties. This is to be expected given that the entrance causes the upstream area to behave as a large basin until the berm is overtopped and begins to fail.

The increases affect the majority of properties within the study area, and result in an additional 39 properties being affected by over floor flooding by 2050. This increases to 56 additional properties by 2100.

It should be noted that these increases are based on current development, and do not account for residents undertaking redevelopment or mitigation works in response to rising sea levels.

Table 5-5 Changes in property flooding as a result of climate change

	2050	2100
% of properties currently affected by flooding with increased flood levels	62%	64%
Additional properties with over ground flooding	20	25
Additional properties with over floor flooding	39	56
Maximum flood level increase (m)	0.36	0.59
Average increase for affected properties (m)	0.24	0.31
25th percentile increase for affected properties (m)	0.23	0.30
75th percentile increase for affected properties (m)	0.24	0.32

5.3.3 Results of Climate Change Sensitivity Assessment

The results of the wave height sensitivity assessment are shown in **Figure 5-16** and **Figure 5-17** for the 2050 and 2100 scenarios respectively. The results of associated property flooding are summarised in **Table 5-6**.

The results show that the inclusion of increases to significant wave heights result in higher predicted flood levels in 2050 and 2100. Similar to the climate change scenarios, flood level increase are relatively consistent across the study area. However, they are increased significantly more than for just increased sea levels alone.

The increased levels resulted in a significant increase in over floor flooding within the study area, with 130 additional properties having over floor flooding by 2050 and 166 additional properties by 2100.

The results suggest that changes to significant wave height have a large impact on flooding in the study area. Given the current level of confidence and research, excluding significant wave height changes from the climate change scenarios is reasonable. However, due to the high level of sensitivity of flood levels to wave height, as more research is conducted, and the confidence of predicted changes to significant wave heights increases, these changes should be incorporated into the climate change scenarios to ensure that the scenarios are reflective of predicted future climatic conditions.

Table 5-6 Changes in property flooding as a result of climate change including a change in wave height

	2050	2100
% of properties with increased flood levels	73%	82%
Additional properties with over ground flooding	45	77
Additional properties with over floor flooding	130	166
Maximum flood level increase (m)	1.10	2.63
Average increase for affected properties (m)	0.77	2.12
25th percentile increase for affected properties (m)	0.76	2.19
75th percentile increase for affected properties (m)	0.80	2.33

5.3.4 Impact of Climate Change on Entrance Management

Sea level rise as a result of climate change is expected to result in changes to the Tabourie Creek entrance. Current predictions are that the entrance berm will rise in line with the sea level (Haines & Thom, 2014). As a result, the entrance is predicted to be 0.23m higher in 2050 and 0.36m higher in 2100.

This change in entrance level does not necessitate a change in entrance management, and the current trigger level would still be required in order to prevent inundation of properties.

Maintaining the existing trigger level does have some consequences. If the same trigger level is maintained:

- The maximum level in the system remains the same.
- There will be a reduced head difference between creek water levels and ocean water levels at the time of breakout, which will result in less sand being scoured from the entrance.
- The entrance will require more frequent openings, as the trigger level would be reached soon.
- The entrance will be more difficult to keep open, as a result of the reduced scour.

If structural options are implemented, it may be possible to raise the trigger level for manual opening of the entrance (refer **Section 12.2.3**). If it is elected to increase the trigger level in line with sea level rise increases:

- There will be a greater inundation of foreshores and development.
- The capacity of the system (storage volume) would increase, which may reduce the frequency of breakouts.
- The relative levels of the creek, entrance and ocean would remain similar, so opening behaviour and duration should remain as per the current regime.

An alternative to the opening approach currently adopted is the construction of a formed entrance that would allow the entrance to remain open permanently. An open entrance would have a relatively small impact during large flood events, but would impact the extent of frequent inundation within the township.

Flooding in Lake Tabourie can occur from both catchment and ocean flood events.

Sensitivity testing undertaken demonstrated that the entrance condition does not significantly affect the flooding behaviour of catchment flood events. This is due to the fact that the entrance quickly washes out once overtopped, and that this overtopping occurs in advance of the peak flood. Consequently, by the time the peak flood arrives, the entrance has been opened by the preceding flood waters.

For ocean flood events however, a closed entrance provides some protection to the township from elevated ocean levels. Permanently opening the entrance would remove this small protection, and increase the likelihood of ocean flooding within the township. The extent of tidal inundation would also increase in the future due to increased sea levels.

These expected changes should be discussed with the community as part of the entrance management process in order to determine which solution best fits the needs and wants of Council and the community.

6 Current Economic Impact of Flooding

6.1 Background

The economic impact of flooding can be defined by what is commonly referred to as flood damages. Flood damages are categorised as tangible and intangible; these are summarised in **Table 6-1**.

Table 6-1 Types of Flood Damages

Type		Description
Tangible	Direct	Building contents (internal) Structural damage (building repair) External items (vehicles, contents of sheds, etc.)
	Indirect	Clean-up (immediate, removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public service)
Intangible		Social (increased levels of insecurity, depression, stress) Inconvenience (general difficulties in post-flood stage)

The direct damage costs, as indicated in **Table 6-1**, are just one component of the entire cost of a flood event. There are also indirect costs. Together, direct and indirect costs are referred to as tangible costs. In addition to tangible costs, there are intangible costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to quantify in economic terms.

Flood damages can be assessed by a number of methods including the use of computer programs such as FLDamage or ANUFLOOD, or via more generic methods using spread-sheets. For the purposes of this project, a custom tool developed by Cardno was used based on a combination of OEH residential damage curves and FLDamage.

6.2 Damage Analysis

A flood damage assessment for the existing catchment conditions has been completed as part of this study.

The assessment is based on damage curves that relate the depth of flooding on a property to the likely damage within the property. Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchments is not available and as such, damage curves from other catchments, and available research in the area, is used as a substitute.

OEH has conducted research and prepared a methodology (draft) to develop damage curves based on state-wide historical data. This methodology is only for residential properties and does not cover industrial or commercial properties.

Commercial damage curves were adopted from the FLDamage Manual (Water Studies Pty Ltd, 1992). FLDamage allows for three types of commercial properties, namely, low value commercial, medium value commercial, and high value commercial.

There were no industrial properties within the study area.

The damage methodology is provided in **Appendix C**.

6.3 Results

The results from the damage analysis are shown in Table 6-2. The results are expressed in terms of total damages and average annual damages. The total damages are the economic value of the tangible damages likely to result from a specific design flood event. The average annual damage (AAD) takes into the account the expected damage from each design event and the likelihood of that event occurring in any given year and provides an average cost to the community per year as a result of flooding over the long term.

The average annual damage for the Tabourie Lake floodplain under existing conditions is estimated to be $593,000.

The results show that there is minimal property inundation in the 50% AEP event. Over floor flooding commences in the 5% AEP event, with a corresponding increase in damages compared to the 50% AEP.

Damages are very similar in the 2% AEP and 1% AEP events as a consequence of the relatively small difference in peak levels between the events.

The PMF results in substantially higher damages than the 1% AEP as a result of the peak flood level being 1.2m higher in the PMF compared to the 1% AEP event.

Table 6-2 Tabourie Lake Existing Damage Analysis Results

	Properties with over floor flooding	Average Over floor Flooding Depth (m)	Maximum Over floor Flooding Depth (m)	Properties with over ground flooding	Total Damages ($June 2014)
PMF					
Residential	175	1.40	2.95	193	$ 16,589,500
Commercial	1	1.53	1.53	1	$ 635,400
Caravan Park	26	1.07	2.03	165	$ 10,243,500
PMF Total	202			359	$ 27,468,400
1% AEP					
Residential	42	0.70	0.85	120	$ 3,352,200
Commercial	0	-	-	1	$ -
Caravan Park	35	0.21	0.89	89	$ 2,183,000
1% AEP Total	77			210	$ 5,535,200
2% AEP					
Residential	41	0.26	0.85	119	$ 3,349,100
Commercial	0	-	-	1	$ -
Caravan Park	31	0.19	0.85	89	$ 1,597,000
2% AEP Total	72			209	$ 4,946,100
5% AEP					
Residential	12	0.19	0.44	60	$ 1,191,000
Commercial	0	-	-	0	$ -
Caravan Park	15	0.16	0.79	7	$ 761,000
5% AEP Total	27			67	$ 1,952,000
20% AEP					
Residential	2	0.02	0.03	21	$ 214,700
Commercial	0	-	-	0	$ -
Caravan Park	6	0.1	0.68	77	$ 346,000
20% AEP	8			98	$ 560,700

7 Environmental & Social Issues

Environmental and social characteristics of the study area may influence the type and extent of flood mitigation options able to be implemented. Environmental characteristics, such as habitats, threatened species, topography and geology are constraints of structural flood mitigation sites.

Social characteristics such as housing and demographics may impact the community's response to flooding and therefore affect the type of flood mitigation options proposed.

The following environmental and social characteristics have been considered in the assessment:

- Geology, Soils, Geomorphology and Groundwater;
- Demographic Characteristics;
- Flora and Fauna; and
- Aboriginal and Non-Aboriginal Cultural Heritage.

The detailed environmental and social assessment is provided in **Appendix D**.

Environmental and social issues to be considered in the development of floodplain management strategies in the Tabourie Lake catchment include:

- A high probability of Acid Sulfate Soils, as shown in **Figure 7-1**.
- A search of the NSW Natural Resource Atlas (NR Atlas) identified 14 groundwater bores within close proximity of Tabourie Creek and one alongside Tabourie Lake. Depending on the chosen flood modification option, groundwater may be intercepted during construction. If groundwater extraction/interference is required, an aquifer interference approval would be required for the work under clause 91(3) of the Water Management Act 2000.
- There are a number of threatened and endangered species in the vicinity of the study area (refer Appendix D for details).
- There are a number of seagrass communities in the lake and entrance. The status of seagrasses around the estuary has been reported as 'very poor' in the NSW State of the Catchment (SoC) Report for estuaries in the Southern Rivers Region (DECCW, 2010). Flood modification works within the vicinity of these seagrasses should both consider the protection of the seagrass from flood damages and compatibility with the flood works.
- There are approximately 100 recognised aboriginal heritage sites within the catchment area. These sites are shown on **Figure 7-2**.
- Almost a third of the residents of Lake Tabourie are over 60, which is significantly higher than the NSW average. The region also had a lower proportion of people aged between 20 and 39 years of age. This results in a community which may face issues with regards to evacuation during a flood event due to limited mobility, inability to drive or health issues associated with an aged community.
- In Lake Tabourie, 83.8% of people were born in Australia. The most common countries of birth outside of Australia were England 4.2%, Germany 1.3 %, Netherlands 1.3% and New Zealand 1.3%. Indigenous (Aboriginal and Torres Strait Islander) people comprised of 2% of the region's population.
- English was the only language spoken in approximately 96.7% of homes in Lake Tabourie. The remainder of other languages spoken at home was Italian.
- The average median weekly income for individuals in the region was $666, compared to the NSW average of $561. This trend of slightly above average income for the region compared to the NSW average was also evident for family and household incomes. This may have implications for the economic damages incurred on property contents during a flood event.

8 Policies & Planning

The Tabourie Lake catchment is located in the Shoalhaven LGA where development is primarily controlled through the Shoalhaven Local Environment Plan (LEP) and the Development Control Plan (DCP). The LEP is a planning instrument which designates land uses and development in the LGA, while the DCP regulates development with specific guidelines and parameters.

8.1 Shoalhaven Local Environment Plan

Due to the Environmental Planning and Assessment Amendment Act 2008 and Environmental Planning and Assessment Amendment Regulation 2009, the standardisation of all NSW Local Authority LEPs is in process. Significant changes within the LGA and in the NSW Planning Reforms implemented by the NSW Government have instigated a process of updating the LEP. The Shoalhaven Local Environment Plan (SLEP) 2014 was finalised on 8 April 2014, and adopted 22 April 2014.

The SLEP incorporates a section on flood affected land. The objectives of *Section 7.3: Flood Planning* are:

- To maintain the existing flood regime and flow conveyance capacity;
- To enable safe occupation and evacuation of land subject to flooding;
- To avoid significant adverse impacts on flood behaviour;
- To avoid significant effects on the environment that would cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; and
- To limit uses to those compatible with flow conveyance function and flood hazard.

The land to which this clause applies is the 1% AEP flood extent plus a 0.5m freeboard.

8.1.1 Current Land Use and Zoning

The Tabourie Lake catchment is comprised predominately of rural land or national parks, with isolated centres of urban development, such as the Tabourie Lake Township.

The land use within the Lake Tabourie catchment is controlled by the draft Shoalhaven Local Environment Plan (LEP). The zoning of the study area is shown in **Figure 8-1**, and the zones are described in **Table 8-1** as per the Standard LEP Instrument (NSW Government, 2013).

8.1.2 Flood Affected Land Use Zones

A number of land uses are affected by flooding in the 1% AEP event and the PMF event, as shown in **Figure 8-2**. The area of flood affected land within in zone is shown in **Table 8-1**.

Zones within the 1% AEP event flood affected area are mainly E1 National Parks and Nature Reserves, RU5 Village and RE1 Public Recreation. There is a pocket of R2 Low Density Residential within Lake Tabourie Township that is affected by the 1% AEP event. Residential properties (RU5, R2) are affected by flooding from Tabourie Creek, and its tributaries Branderee Creek and Lemon Tree Creek.

A number of developments permissible under these landuses may not be flood compatible. Summarised in **Table 8-2** are permissible development within these land use zones, that may not be flood compatible due to at risk populations (young children, the elderly, the disabled), seasonally high numbers of visitors who may not be aware of flood risks in the area or are critical infrastructure.

Table 8-1 Tabourie Lake Catchment Land Uses (based on NSW Government, 2013)

Zone	Land Use	Description	1% AEP Flood Affected Area
Env. Protection	E1 National Parks and Nature Reserves	▪ To enable the management and appropriate use of land that is reserved under the National Parks and Wildlife Act 1974 or that is acquired under Part 11 of that Act. ▪ To enable uses authorised under the National Parks and Wildlife Act 1974. ▪ To identify land that is to be reserved under the National Parks and Wildlife Act 1974 and to protect the environmental significance of that land.	207 ha
	E2 Environmental Conservation	▪ To protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values and to prevent development that could destroy, damage or otherwise adversely affect those values ▪ To protect water quality, natural water systems, wetlands rainforest and habitat linkages	2 ha
	E3 Environmental Management	▪ Generally intended to be applied to land that has special ecological, scientific, cultural or aesthetic attributes, or land highly constrained by geotechnical or other hazards. ▪ This zone can also be suitable as a transition between areas of high conservation value and other more intensive land uses such as rural or residential.	Not flood affected
Residential	R1 General Residential	▪ To provide for a variety of residential housing types and densities, including dwelling houses, multi-dwelling housing, residential flat buildings, boarding houses and seniors housing ▪ Also to provide facilities or services to residents, including neighbourhood shops and child care centres	Not flood affected
	R2 Low Density Residential	▪ Land where primarily low density housing is to be established or already exist. ▪ Also to encourage the provision of facilities or services that meet the day-to-day needs of residents	2.5 ha
Recreation	RE1 Public Recreation	▪ Generally intended for a wide range of public recreational areas and activities including local and regional parks and open space. For example, recreation facilities	30 ha
Rural	RU2 Rural Landscape	▪ Rural land with general landscape values or that has reduced agricultural capability but which is suitable for grazing and other forms of extensive agriculture.	27 ha
	RU3 Forestry	▪ Rural land to enable development for forestry purposes, or development that is compatible with forestry purposes ▪ To encourage recreational use of forest resources and to recognise the role of forest resources	Not flood affected
	RU5 Village	▪ Rural land to provide for a range of uses, services and facilities that are associated with a rural village.	17 ha

Zone	Land Use	Description	1% AEP Flood Affected Area
Special Purpose	SP2 Infrastructure	▪ Infrastructure land that is highly unlikely to be used for a different purpose in the future, for example cemeteries and major sewage treatment plants ▪ Also appropriate for major state infrastructure or strategic sites such as major hospitals and large campus universities/TAFEs.	3 ha
Waterways	W1 Natural Waterways	▪ To protect the ecological and scenic values of natural waterways ▪ To prevent development that would have an adverse effect on the natural values of waterways in this zone ▪ To provide for sustainable fishing industries and recreational fishing	2 ha
	W2 Recreational Waterways	▪ To protect the ecological, scenic and recreation values of recreational waterways ▪ To allow for water-based recreation and related uses ▪ To provide for sustainable fishing industries and recreational fishing	23 ha

Table 8-2 Permissible Development in Flood Affected Land Use Zones

Land Use Zone	Permissible Developments that may not be flood compatible
RE1 (Public Recreation)	▪ Camping grounds ▪ Caravan parks ▪ Childcare centres ▪ Community facilities ▪ Respite day care centres
R2 (Low Density Residential)	▪ Bed & Breakfast accommodation ▪ Childcare centres ▪ Community facilities ▪ Emergency services facilities ▪ Respite day care centres
RU5 (Village)	▪ Caravan parks ▪ Childcare centres ▪ Community facilities ▪ Dwelling houses ▪ Function centres ▪ Registered clubs.

8.2 Development Control Plan

A Development Control Plan (DCP) is prepared by Council and applied to specific types of development or areas of land and provide detailed development guidelines and controls. A DCP outline specific controls and parameters that apply to development proposals.

In accordance with changes to the planning system in NSW, Shoalhaven Council has prepared a single DCP for the LGA. The new DCP; DCP2014, was adopted by Council on 14 October 2014 and came into effect on 22 October 2014.

The following sections of the DCP have relevance to floodplain management.

Chapter G9 – Development on Flood Prone Land

The purpose of this Chapter is to provide information and development controls needed to prepare and assess development applications on flood prone land.

The chapter offers a consolidated document for the relevant flood planning controls, and applicable flood policies in the Shoalhaven LGA. The chapter provides context of all flood planning requirements in the Shoalhaven LGA. An overview of the flood planning controls applicable to the LGA is included, as well as the requirements of management of flood prone land, technical reporting requirements and flood proofing guidelines.

A development should satisfy the requirements as shown in the planning matrix at Schedule 6 including climate chance considerations.

Schedule 5 provides flood related development controls for site specific areas. These controls have been developed within the individual Floodplain Risk Management Plans for each area. No site specific controls are included for Tabourie Lake. It is expected that the recommendations of this FRMS&P would be considered for inclusion in the DCP.

Chapter G11 – Subdivision

The purpose of this Chapter is to outline controls and guidelines for the subdivision of land and strata subdivision. Section 5.10 outlines performance criteria and solutions with regards to controlling and minimising the risk of flooding.

It is required that Ground/floor levels of all buildings are able to be located above the design flood level to provide protection to property in accordance with the accepted level of risk. Specifically, it is stated that habitable floor levels are consistent with the requirement in Chapter G9: Development on Flood Prone Land of the DCP.

The design of bridges must address the effects of the Probable Maximum Flood event. All bridges are required to be designed for the 1% AEP storm event. Where the approach road, excluding the bridge approaches, is less than the 1% AEP flood level, a lower standard level may be considered.

Small scale infill subdivision on flood prone land be provided above the 1% AEP flood level on each proposed lot in the subdivision.

It is noted that subdivision proposals must also comply with the requirements in Chapter G9 of the DCP. These requirements are outlined in the generic matrix in Schedule 6. It is noted that subdivision is not permissible in High Hazard and reliable access needs to be provided during a flood events for properties within the low hazard extent.

Chapter G12 – Dwelling Houses, Rural Worker's Dwellings, Additions & Ancillary

As part of the chapter, the following performance criteria are set out for the construction of buildings on flood prone land:

- Dwellings and ancillary structures do not adversely impede the flow of floodwaters on flood liable land;

- The floor level of habitable rooms in a dwelling are above the relevant flood criteria including a suitable free board (i.e. flood planning levels);
- The design of all buildings and construction elements must resist the impacts of flood waters;
- Access is provided to the dwelling during time of localised flooding to assist evacuation; and
- Site works and building structures meet the standards of Councils Flood Policy, and relevant NSW Floodplain Development Manual guidelines. Applicants should also refer to Section G9 of the DCP.

8.3 South Coast Sea Level Rise Assessment

The 2009, NSW Government Sea Level Rise Policy required that Council consider, as a minimum, 40cm sea level rise by 2050 and 90cm rise by 2100. This policy has now been repealed by the State Government which now encourages each council to adopt their own sea level rise projections. In response, Council in partnership with Eurobodalla Council engaged consultants to develop a South Coast Regional Sea Level Rise Policy and Planning Framework (Whitehead & Associates, 2014). This document was not adopted by Council however part of it together with submissions from the NIPCC and local civil engineers were used by Councillors to adopt the following sea level rise projections on 10 February 2015.

- 100mm for 2030;
- 230mm for 2050; and
- 360mm for 2100.

These numbers correspond to the sea level rise projections associated with RCP6.0 (mid-range greenhouse gas emissions scenario). The adopted 2030 and 2050 projections have a 15% chance (high probability line) of being exceeded while the 2100 projection of 360mm has a 85% chance of being exceeded (low probability line).

8.4 Recommended Controls for Tabourie Lake

As a result of the investigation into flood related planning controls in the previous sections, a number of recommendations are proposed to increase the effectiveness of the planning controls both for the Tabourie Lake Floodplain specifically and across the LGA. Recommended amendments to existing controls are summarised in Table 8-3.

Table 8-3 Review of Existing Flood Planning Controls in Tabourie Lake

Existing Control	Comments
Climate Change	**General to LGA**
The required inclusion of sea level rise in the DCP (0.4m or 0.9m) does not correlate with the now adopted values of 0.1m, 0.23m and 0.36m.	The DCP should be updated to reflect the most recently adopted sea level rise projections and to provide guidance to the applicant as to how and when they should be applied.

Existing Control	Comments
Minor Development For proposed dwelling extensions where it is impractical to raise the floor level, applications for extensions of the building at the existing level will be treated on their individual merits up to a maximum cumulative total increase in habitable floor area of: • $50m^2$ for residential and rural residential dwellings; and • $100m^2$ for dwellings associated with bona fide large area rural enterprises such as dairying	**General to LGA** It is recommended that this be allowed where it does not have an adverse impact on flooding.
Flood Evacuation Plan All residential and commercial developments (including minor development) within the high hazard areas are required to have a flood evacuation plan that ensures the timely, orderly and safe evacuation of people from the area and that it will not add significant cost and disruption to the community or the SES. A flood evacuation plan is also required for carparks within the flood planning area.	**Floodplain Specific** Due to access issues associated with flooding on main access roads within the Tabourie Lake Floodplain and the relatively short period of time available to alert residents, initiate and execute evacuation, shelter in place may provide a more suitable response to flooding. It is recommended that any new development within the Tabourie Lake Floodplain be required to prepare a flood evacuation plan and if the requirements of the DCP for effective evacuation cannot be met, that a suitable local evacuation location above the PMF be identified either within the residence or nearby. The duration of flooding should also be considered when determining whether shelter-in-place is an appropriate response to flooding.
Management and Design Special provisions apply to certain uses regarding storage of hazardous and valuable goods above the 1% AEP Flood Level, bunding to the FPL around hazardous chemical storage areas and animal refuge provisions above the 1% AEP Flood Level.	**General to LGA** Council may want to consider increasing the design level for the storage of hazardous and valuable goods and animal refuge to the flood planning level (1% AEP + 0.5m). This would provide consistency with Councils other controls.

Existing Control	Comments
Hydraulic Impact Flood impact assessments (for impacts up to the PMF) are required for all developments likely to have a flood impact (except ‘Minor Developments’) within High Hazard areas. However, no flood impact assessment is required if the building is raised on piers allowing free flow for a 1% AEP flood event.	**General to LGA** Depending on the location and the flood behaviour of the proposed works, a structure raised on piers above the 1% AEP flood event may still have impacts associated with events greater than the 1% AEP event. It may be more appropriate to require that in order to demonstrate no adverse effect on flood behaviour; a flood impact assessment is required unless a replacement of the exact footprint is proposed. Developments are not to increase the likelihood of flood damage to any other property. In addition, Council may consider reviewing the adoption of the PMF for flood impact assessments. This is a fairly onerous requirement when compared to other Council controls in NSW. The adoption of the 1% AEP as the upper limit for impact assessments may be more suitable.

9 Flood Planning Level Review

9.1 Background

The Flood Planning Level (FPL) for the majority of areas across New South Wales has been traditionally based on the 1% AEP flood level plus a freeboard. The freeboard for habitable floor levels is generally set between 0.3 – 0.5m for residential properties, and can vary for industrial and commercial properties.

A variety of factors are worthy of consideration in determining an appropriate FPL. Most importantly, the flood behaviour and the risk posed by the flood behaviour to life and property in different areas of the floodplain and different types of land use need to be accounted for in the setting of an FPL.

The Floodplain Development Manual (NSW Government, 2005) identifies the following issues to be considered:

- Risk to life;
- Long term strategic plan for land use near and on the floodplain;
- Existing and potential land use;
- Current flood level used for planning purposes;
- Changes in potential flood damages caused by selecting a particular flood planning level,
- Consequences of floods larger than the flood planning level;
- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Land values and social equity; and,
- Duty of care.

These issues are dealt with collectively in the following sections.

9.2 Planning Circular PS 07-003

The Planning Circular was released by the NSW Department of Planning in January 2007, and provides advice on a number of changes concerning flood-related development controls on residential lots. The package included:

- An amendment to the Environmental Planning and Assessment Regulation 2000 in relation to the questions about flooding to be answered in section 149 planning certificates;
- A revised ministerial direction regarding flood prone land (issued under section 117 of the Environmental Planning and Assessment Act 1979); and,
- A new Guideline concerning flood-related development controls in low flood risk areas.

The Guideline states that, unless there are exceptional circumstances, councils should adopt the 1% AEP +0.5m as the FPL for residential development. The need for another FPL to be adopted would be based on an assessment local flood behaviour, flood history, associated flood hazards or a particular historic flood.

9.3 Current FPL

Based on the Shoalhaven DCP 2014 (**Section 8**), Council currently utilises the following FPLs:

- Residential, commercial, industrial and agricultural buildings: Floor levels should be no lower than the 2050 1% AEP flood level + 0.50M freeboard.
- Carparks: Floor levels should be set high enough to ensure a velocity - depth product of less than 0.3 m^2/s for a 2050 1% AEP flood event.
- Critical Infrastructure Assets/ Potentially Polluting Activities: Flood levels to be no lower than the 5% AEP flood level.
- Minor Development: If it is not possible to construct the proposed floor levels at the 2050 1% flood level + 0.5m freeboard, then the proposed floor levels are to be at the level of the existing habitable floor level or higher as practical.
- Buildings and activities requiring special evacuation consideration: Floor levels to be no lower than the Probable Maximum Flood level.
- Subdivision applications do not have floor level controls. However, it is noted that any building to be constructed as a result of the subdivision should comply the with the controls outline above.
- For new building applications below 4m AHD, the impact of a 0.4m sea level rise for individual properties and 0.9m for subdivision is to be included when determining the flood planning level. Council has recently adopted sea level rise projections of 0.23m by 2050 and 0.36m by 2100, which replaces the previous projections of 0.4m and 0.9m respectively. It is understood that DCP 2014 will shortly be updated to reflect Council's current position.

9.4 Likelihood of Flooding

As a guide, **Table 9-1** has been reproduced from the NSW Floodplain Development Manual 2005 to indicate the likelihood of the occurrence of an event in an average lifetime to indicate the potential risk to life.

Analysis of the data presented in **Table 9-1** gives a perspective on the flood risk over an average lifetime. The data indicates that there is a 50% chance of a 1% AEP event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 1% AEP flood event as the basis for the FPL. Given the social issues associated with a flood event, and the non-tangible effects such as stress and trauma, it is appropriate to limit the exposure of people to floods.

Note that there still remains a 30% chance of exposure to at least one flood of a 0.5% AEP magnitude over a 70 year period. This gives rise to the consideration of the adoption of a rarer flood event (such as the PMF) as the flood planning level for some types of development.

Table 9-1 Probability of Experiencing a Given Size Flood or Higher in an Average Lifetime (70yrs)

Likelihood of Occurrence in any year (AEP)	Probability of experiencing at least one event in 70 years (%)	Probability of experiencing at least two events in 70 years (%)
10%	99.9	99.3
5%	97	86
2%	75	41
1%	50	16
0.5%	30	5

9.5 Land Use and Planning

The hydrological regime of the catchment can change as a result of changes to the land-use, particularly with an increase in the density of development. The removal of pervious areas in the catchment can increase the peak flow arriving at various locations, and hence the flood levels can be increased. However, the dominant land uses within the wider catchment area are National Parks and Rural Landscape, which are unlike to experience significant changes in impervious areas.

A potential impact on flooding can arise through the intensity of development on the floodplain, which may either remove flood storage or impact on the conveyance of flows. DCP 2014 restricts building within the floodway, and recommends against filling in flood storage areas. In general, DCP 2014 limits development in flood prone regions. Consequently, this is not considered to be a significant issue within the catchment.

Based on the low risk of changes in hydrological and hydraulic regime as a result of changes in land use, it is not considered necessary to include this as a factor in the selection of an appropriate FPL for the floodplain.

9.6 Damage Cost Differential Between Events

Based on an approximate typical over floor flood damage for a property of $50,000, the incremental difference in Annual Average Damage (AAD) for different recurrence intervals is shown in **Table 9-2**. The table shows the AAD of a given property that experiences over floor flooding in each design event, and the net present value (NPV) of those damages over 50 years at 7%.

Table 9-2 indicates that the largest incremental difference between AAD per property occurs between the more frequent events. The greatest difference between damages occurs between the 50% and 20% AEP events. It can be seen that the differences between the 5% and 1% AEP event, and the 1% AEP event and the PMF are relatively small, suggesting that increasing the FPL beyond the 2% AEP level does not significantly alter the savings achieved from a reduction in damages.

Table 9-2 Differential Damage Costs between AEP Events

Event (AEP)	AAD	Change in AAD	NPV of AAD	Change in NPV
50%	$25,000	-	$345,000	-
20%	$10,000	$15,000	$138,000	$207,000
10%	$5,000	$5,000	$69,000	$69,000
5%	$2,500	$2,500	$34,500	$34,500
1%	$1,000	$1,500	$13,800	$20,700
PMF	$500	$500	$6,900	$6,900

9.7 Incremental Height Differences Between Events

Consideration of the average height difference between various flood levels can provide another measure for selecting an appropriate FPL.

Based on the existing flood behaviour, the average incremental height difference between events is shown in **Table 9-3** for selected events. These are determined based on the flood levels determined at each of the properties within the catchment as part of the flood damages analysis. Note that differences are only calculated where flood levels are reported for properties in the 5% AEP event.

Table 9-3 Relative Differences Between Design Flood Levels

Event (AEP)	Difference to PMF (m)	Difference to 1% AEP (m)	Difference to 2% AEP (m)
1%	1.38	-	-
2%	1.45	0.07	-
5%	1.57	0.19	0.11

Table 9-3 indicates a significantly larger difference in flood level of the PMF event compared to other events. The adoption of the 1% AEP event as the flood planning level is only marginally different from that of the 2% event (on average 0.07m higher). Therefore, the adoption of the 1% AEP event would provide an increased level of risk reduction over the 2% AEP event without a significant difference in flood planning level and associated cost for property owners.

The adoption of the PMF event as the flood planning level would result in more significant increases in levels over the 1% AEP event (in the order of 1.38 metres) and may therefore potentially present an issue for the setting of flood planning levels in the catchment with regards to compliance with other design controls, access and cost.

9.8 Consequence of Adopting the PMF as a Flood Planning Level

Analysis of the flood damages (**Section 6.3**) indicates that the incremental AAD per building from the 1% AEP to the PMF is relatively low. Therefore the choice of the PMF event over the 1% AEP event as the FPL would result in limited economic benefits (in annualised terms) to the community.

The difference in average flood levels between the 1% AEP and the PMF event (**Section 9.6**) indicate that the use of the PMF as the FPL would result in higher levels (1.38 metres on average), and as a result higher economic costs and inconvenience to the community.

Given this, the economic costs may in fact outweigh the benefits of using the PMF event as the FPL. The use of the PMF level as the FPL may also conflict with other development/building controls in Councils DCPs.

Given the risk of exposure outlined in **Table 9-1**, it is recommended that emergency response facilities be located outside of the floodplain (i.e. the PMF extent) and any other proposed critical facilities (such as schools, aged care facilities and day care centres) be limited to areas outside of the floodplain. Proposed modifications to critical facilities already located within the PMF extent, are suggested to have floor levels at the PMF level.

9.9 Environmental and Social Issues

The FPL can result in housing being placed higher than it would otherwise be. If the FPL, is set at a level that is too high this can lead to a reduction in visual amenity for surrounding property owners, and may lead to encroachment on neighbouring property rights. This may also cause conflict with other development controls already present within the Council's development assessment process.

The average height above the ground of flood levels is shown in **Table 9-4**. If the 1% AEP level is adopted for the basis of the FPL (plus 0.5m freeboard), the habitable floor levels would be on average 1m above the existing ground level. This would likely be reasonable within the context of visual amenity and impacts on neighbouring properties. However, if the PMF was selected as the basis for the FPL the habitable floor levels would be on average 2.36m and 1.86m above the existing ground level, with and without a freeboard of 0.5m respectively. This may pose impacts on the visual amenity of the street scape and impacts on neighbouring properties.

Table 9-4 Average Depth of Design Flood Levels

Event (AEP)	Average Height of Flooding (m)	Average Height of Properties if Raised to 0.5m above Flood Levels (m)
PMF	1.86	2.36
1%	0.48	0.98
2%	0.47	0.97
5%	0.39	0.89

9.10 Climate Change

Sea level rise associated with climate change, is projected to increase flood levels and the extent of floodwaters over coastal floodplains. As sea levels rise, a FPL based on the existing 1% AEP flood event will become progressively less effective in providing the same level of protection against flood events as in the present day.

The 2009, NSW Government Sea Level Rise Policy required that Council consider, as a minimum, 40cm sea level rise by 2050 and 90cm rise by 2100. In accordance with this, Shoalhaven Council's DCP requires the potential impacts of climate change to be incorporated into the FPL through the application of the following:

- For new building applications below 4m AHD, the impact of a 0.4m sea level rise is to be included when determining the flood planning level.
- Throughout the DCP various AEP flood events are referred to as well as the flood planning level. It is up to the applicant to use the appropriate climate change conditions for these AEP flood events and the flood planning level.

The NSW Government Sea Level Rise Policy has now been repealed by the State Government which now encourages each council to adopt their own sea level rise projections. In response, Council in partnership with Eurobodalla Council engaged consultants to develop a South Coast Regional Sea Level Rise Policy and Planning Framework (Whitehead & Associates, 2014). This document was not adopted by Council however part of it together with submissions from the NIPCC and local civil engineers were used by Councillors to adopt the following sea level rise projections on 10 February 2015:

- 100mm for 2030;
- 230mm for 2050; and
- 360mm for 2100.

It is noted that no allowance for changes in rainfall patterns as a result of climate change are required as part of Council's existing controls.

9.11 Risk

The selection of an appropriate FPL also depends on the potential risk of different development types. For example, consideration should be given for different FPLs for industrial, commercial and residential properties, which have different implications should over floor flooding occur. Damages to household contents can have greater impacts than just financial burden due to the sentimentality associated with residential household possessions. However, damages to commercial and industrial properties will likely be covered by insurance without the additional emotional burden. In addition, the risk to life at a residential property can be significantly high than for a commercial or industrial property due to the residents being present during the night, potentially unaware of flooding occurring while they are asleep and potential including less mobile people (such as children or the elderly).

Critical infrastructure, such as hospitals, fire stations, electricity sub-stations and other critical infrastructure, have wider spread implications should inundation occur. As such, FPLs are typically selected for these types of structures higher than for residential, commercial or industrial properties.

9.12 Freeboard Selection

As outlined in **Section 3.1**, a freeboard ranging from 0.3 - 0.5 m is commonly adopted in determining the FPL. It should be realised that the freeboard accounts for uncertainties in deriving the design flood levels and as such should be used as a safety margin for the adopted FPL. This consideration may result in the adopted FPL being higher than the PMF in certain cases. However, given the inherent purpose of freeboard, the FPL should still be used in such cases.

The freeboard may account for factors such as:

- Impacts on flood levels as a result of changes in the catchment;
- Impacts on flood levels as a result of changes in the creek/channel vegetation;
- Impacts on flood levels as a result of the conditions of creek entrance to the ocean;
- Accuracy of model inputs (e.g. accuracy of ground survey, accuracy of design rainfall inputs for the area);
- Model sensitivity to:
    - Local flood behaviour (e.g. due to local obstructions etc.),
    - Wave action (e.g. such wind-induced waves or wash from vehicles or boats),
    - Culvert or bridge blockages,
    - Climate change (affecting ocean water levels and rainfall).

The impact of typical elements factored into a freeboard can be summarised as follows:

- Afflux (local increase in flood level due to a small local obstruction not accounted for in the modelling) (0.1m) (Gillespie, 2005),
- Local wave action (allowances of ~0.1 m are typical) (truck wash etc.),
- Accuracy of ground/ aerial survey ~ +/-0.15m,
- Sensitivity of the model ~ +/-0.05m

Based on this analysis, the total sum of the likely variations is in the order of 0.4m, excluding climate change.

Council currently manage flood uncertainties associated with climate change impacts on the sea level through adjusting the 1% AEP flood level used for planning purposes (refer **Section 9.3**) rather than including climate change uncertainty in the freeboard. This approach is appropriate, given the variation in climate change impacts across the catchment. However, no planning provisions are in place to manage he uncertainty of the impacts of climate change on rainfall. Sensitivity testing undertaken as part of the Flood Study (BMT WBM, 2010) of a 10% increase in rainfall found the 1% AEP flood levels increased by up to 0.07m.

Given the above, a freeboard allowance of 0.5m is considered appropriate.

9.13 Planning Level Scenarios

A selected number of FPL scenarios have been assessed, to test the implications on the floodplain, in regards to the number of existing buildings which are below this level as well as the flood protection provided in various design events. **Table 9-5,** on the following page, summarises potential benefits for the setting of a 1% AEP and PMF FPL options with freeboards. The analysis does not differentiate between residential, industrial and commercial buildings.

Table 9-5 Selected Flood Planning Level Scenarios & Impacts on Properties

Description	Existing Property Levels	FPL set at 1% AEP + 0.5m	FPL set at 2050 1% AEP + 0.5m	FPL set at 2100 1% AEP + 0.5m	Freeboard Set at PMF
Number of properties requiring raised floor level (above current elevation)	-	134	163	170	202
PMF					
Properties flooded above floor level	202	202	202	202	0
Maximum depth of above floor flooding (m)	2.95	1.63	1.61	1.44	0
Average depth of above floor flooding (m)	1.40	1.11	0.93	0.86	0
1% AEP Existing					
Properties flooded above floor level	42	0	0	0	0
Maximum depth of above floor flooding (m)	0.85	0	0	0	0
Average depth of above floor flooding (m)	0.25	0	0	0	0
1% AEP 2050					
Properties flooded above floor level	89	0	0	0	0
Maximum depth of above floor flooding (m)	1.06	0	0	0	0
Average depth of above floor flooding (m)	0.32	0	0	0	0
1% AEP 2100					
Properties flooded above floor level	106	7	0	0	0
Maximum depth of above floor flooding (m)	1.10	0.28	0	0	0
Average depth of above floor flooding (m)	0.33	0.07	0	0	0

9.14 Flood Planning Level Recommendations

The FPL investigation supports Council's current FPLs, namely:

- Residential, commercial, industrial and agricultural buildings: Floor levels should be no lower than the 2050 1% AEP flood level + 0.50m freeboard.
- Carparks: Floor levels should be set high enough to ensure a velocity - depth product of less than 0.3 m^2/s for a 2050 1% AEP flood event.
- Critical Infrastructure Assets/ Potentially Polluting Activities: Floor levels to be no lower than the 5% AEP flood level.
- Minor Development: If it is not possible to construct the proposed floor levels at the 1% flood level + 0.5m freeboard, then the proposed floor levels are to be at the level of the existing habitable floor level or higher as practical.
- Buildings and activities requiring special evacuation consideration: Floor levels to be no lower than the Probable Maximum Flood level.
- Subdivision applications do not have floor level controls. However, it is noted that any building to be constructed as a result of the subdivision should comply the with the controls outline above.

The Flood Planning Area (FPA) covered by the FPL for the existing, 2050 and 2100 scenarios are shown in **Figure 9-1** to **Figure 9-3**.

The hazard categories

The hazard categories of the FPL for the existing, 2050 and 2100 scenarios are shown in **Figure 9-4** to **Figure 9-6**.

The hydraulic categories of the FPL for the existing, 2050 and 2100 scenarios are shown in **Figure 9-7** to **Figure 9-9**.

10 Emergency Response Arrangements

Flood emergency measures are an effective means of reducing the risks of flooding and managing the continuing and residual risks to the area. Current flood emergency response arrangements for managing flooding in Shoalhaven LGA are discussed below.

10.1 Emergency Response Documentation

10.1.1 DISPLAN

Flood emergency management for the Shoalhaven LGA is organised under the Shoalhaven City Local Disaster Plan (DISPLAN) (2011) and has been issued under the authority of the State Emergency and Rescue Management Act, 1989 (as amended).

The DISPLAN details emergency preparedness, response and recovery arrangement for the region to ensure the coordinated response to emergencies by all agencies having responsibilities and functions in emergencies.

The plan is consistent with similar plans prepared for areas across NSW and covers roles and responsibilities in emergencies, preparedness measures, response operations and co-ordination of immediate recovery measures.

The DISPLAN outlines the key responsibilities of the different organisations involved in emergency management. It is generally the responsibility of the SES, as the “combat” agency, to respond to and coordinate the flood emergency response. It is the responsibility of Council and OEH to manage flood prevention / mitigation through development controls, the floodplain management process and mitigation schemes.

The Shoalhaven DISPLAN identifies flood hazard to be a high probability with high consequences. It should be noted that this categorisation is a general one for the whole LGA.

10.1.2 Shoalhaven Local Flood Plan

A sub-plan to the local EMPLAN has been prepared by the SES, in conjunction with Council. The Shoalhaven Flood Emergency Plan (the Flood Plan) was prepared in 2014 and covers the preparation, response and recovery of flooding emergencies for the Shoalhaven City Council Area.

The Flood Plan focuses exclusively on flooding emergencies, and more explicitly defines the roles and responsibilities of parties in a flood event. It also makes note of which key roads can be flood affected, and details evacuation centres for flood affected areas of the Shoalhaven catchment.

The Flood Plan notes that Tabourie Lake is a flood prone region of the catchment. The Flood Plan lists flood evacuation points for flood affected regions. For Tabourie Lake, the flood evacuation centre is noted as the Tabourie Lake Motor Inn, Princes Highway.

Whilst this location is flood free in the PMF, it is not accessible for the whole community during a flood event. The loss of access across the River Road / Centre Street Bridge prevents residents living east of Lemon Tree Creek from being able to reach this evacuation point. It is recommended that an additional evacuation location be provided east of Lemon Tree Creek to provide these residents with refuge during a flood event.

10.2 Emergency Service Operators

The Tabourie Lake floodplain lies within the Illawarra / South Coast region of the State Emergency Service (SES). The Illawarra / South Coast region office is located at 6-8 Regent St, Wollongong. The SES maintains a Local Operations Centre for response to storms and floods in Ulladulla.

The access road from the Local Operations Centre to Tabourie Lake is the Princes Highway, which is flood affected during large storm events within the study area and is likely to be affected elsewhere.

The SES is listed as the "Combat Agency" for flooding and storm damage control in the DISPLAN, as well as the primary coordinator for evacuation and the initial welfare of affected communities.

The SES is primarily a volunteer organisation. In times of emergency, the SES operates a paging service for on-call volunteers. However, more experienced crew know when to mobilise based on their understanding of the local area.

The role of the SES in flash flood areas such as local creeks is generally at the clean-up stage. For longer duration flooding, the SES can assist in evacuation and protection of properties.

The locations of key emergency services for Tabourie Lake are outlined in **Table 10-1**.

Table 10-1 Emergency Service Providers Locations

Emergency Service	Location
Shoalhaven Hospital	2 Shoalhaven Street, Nowra
Milton Hospital	104 Princes Highway, Milton
Ulladulla Police Station	73 Princes Highway, Ulladulla
Ulladulla Fire Station	46 Nurrawallee Street, Ulladulla

10.3 Access and Movement During Flood Events

Any flood response suggested for the study area must take into account the availability of flood free access, and the ease with which movement may be accomplished. Movement may be evacuation of residents from flood affected areas, medical personnel attempting to provide aid, or SES personnel installing flood defences.

10.3.1 Access Road Flooding

Summarised in **Table 10-2** below are the key access routes out of, and through, the Tabourie Lake Township. The locations at which flood depths have been extracted are shown in **Figure 10.1**.

The table shows that while all access routes are flood free in the 20% AEP event, most are impacted by flood waters in the 5% AEP and all are inundated by flood waters in the 2% AEP event.

Book 9, Chapter 6 of ARR (currently under review) examined the stability of pedestrians and vehicles during flood events. The assessment found that:

- The maximum depth stability limit was 0.5m for children and 1.2m for adults. However this reduces to 0.15m and 0.2m if velocities exceeded 3m/s.
- Small cars became unstable at 0.3m of still water, or at 0.1m if velocities exceeded 3m/s.

Based on these findings, the majority of crossings are unsuitable for cars and children in events larger than the 2% AEP. All crossings were found to be unsuitable for adults in the PMF.

It is noted that roads outside of the study may also be flood affected during storm events, so that even if roads within the study area are flood free, access may still be lost between adjacent townships (and emergency response units).

Table 10-2 Flooding Depth of Key Access Roads

Location	ID	20% AEP Depth (m)	5% AEP Depth (m)	2% AEP Depth (m)	1% AEP Depth (m)	PMF Depth (m)
Princes Highway	A	-	0.15	0.51	0.52	2.56
Portland Way, North	B	-	0.21	0.53	0.53	2.19
Portland Way, South	C	-	0.22	0.55	0.55	2.19
Centre Ave and Oak Ave intersection	D	-	0.27	0.57	0.57	2.21
Centre Ave and Dermal St intersection	E	-	0.19	0.50	0.50	2.12
Lyra Rd and River Rd intersection	F	-	0.40	0.70	0.70	2.33
Lyra Rd and Venus Ave intersection	G	-	-	0.36	0.36	1.95
Caravan Park Access Road	H	0.22	0.37	0.48	0.48	2.14

10.3.2 Driving Condition Analysis

Movement during a storm event is likely to be undertaken by car, or similar vehicle. The safety of operating such a vehicle needs to be determined if movement options are to be recommended.

During an extreme rainfall event, the intensity of rainfall as well as other factors (such as wind and debris), would make driving either difficult or potentially more dangerous than sheltering in place. These factors would not be unique to a floodplain, and would be equally as dangerous if an extreme event were to occur in any location. It would be expected that the risk to life of driving in these conditions would increase with lower frequency rainfall events.

A review was therefore undertaken on driver safety related to rainfall events. This assessment has been undertaken on the rainfall intensity and does not account for risks associated with flood depths and velocities (refer **Section 10.3.1**)

A study into rainfall effects on single-vehicle crash severities based on an analysis of crash and traffic data for the Wisconsin, USA area for the period 2004-2006 found that rainfall events with a mean rainfall intensity of 3.16 mm/hr resulted in an increased likelihood of crashes ranging in severity from fatal to possible injury (Jung, Qin, & Noyce, 2009). An analysis of data for the cities of Calgary and Edmonton, Canada during 1979-1983 concluded that the overall accident risk during rainfall conditions was found to be 70% higher than normal (Andrey, 1993).

Andreescu and Frost (1998) in an analysis of data for Montreal, Canada 1990-1992, found that a best fit line of data found a linear increase in number of accidents in relation to increased daily rainfall intensity (mm/day). This is reproduced in **Figure 10-2**. It is noted that there is significant scatter in the source data and that the correlation is relatively low. However, the data does demonstrate a link between daily rainfall and accidents.

The NSW Governments Roads and Traffic Authority (RTA) *Road User's Handbook* (2010) states that "Driving during extreme weather events or conditions should be undertaken with care and caution. Driving should be avoided in extreme conditions."

The rainfall intensity temporal distribution for the 1% AEP 9 hour event is shown in **Figure 10.3**. It is noted that these are exclusive of climate change impacts on rainfall intensities. The figure shows that rainfall intensities are generally greater than 10mm/hr, with peaks of 16mm/hr, 27mm/hr and 45mm/hr at 1 hour, 3 hours, and 5 hours into the storm respectively.

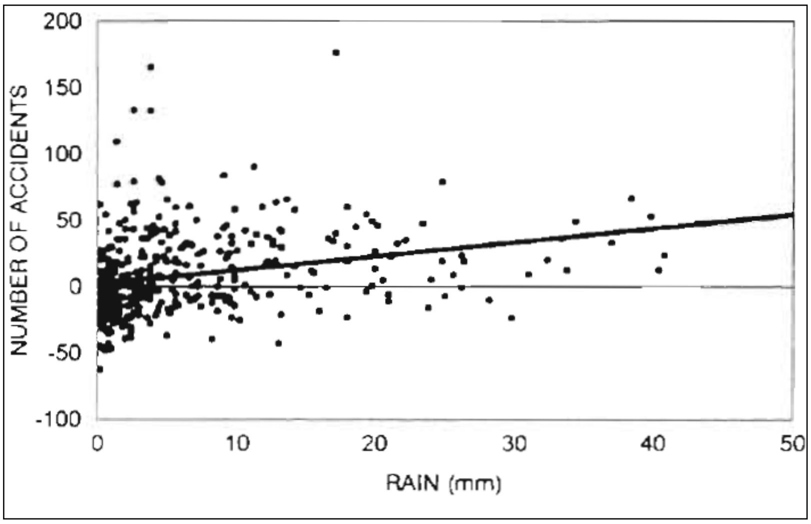

Figure 10-2 **Accidents per day vs daily rainfall (Andreescu & Frost, 1998)**

The literature evaluated does not give a definitive threshold of rainfall intensity for which unsafe driving can be expected (with the exception of Jung (2009) which has a very low intensity of only 3 mm/hr, which can be expected in relatively frequent events).

Average rainfall intensities for the 1% AEP 9 hour event are well in excess of the values identified in the literature as beginning to have an effect on driving risk.

Consequently, it is not recommended that people attempt to drive during a significant rain event. As the most intense rainfall will be associated with short duration storms, the safer option is to wait for the rain to lessen before attempting to drive. During longer duration events, where flood warning may be possible, the rainfall intensity will be reduced, and may allow evacuation whilst the rain is falling. However, in general, it is recommended that driving not be undertaken during intense rainfall periods unless there is a risk to life at the property resulting from rising flood waters.

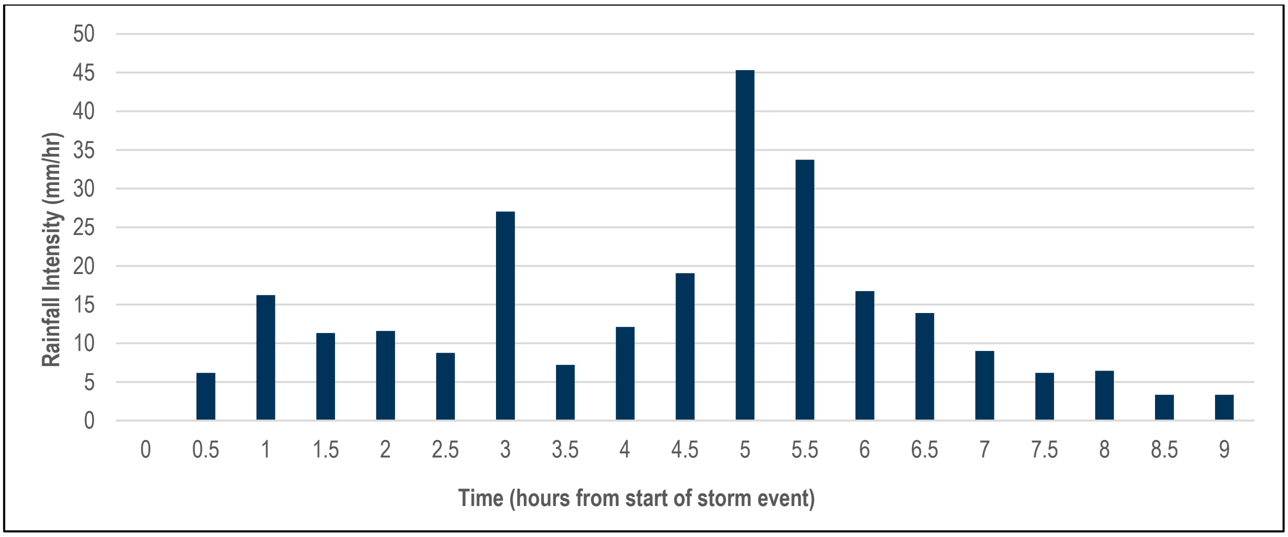

Figure 10-3 **Tabourie Lake 1% AEP 9hr Temporal Rainfall Distribution**

10.4 Flood Emergency Response

10.4.1 Flood Response Time

Flood response time is a key factor in determining appropriate flood emergency response. Flood response time is the time required determine a flood event is taking place, alert those at risk, and to begin responding to the risks posed by flood event. This time is influenced by the flood warning available, the ease of communication with the population at risk, the population's appreciation of the risk, and the population's knowledge of appropriate emergency responses.

Flash flooding results in limited flood response times. The Australasian Fire and Emergency Service Authorities Council (AFAC) define flash flooding as:

> *Flash flooding may be defined as flooding that occurs within 6 hours or less of the flood-producing rainfall within the affected catchment. Flash flood environments are characterized by the rapid onset of flooding from when rainfall begins (often within tens of minutes to a few hours) and by rapid rates of rise and by high flow velocity.*

Although the critical duration for the study area is the 9 hour event, this event still results in peak flows occurring within 6 hours of the time from which rainfall starts. Furthermore, shorter duration events still result in significant flooding within the study area.

Therefore, for the purposes of considering response to flooding in this study it is concluded that the rate of rise for the study area can be classed as flash flooding.

Flash flooding poses flood risk with regards to responding to flooding. The available response time is likely to be in the scale of hours, or in many cases sub-hourly, placing more emphasis on the ability to evacuation compared to shelter-in-place as a flood response strategy.

10.4.2 Flood Warning

There is no official flood warning system for the Tabourie Lake catchment. Furthermore, the catchment is susceptible to flash flooding, meaning that the effectiveness of warning systems are limited due to the relatively short interval between the initial rainfall and the peak of the flood. However, sources of real-time flood intelligence during times of flooding that may be used to prepare for flood events are:

- Bureau of Meteorology (BoM); and
- State Emergency Service (SES).

Warnings are provided as:

- BoM Flood Watches: SES Flood Bulletins are issued by the Illawarra South Coast SES Region Headquarters to various media outlets and agencies each time the BoM issues a Flood Watch. However, as this catchment is subject to flash flooding, the BoM will not issue a warning for this catchment in particular. Only a generic warning across the whole Shoalhaven would be available.
- BoM Severe Weather Warnings: For the management of coastal erosion and inundation, BoM will issue Sever Weather Warnings to the SES, radio stations and other organisations prior to and during potential and actual coastal erosion events.
- SES Livestock and Equipment Warnings: following heavy rain, or when there are indications of significant creek or river rises, the SES Local Operations Controllers will advise SES Region Headquarters which will issue SES Livestock and Equipment Warnings.
- Evacuation Warnings by radio, door-knocks and telephone.

There is an existing water level gauge within Tabourie Creek, immediately upstream of the entrance. There are also a number of daily rainfall stations and one pluvio-station in the region around Tabourie Lake, but none within the catchment area. It may be possible to tie manual or automatic alerts to the data gathered by these instruments. Council and the SES have access to BoM's Enviromon software, which provides live water level and rain gauge readings. Automated emails can be sent from this program to Council for set trigger levels at the Tabourie gauge. These alerts could then be forwarded to the SES.

It is noted that this would likely only provide adequate warning for lower intensity, longer duration events. During short duration events, the response and warning time would be similar to the local creeks. The trigger level adopted should be determined in consultation with the community. Lower trigger levels will provide more warning time, but will result in the alarm being triggered more frequently. Given the relatively short evacuation distances required (as all evacuation will be local, within the township), significant warning times are not required.

10.4.3 Regional vs Localised Evacuation Timeline

Evacuation during a flood event may be triggered by either regional notifications or localised observations.

The time for regional evacuation notices is substantially longer, due to:

- Time required to notify a region;
- Forecast and actual rainfall monitoring: There is inadequate flood forecasting tools in place for forecasting to be used to inform flood evacuation. Instead actual rainfall monitoring is the only feasible warning system. This type of system requires heavy rainfall to be observed before an alert is issued.
- The time required for mobilisation of the SES in response to a flood event.

As a result of the above factors, the time to evacuate an at-risk region would be expected to be in the order of 5 or more hours. Localised evacuation however, occurs at a smaller scale level through a different sequence of events, namely residents visually see flooding in their vicinity and respond instinctively by moving to higher ground.

This sequence relies less on emergency services co-ordination and relies on the common sense of the resident to respond to observed flooding through evacuation. In this sequence, residents evacuate to higher ground when they observe the rising flood levels. Compared to the regional timeline above, localised evacuation significantly reduces the time required to evacuate.

Though the time available varies for all areas of the floodplain across the study area, the catchment response time suggests that flood prone areas will have an available evacuation time significantly less than 5 hours.

Consequently, a co-ordinated regional evacuation as an emergency response is not feasible for the study area. This aligns with comments from the AFAC guideline (2013) which states that detection of rainfall or water level provide limited prospects for using such systems to trigger planned and effective evacuation.

Localised evacuation strategies for developments, however, may be feasible in certain locations within the floodplain, particularly on the fringes of the floodplain where evacuation routes are shorter.

10.4.4 Community Response to Flooding

As discussed in **Section 10.4.1**, the study area is largely characterised by a quick flood response to rainfall. This limits the options available to the community. The options available may be broadly grouped into local evacuation and shelter in place.

Unlike property damage assessments of flood risk, when determining the flood risk to life the flood hazard for an area does not directly imply the danger posed to people in the floodplain. This is due to the capacity for people to respond and react to flooding, ensuring they do not enter floodwaters.

To help minimise the flood risk to residents, it is important that developments have provisions to facilitate the safe evacuation of residents in advance of the flood.

The two key requirements for an evacuation strategy are appropriate prior warning to allow evacuation, and a safe refuge to evacuation to.

At present, the community does not have sufficient warning time to allow evacuation. The first knowledge many will have of flooding will be inundation of their property, by which time either access from their property, or access to the refuge, may be lost. Unlike shelter in place that would require significant redevelopment to existing properties in order to be effective, it would be possible to construct ramps, or regrade front yards, in order to provide rising access to flood affected properties.

As evacuation will be undertaken on a local scale, significant warning time would not be required, as residents will be able to evacuate relatively rapidly. A warning time of an hour would give residents sufficient time to relocate some household objects, pack some belongings, and walk to the refuge centre. This warning could be provided by a warning linked to the water level gauge in Tabourie Creek.

In order for an evacuation strategy to be effective, a flood refuge will need to be constructed somewhere in the township that is above the PMF level, and of a suitable size to shelter those residents whose properties are flood affected in the PMF event. As the township becomes fragmented due to access road flooding in large flood event, it would be necessary to provide multiple refuges in the township so that all residents are able to safely access a refuge.

10.4.5 High Flood Risk Locations

10.4.5.1 Childcare Centre

The Tabourie Childcare Centre is located at 20 River Road, on the corner with the Princes Highway. The site is subject to frequent flooding, with inundation of the lot occurring in the 20% AEP, although the building does not experience over floor flooding until the PMF event. Both the Princes Highway to the west and River Road to the south of the site are on higher ground, and are flood free in the 1% AEP event.

The flooding that occurs on the site is classified as flood storage for all events. Up to the 1% AEP, the hazard is classed as low, however it increases to high in the PMF, as a result of the depth of flooding which reaches 2m. This corresponds to an over floor flooding depth of 1.5m in the PMF event.

Given the frequency of inundation that results is access issues, and the high risk nature of the people present (young children) it is recommended that the centre be relocated if an alternative site can be found. In the interim, a Flood Emergency Response Plan should be prepared for the site to ensure that appropriate actions are taken in case of a flood event.

The Princes Highway is adjacent to the site, and provides flood free access in the 1% AEP event and rising road access in the PMF to a high, flood free region at the local shops, 600m north of the site.

10.4.5.2 Caravan Park

The Lake Tabourie Tourist Park caravan park is located on the Princes Highway, between Tabourie Creek and the ocean. Regions of the park are located on low-lying land adjacent to the creek, and are affected by flooding from both catchment rainfall and ocean surges.

The caravan park is of particular concern during flood events, due to:

- Access being lost before the site experiences flooding;
- The possibility of a number of people being concentrated at the property during a flood event;
- The likelihood that patrons will be from outside the catchment, and may not appreciate the flood risks during a storm event; and,
- A lack of vertical evacuation and shelter in place options.

Options to raise the access road to the 1% AEP to provide emergency evacuation in events up to the 1% AEP event and to provide a flood refuge on site were investigated (refer to **Section 12** for further information). However, an evacuation strategy would still be required for a response to flood events larger than the 1% AEP event.

A Flood Emergency Response Plan is required for the development as part of the Section G10 of the DCP (refer **Section 8.1**).

10.4.5.3 Tourists

Tabourie Lake attracts a large number of tourists, who may visit the region for a day, or stay in the numerous local accommodation options available.

These temporary tourists are a high risk group during flood events, as they are unlikely to be aware of the flooding behaviour and flood risks associated with the study area.

If tourists are staying at a flood prone location (the caravan park for example) it is recommended that they be provided with information about the associated flood risk and appropriate responses to take if a flood occurs. This information may be provided by signs placed at the entrance and within the site and / or by material provided when checking in.

10.5 Recovery

In a major flood event, structural damage to flood-affected properties may occur and residents may need to be accommodated temporarily during the recovery operation. The Department of Community Services is responsible for the long term welfare of the affected community. However, the immediate action is likely to be undertaken by the SES Local Controller.

11 Community Education & Awareness

Community awareness of flood behaviour and flood risks is essential to minimise risk to life during flood events. An aware and educated population will be able to respond to flood events quickly and appropriately, reducing risks to themselves, their property and to others.

11.1 Current Community Awareness of Flood Behaviour and Risk

The community survey and workshops undertaken (refer **Section 4**) showed that generally current residents have a good awareness of flood behaviour and flood risk.

As part of the community consultation process a questionnaire was distributed to residents, and from this information was gathered on respondents' history and awareness of flooding.

The questionnaire results showed that 70% of respondents were living in Tabourie Lake at the time of the 2005 flood event.

During the community workshop that was held as part of the consultation process, attendees demonstrated a high level of awareness of flood behaviour within their Township, and an understanding of the flood risks resulting from this behaviour. However, the communities appreciation of the magnitude of the risk was underestimated, with the community being unaware of what the full flood extents were and of the height of peak flood levels.

11.2 Maintaining Community Awareness

The aim of the education and awareness program is to maintain and improve the current level of flood awareness within the Community.

As stated above, due in large part to recent flood events in the catchment, there is currently a high level of flood awareness among residents; however, over time new residents will arrive who do not have any experience of flooding within the catchment. It is also possible that there will be a period of time with no rainfall events, over which period peoples' appreciation of flood risks may begin to wane.

11.3 Education and Awareness Program

Discussed below are strategies that may be implemented to raise community knowledge and awareness of flooding within the study area.

11.3.1 <u>Short Term</u>

11.3.1.1 Develop FloodSafe Brochure and FloodSafe Toolkit

The SES has developed Local FloodSafe Guides, which give specific information for areas at risk of floods. These guides are produced in collaboration with Council and regional and local SES units. The SES recommends that these guides are reviewed every 5 years.

The SES has also prepared templates allowing Local Guides to be prepared for individual regions. Different guides may be prepared for general township flooding, flash flooding and rural flooding. Development of the forms can be organised through contacting the SES.

The SES FloodSafe website (www.floodsafe.com.au) also allows for the creation of personal plans and business plans. Variations of plans are also available for riverine and flash flooding regions. It is recommended that a reference to this tool be made in the FloodSafe Guide to make residents and owners aware of this tool, and that residents and businesses are encouraged to prepare a personal or business plan.

11.3.1.2 Develop a Post-Flood Data Collection Strategy

The collection of post-flood data was recommended as part of the Tabourie Lake Floodplain Risk Management Study. In addition to this, it is recommended that the data collected be expanded to create information that will help the community to better understand the flood event and general catchment flood behaviour. This may include the collection / determination of data such as:

- The approximate recurrence internal of the rainfall intensity and peak river / creek flows;
- The approximate recurrence interval of any major over ground flooding;
- A comparison of the storm event with previous historical events and design events. Comparison could be made against rainfall, flows or depths;
- Timings of peak flows or levels; and,
- The timing and duration of road overtopping / closures.

11.3.2 Medium Term

11.3.2.1 Hold a FloodSafe Launch Event

Following the development of the Flood Safe documents, a public launch may be held to inform the community of the availability of this material and provide an opportunity for the community to discuss flooding issues with Council staff.

11.3.2.2 Develop a Flood Information Package for New Residents

The documents prepared for the Flood Safe initiative will provide new residents an introduction to flood behaviour and risks within the study area. It is recommended that an information package be distributed to new residents that contains a short letter from Council discussing the current flood management program, the flood safe documents, links to further information, and contact details of Council staff should they have any further queries or concerns.

Council may already have a welcome package that they provide to new residents, which would provide an existing process that can be expanded to include flood related information.

11.3.2.3 Develop a Post Flood Information Mail-Out

Following the development of the post-flood collection strategy, a post-flood information mail-out should be developed to pass this information on to the community. The purpose of presenting this data to the community is to allow them to relate their recent flood experience to other historical events and to design events.

Being able to compare their recent flood experience with predicted flows and levels from a 2% or 1% AEP event, would give them a greater understanding of what such an event would look like, and what would be required for them to be safe in such an event.

11.3.3 Long Term

11.3.3.1 Develop and Implement School Education Program

It is important that education and awareness programs target everyone within the community. Children are an important part of a community and can also be influential members of the family unit. They are also a high risk population during a flood event. As such, it is important that children are educated about flood risks and appropriate behaviour during a flood.

The SES has developed a tailored program for school children in primary schools. The program, which includes teacher’s resources, newsletters, activities and games, is designed to deliver knowledge and awareness of floods to young children. SES personal are also available to visit schools to talk about flooding and flood response.

Further details of these programs are available on the SES StormSafe website (www.stormsafe.com.au/information-for-schools). It is recommended that local schools be informed of these initiatives, and encouraged to take part in them.

11.4 Triggers for Education & Awareness Actions

It is recommended that the education and awareness program be monitored for its effectiveness, and revised as required based on feedback and new data.

In addition to revisions based on feedback, it is recommended that revisions and actions be undertaken if:

- There is a large flood event; or,
- There has been a period of 3 years without a large flood event.

11.4.1 Actions resulting from a large flood event

Immediately following a large flood event is a good time to encourage residents to take an interest in flood behaviour in the catchment. At this time many residents actively seek flood information on the event and general flood behaviour. This should also be seen as an opportunity to encourage residents to develop personal flood response plans with the flood event still clear in their minds.

It is recommended that the following actions be undertaken following a large flood event in the catchment:

- Undertake the post-flood data collection;
- If mitigation strategies have been adopted, assess their effectiveness in the flood event;
- Prepare the post flood mail-out for the event; and,
- Undertake the post flood mail-out to inform residents about the recent flood.

11.4.2 Actions resulting from a Period of 3 years without a large flood event

After a period of time without a large flood event, there is a risk that community flood awareness will begin to fall.

As such, it is recommended that if a period of three years elapses without a large flood event, a community mail-out be undertaken to inform / remind residents of flood risks within the catchment.

This mail-out may include a short letter from Council detailing the reasons for the mail-out and discussing historical flood events, the FloodSafe brochures, any previous post-flood mail-out forms, and links to other information sources.

The aim of this exercise is to ensure that residents remain aware of both flood risks within the catchment and appropriate actions to take in flood events to manage the risk.

12 Floodplain Risk Management Options

Flood risk can be categorised as existing, future or residual risk:

- **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding.
- **Future Flood Risk** – buildings and developments that may be built on flood prone land. Such buildings and developments would be exposed to a flood risk when they are built.
- **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 12-1**.

Table 12-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels.
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention.
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding.
Transferring risk	Via insurance – may be applicable in some areas depending on insurer.
Financing risk	Natural disaster funding.
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management;

- **Flood modification measures** – Flood modification measures are structural options aimed at preventing / avoiding or reducing the likelihood of flood risks through modifying the flood behaviour.
- **Property modification measures** – Property modification measures are focused on preventing / avoiding and reducing consequences of flood risks.
- **Emergency response modification measures** – Emergency response modification measures aim to reduce the consequences of flood risks through modifying the way the community and emergency services respond during a flood event.

12.2 Flood Modification Measures

Based on the flood model results, historical information, community feedback and engineering judgement, possible flood modification options (i.e. structural options) for the study area were identified. These options are outlined in **Table 12-2** and shown in **Figure 12-1**.

Table 12-2 Tabourie Lake Flood Mitigation Options

Option ID	Option	Details	Expected Benefit	Constraints
Levees These options are focused on the construction of levee banks or flood walls to create barriers to flood waters				
FM 1.1	Princes Highway Creek Side Levee	Construction of levee at 5% AEP level behind properties on Princes Highway, near the Princes Highway bridge. Requires a levee height of ~1.2m above the existing bank level.	Removal of flooding of 13 properties in events up to the 5% AEP event.	Levee height is relatively high, which may impact views and access to creek. May create a false sense of flood protection resulting in properties being unprepared for the impacts of flooding in events greater than the 5% AEP event.
FM 1.2	Portland Way Levee	Levee along creek side of Portland Way to the 1% AEP level. Requires a levee height of ~0.5m above the existing bank height.	Removal of flooding on protected properties in events up to the 1% AEP event.	May create a false sense of flood protection resulting in properties being unprepared for the impacts of flooding in events greater than the 1% AEP event.
Road Raising These options propose improve access during flood events by raising road levels and, where possible, create detention basins (using the raised road as a levee) upstream of flooding issues				
FM 2.1	Caravan Park Road Raising	Raising the Caravan Park access road to reduce overtopping depths to 0.2m in the 1% AEP event. Requires average raising of approximately 0.4m and a maximum of 1.0m at the current low point.	Will allow emergency access and egress to / from the caravan park in events up to and including the 1% AEP event. Will not reduce damages, but will reduce risk to life.	Disruptive to caravan park access during construction.
FM 2.2	River and Lyra Road Raising	Raising of River Road and incorporation of a levee behind Lyra Road, both to the 5% AEP level. Requires a levee height of ~0.8m.	Removal of flooding on protected properties in events up to the 5% AEP event.	Road works disruptive, and may result in access issues for properties.
FM 2.3	Beach and Bridge Street Raising	Raising of sections of Beach and Bridge Streets and construction of a levee behind Beach and Dermal Streets, both to the 5% AEP level. Requires raising of ~0.6m.	Removal of flooding on protected properties in events up to the 5% AEP event.	Road works disruptive and may result in access issues for properties.
FM 2.4	Bridge and Centre Street Raising and flood levee construction	Raising of sections of Bridge St and Centre St, and construction of a levee or flood wall behind properties on Oak Avenue and Centre Road, both to the 5% AEP level. Requires road raising of ~0.6m and a levee height of ~1.5m.	Removal of flooding on protected properties in events up to the 5% AEP event.	May have environmental constraints depending on value of creek habitat. Significant levee height could have aesthetic and access impacts.
FM 2.5	Local Road Raising Combination	Combination of 2.1 + 2.2 + 2.3 + 2.4	Removal of flooding on protected properties in events up to the 5% AEP event.	Extensive works - high costs.
FM 2.6	Princes Highway Raising	Road raising of Pacific Highway adjacent to bridge to provide flood free access in 1% AEP event. Requires raising by ~0.2m.	Improved access during flood events. May also benefit downstream properties in catchment flooding events.	Road works disruptive.
Dredging These options are focused on improving the conveyance of channels within the study area through removing accumulated sediment from the channel.				
FM 3.1	Lake Dredging	Dredging of the entire lake bed (assume average 1m dredging depth).	Flooding improvements downstream through the township, as a result of more efficient flow from the lake through Tabourie Creek to the entrance.	Significant cost, difficulty in disposing of dredged material, only a temporary measure as deposition will continue over time. May need to be repeated regularly.
FM 3.2	Entrance Dredging	Dredging upstream of entrance (assume average 0.5m dredging depth).	Flooding improvements upstream through the township, as a result of better conveyance of flows through the entrance	Significant cost, difficulty in disposing of dredged material, only a temporary measure as deposition will continue over time. May need to be repeated regularly.
FM 3.3	Lemon Tree Creek Dredging	Dredging of Lemon Tree Creek (assume 0.6m dredging depth).	Reduction in peak flood levels along the creek in catchment driven flood events.	Significant cost, difficulty in disposing of dredged material, only a temporary measure as deposition will continue over time. May need to be repeated regularly.
Vegetation Management This option primarily focus on increasing capacity and efficiency of creeks through the removal of debris and invasive species				
FM 4.1	Lemon Tree Creek Vegetation Management	Clearing of debris and weeds within Lemon Tree Creek to improve conveyance.	A reduction in peak levels along the creek for catchment events, but is unlikely to improve ocean driven flooding.	Only temporary - would require ongoing maintenance to keep creek clear.

12.2.1 Preliminary Option Assessment

To test the feasibility of each of the hydraulically assessed structural options, they were first run for the 1% AEP event and the AEP event corresponding to the levee / road raising height to ensure they produced flood benefits and did not result in adverse flooding behaviour. The dredging options and vegetation management option were run for the 10% AEP event. The results of this analysis are summarised below in **Table 12-3**. The table summarises whether the option should be considered for further analysis (i.e. for all flood events). Impact plots for the options have been prepared for each option, and the figure numbers are shown in the table.

Table 12-3 Preliminary Options Assessment Outcome

ID	Assessment Outcome	Suitable for further assessment?	Impact Figure Number
FM 1.1 Princes Highway Creek Side Levee	Removal of flooding on protected properties in events up to the 5% AEP event. No impact on flood behaviour in larger events.	Yes	12-2
FM 1.2 Portland Way Levee	Removal of flooding on protected properties in events up to the 1% AEP event. No impact on flood behaviour in larger events.	Yes	12-3
FM 2.1 Caravan Park Road Raising	Reduction in road overtopping depths to 0.2m to allow emergency access in events up to the 1% AEP. There was no impact on flood behaviour.	*NA*	*No impacts*
FM 2.2 River and Lyra Road Raising	Removal of flooding on protected properties in events up to the 2% AEP event. There was a minor impact of 0.02m in the 2% and 1% AEP events upstream of the works, but the impact did not occur over properties.	Yes	12-4
FM 2.3 Beach and Bridge Street Raising	Removal of flooding on protected properties in events up to the 5% AEP event. Minor increases of 0.04m on properties in the 5% AEP event. Option would need to be implemented with FM 2.2 above to protect these properties from flood level increases	Yes	12-5
FM 2.4 Bridge and Centre Street Raising and flood levee construction	Removal of flooding on protected properties in events up to the 5% AEP event. Minor increases of 0.01m within the upstream creek. These impacts do not affect properties.	Yes	12-6
FM 2.5 Local Road Raising Combination	Removal of flooding across properties around Lemon Tree Creek in events up to the 5% AEP event. Some minor upstream and downstream impacts but these impacts do not impact properties.	Yes	12-7

ID	Assessment Outcome	Suitable for further assessment?	Impact Figure Number
FM 2.6 Princes Highway Raising	Increases of 0.03m observed for 400m along Brandaree Creek in the 1% AEP event which affect some properties along the north side of the Princes Highway. A 0.4m levee along the rear of these properties would protect them from these impacts.	No	12-8
FM 3.1 Lake Dredging	Dredging of the lake and upstream reaches of Tabourie Creek had no impact on peak flood levels	No	*No impacts*
FM 3.2 Entrance Dredging	Dredging of the entrance resulted in reduced peak water levels for ocean driven events. Reductions of 0.1m were observed immediately upstream of the entrance, but they did not benefit properties. The option had no benefits in catchment flood events.	No	*No impacts overall*
FM 3.3 Lemon Tree Creek Dredging	Upstream reductions of up to 0.1m in the 5% AEP event. Increased channel effectiveness in the 1% AEP with 0.01m reductions observed. However, these reductions do not benefit properties.	No	12-9
FM 4.1 Lemon Tree Creek Vegetation Management	Minor increases at confluence of Lemon Tree Creek and Tabourie Creek of 0.02m. No reductions were observed along the creek.	No	12-10

12.2.2 Environmental Considerations

According to State Environmental Planning Policy (SEPP) (Infrastructure) 2007, flood mitigation works "may be carried out by or on behalf of a public authority without consent on any land". These works include construction, routine maintenance and environmental management works which applies to most of the flood mitigation options in **Table 12-3**. Although consent is not required, most flood mitigation works will require further environmental assessment to ensure potential environmental impacts associated with the works are identified and, if necessary, appropriately managed.

The determining authority, in this case Shoalhaven Council, is required to "examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity" complying with Section 111 of the EP&A Act, most likely in the form of a Review of Environmental Factors.

When carrying out flood mitigation works, further permits, licenses and approvals may be required, such as:

- Flood mitigation works which extend into a water body will need an Environment Protection Licence complying with the Protection of the Environment Operations Act (POEO) 1997,
- Any removal of vegetation and debris in the water body may need a Threat Abatement Plan complying with the Fisheries Management Act 1999,
- A licence to harm threatened species, population or ecological community or damage habitat under the Fisheries Management Act 1999.

The environmental assessment undertaken in the Stage 1 report showed that potential acid sulfate soils are present along the creeks and their overbank areas. A number of options including dredging and levees will require works in these regions. There are also a number of aboriginal heritage items along Lemon Tree Creek that may affect the development of levee options in this area. These considerations have been addressed in the multi-criteria assessment (refer **Section 14**).

12.2.3 Impact of Structural Options of Entrance Management

As discussed in **Section 3.1**, the trigger level for the manual opening of the entrance is set to ensure that access is maintained between roads and properties. Some properties will experience inundation of their lot at the trigger level, but all residents will be able to move from their property to the roadways without interference.

Some of the structural option investigated to address flooding, also have an impact on the range of trigger levels that can be adopted. These options were designed to protect properties from flooding, but will also serve to protect them from elevated creek levels that may occur if a higher trigger level was adopted.

Summarised in **Table 12-4** are the maximum trigger levels that could be adopted if certain structural options were implemented. An inundation map for these levels is shown in **Figure 12-11**

The table shows that the construction of the Princes Hwy levee (Opt 1.1) would allow the trigger level to be raised to approximately 1.4m. While the levee would protect properties along the Princes Hwy from higher levels, any increases beyond this without further mitigation would result in properties along Oak Avenue and Beach Street being inundated due to elevated creek levels.

The construction of both the Princes Hwy levee (Opt 1.1) and the levee around Oaks Avenue (Opt 2.4) would allow the trigger level to potentially be raised as high as 2mAHD. This is approximately the level of 20% AEP event, which the levees were designed to protect properties against.

Figure 12-11 shows that should a trigger level of 2.0mAHD be desired, additional structural works would be required at two locations:

- The caravan park, to prevent inundation of existing caravan sites; and,
- The north side of the Princes Highway, adjacent to the bridge over Tabourie Creek, in order to prevent backwaters upstream of the bridge inundating the lots on the north side of the Princes Highway.

Table 12-4 Possible trigger levels resulting from structural options

ID	Option	Maximum Trigger Level
FM 1.1	Princes Highway Creek Side Levee	1.4m
FM 1.1 & FM 2.4 *	Princes Highway Creek Side Levee & Bridge and Centre Street Raising and flood levee construction	2.0m

* Note that the combination option, FM 2.5, would have the same result

12.2.4 Impact of Climate Change on Structural Modification Options

Climate change has the potential to reduce the effectiveness of structural options due to increased peak flood levels as a result of increased rainfall intensity and higher sea levels. Flooding under 2050 climate conditions for example predict that the 2050 5% AEP will be larger than the existing 1% AEP level. This change affects the structural options in two key ways:

- As peak flood levels rise, the level of protection offered by levees and road raising will be reduced. This means that a levee that provides 1% AEP protection in 2014 will provide less than 5% AEP protection in 2050.

- The damages arising from frequent events will increase. As noted above, the 5% AEP damages in 2050 are expected to be greater than the current 1% AEP event. Consequently, levees will provide a greater savings in damages in frequent events, which is where the greatest AAD costs arise.

The assessment of the effect of climate change on the economic feasibility of structural options is provided in **Section 13.5**.

12.3 Property Modification Options

A number of property modification options were identified for consideration in the Tabourie Lake floodplain. These options fall into two categories; those for which OEH support is available, and those which would be required to be implemented fully by Council.

- House Raising P 1
- Voluntary Purchase P 2

Details of the OEH grants are available online and may be downloaded from the following website: www.environment.nsw.gov.au/coasts/Floodgrants.htm

Additional property modification options that may be pursued by Council are:

- Building and Development controls P 3
- House Rebuilding P 4
- Land Swap P 5
- Council Redevelopment P 6
- Flood Proofing P 7

These options are discussed in detailed in the following sections.

12.3.1 P 1 – House Raising

As there are no properties which experience over floor flooding in the frequent events, and minimal numbers of properties in the mid-range AEP events, the cost of raising is significantly greater than the benefit achieved. Consequently, house raising is not considered a viable option for the Tabourie Lake area.

12.3.2 P 2 – Voluntary Purchase

As no properties were found to be within high hazard floodways, or affected by frequent flooding, voluntary purchase is not considered a viable option for the Tabourie Lake area.

It is noted that despite not experiencing overfloor flooding in frequent events, the childcare centre would still be a candidate for voluntary purchase (the property, not the business) due to the high risk nature of the occupants. However, to be eligible for voluntary purchase, the developed must have been approved before 1986. As the building was approved in 1991, it is not eligible for voluntary purchase.

12.3.3 P 3 – Building and Development Controls

The key document for flood related controls in the Shoalhaven LGA is Chapter G9 of DCP 2014. The following amendments have been recommended to this document:

- Buildings that serve a critical purpose or require special evacuation needs should be located outside of floodprone land.
- Evacuation plans to be required for developed in high risk areas. This has been undertaken for the Caravan Park. It is recommended that a similar plan be developed for the day care centre on River Road.

These recommendations are discussed in more detail in the Stage 1 Report (Cardno, 2013).

12.3.4 P 4 – House Rebuilding

As no properties were found to be flood affected in frequent evets, this option is not considered viable for the Tabourie Lake area.

12.3.5 P 5 – Land Swap

As no properties were found to be flood affected in frequent evets, this option is not considered viable for the Tabourie Lake area.

12.3.6 P 6 – Council Redevelopment

Under a Council redevelopment scheme, Council would purchase the worst affected properties, and would rezone and / or redevelop these properties in a flood compatible manner.

As discussed above, the childcare centre, while not subject to frequent over floor flooding, does contain a number of high risk occupants. Although the property is not eligible for voluntary purchase through the OEH scheme, Council are still able to purchase this lot outside of any OEH subsidies. It is noted that the purchase would only be for the building, not the business.

12.3.7 P 7 – Flood Proofing

Flood proofing involves undertaking structural changes and other procedures in order to reduce or eliminate the risk to life and property, and thus the damage caused by flooding. Flood proofing of buildings can be undertaken through a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding.

These include modifications or adjustments to building design, site location or placement of contents. Measures range from elevating or relocating, to the intentional flooding of parts of the building during a flood in order to equalise pressure on walls and prevent them from collapsing.

Examples of proofing measures include:

- All structural elements below the flood planning level constructed from flood compatible materials
- All structures must be designed and constructed to ensure structural integrity for immersion and impact of debris up to the 1% AEP flood event. If the structure is to be relied upon for shelter-in-place evacuation then structural integrity must be ensured up to the level of the PMF
- All electrical equipment, wiring, fuel lines or any other service pipes and connections must be waterproofed to the flood planning level

In addition to flood proofing measures that are implemented to protect a building, temporary / emergency flood proofing measures may be undertaken prior to or during a flood to protect the contents of the building. These measures are generally best applied to commercial properties. It is noted that there are 3 commercial properties that experience flooding in the 5% AEP event or greater.

These measures should be carried out according to a pre-arranged plan. These measures may include:

- Raising belongings by stacking them on shelves or taking them to a second storey of the building
- Secure / re-locate objects that are likely to float and cause damage
- Re-locate waste containers, chemical and poisons well over floor level

The SES business *Flash Flood Tool Kit* (SES, 2012) provides businesses with a template to create a flood-safe plan and to be prepared to implement flood proofing measures. It is recommended that this tool kit is distributed to the flood affected businesses within the Tabourie Lake floodplain.

12.3.8 Impact of Climate Change on Property Modification Options

The assessment undertaken of property modification options found that a number of options were not feasible given existing flooding conditions. As peak flood levels increase in the future due to increased rainfall intensity and higher sea levels, a number of these options may become feasible.

Under a 2050 climate change scenario for example, an additional 23 properties would be impacted by over floor flooding in the 5% AEP event. This increased affectation of properties would make a number of property modification options, such as house raising, rebuilding and voluntary purchase, substantially more feasible.

It is recommended that as changes to flood behaviour as a result of climate change become more apparent that these property modification options be revisited to determine if the criteria for feasibility discussed for the options has been met.

12.4 Emergency Response Modification Options

A number of emergency response modification options are suitable for consideration within the Tabourie Lake floodplain. These are:

- Information transfer to the SES — EM 1
- Preparation of Local Flood Plans and Update of DISPLAN — EM 2
- Flood warning system — EM 3
- Public awareness and education — EM 4
- Flood warning signs at critical locations — EM 5
- Local Evacuation Centres — EM 6
- Relocation of Childcare Facility — EM7a
- Prepare Flood Emergency Response Plan for Childcare Centre — EM7b

These options are discussed in detail below.

12.4.1 EM 1 – Information transfer to SES

The findings of the Flood Study and the Flood Risk Management Study and Plan provide an extremely useful data source for the State Emergency Service (SES). Details of the transfer of this information to the SES will be detailed in the Flood Emergency Plan, to be prepared as part of the next stage of the study.

12.4.2 EM 2 – Update of the Local Flood Plan and DISPLAN

This option would implement the updates and alterations to the Local Flood Plan and the DISPLAN. A review of the current emergency response arrangements in the study area, including a review of these documents, will be undertaken in the next stage of the study.

12.4.3 EM 3 – Flood Warning System

The critical duration for the Lake Tabourie system was found to be 9 hours. Shorter durations also resulted in significant flooding; the 6 hour duration typically resulted in peak levels within 0.1m of the 9 hour duration levels.

Presently there are no pluvio-stations in the upper catchment that could be used for flood warning. It should also be noted that gauges within the catchment will not be able to warn of ocean driven flood events. Depending on their location within the catchment, it would be expected that a warning time of around 6 hours could be provided for catchment flooding events if pluvio-stations are implemented in the upper catchment.

A more applicable system would be to utilise the existing water level gauge within Tabourie Creek to issue flood alerts when trigger levels are reached. This alternative is considered more applicable as the system would be suitable for both catchment and ocean driven flood events, and could make use of the existing gauge. Although the warning time would be approximately 1 hour, given the short distance required for local evacuation, this warning time is sufficient to allow people to safely make their way to a safe refuge prior to their lot being inundated.

It should be noted that even a 6 hour warning time will not allow sufficient time for residents to leave the township, as access along the Princes highway both north and south is likely to be cut during a flood event. The warning time should instead be used to move household items higher and to relocate to a flood free refuge within the township.

12.4.4 EM 4 – Public Awareness and Education

Flood awareness is an essential component of flood risk management for people residing in the floodplain. The affected community must be made aware, and remain aware, of their role in the overall floodplain management strategy for the area. This includes the defence of their property and evacuation, if required, during the flood event.

Flood awareness campaigns should be an ongoing process and requires the continuous effort of related organisations (e.g. Council and SES). The major factor determining the degree of awareness within the community is the frequency of moderate to large floods in the recent history of the area. The more recent and frequent the flooding, the greater the level of community awareness. The community consultation identified a high level of flood awareness within the community (Cardno, 2014). The consultation found that the community was relatively aware of flooding behaviour and the influence the entrance has on flood behaviour, but that an appreciation of how significant large flood events would be was lacking.

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

It is recommended that the following awareness campaigns be considered for the floodplain. These should be prepared together with the SES, as they have a responsibility for community awareness under the DISPLAN.

- Preparation of a FloodSafe brochure. Such a brochure with a fridge magnet may prove to be a more effective means of ensuring people retain information. Additional details on FloodSafe tools and resources is provided in **Section 11.3.1.1**.
- Development of a Schools Package from existing material developed by the SES and distribution to schools accordingly. Education is not only useful in educating the students, but can be useful in dissemination of information to the wider community. This option would require implementation with other floodplains as there are no primary or secondary schools within the township. Additional details on existing SES schools programs and possible initiatives are provided in **Section 11.3.3.1**.

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

Once prepared, the FloodSafe brochure can then be uploaded to the Council and SES websites in a suitable format, where it would be made available under the flood information sections of the website. The brochures could also be made available at Council offices and community halls.

Information dissemination is recommended to be included in Council rates notices for all affected properties on a regular basis. It is also recommended that an information package be distributed to new residents that contains a short letter from Council discussing the current flood management program, the flood safe documents, links to further information, and contact details of Council staff should they have any further queries or concerns. Council may already have a welcome package that they provide to new residents, which would provide an existing process that can be expanded to include flood related information.

12.4.5 EM 5 – Flood Warning Signs at Critical Locations

A number of public places in the catchment experience high hazard flooding in the 1% AEP event, namely:

- Caravan Park
- Tabourie Creek boardwalk
- Tabourie beach
- Local parks and open space along Tabourie Creek
- River Road / Centre Road over Saltwater Creek.

It is therefore important that appropriate flood warning signs are posted at these locations. These signs may contain information on flooding issues, or be depth gauges to inform residents of the flooding depth over roads and paths.

It is recommended that additional depth markers be installed at road crossings which are subject to inundation in frequent events. Depth markers are recommended at the low points on the Caravan Park access road, Centre Road, River Road and Beach Street.

12.4.6 EM 6 – Local Evacuation Centres

The evacuation centre listed in the Shoalhaven Flood Plan for Tabourie Lake is the Tabourie Motor Inn, located on the Princes Highway. As discussed in Section 10.1.2, the site is flood free, and suitable for those properties located east of Lemon Tree Creek.

However, early flooding of the bridge over Lemon Tree Creek results in those properties east of the creek being trapped during flood events. It is recommended than an alternative Local Evacuation Centre be designated for properties east of Lemon Tree Creek.

A possible site is the existing Rural Fire Service building at the end of Beach Road. This site is above the PMF flood level, and would be a site that would be easy for residents to recall during a flood event, as the RFS is already associated with emergency response.

Regardless of the alternative site chosen, residents should be made aware of the new site, and how it would be operated in a flood event.

12.4.7 EM7a – Relocation of Childcare Facility

As discussed in **Section 10.4.5** the Tabourie Childcare is subject to frequent flooding, with inundation occurring in the 20% AEP.

Given the frequency of inundation, and the high risk nature of the people present (young children) it is recommended that the centre be relocated to an alternative site. The site should be free of flooding in events up to and including the PMF, and be located west of Lemon Tree Creek, so that access to the centre is not lost during flood events.

12.4.8 EM7b – Prepare Flood Emergency Response Plan for Childcare Facility

While an alternative site for the childcare centre is being investigated, a Flood Emergency Response Plan should be prepared for the site to ensure that appropriate actions are taken in case of a flood event. The Princes Highway is adjacent to the site, and provides flood free access in the 1% AEP event and rising road access in the PMF to a high, flood free region at the local shops, 600m north of the site.

This plan should be communicated to parents so that they are aware of where their children will be during a flood event, and to also prevent parents from entering floodwaters in an attempt to reach their children.

12.5 Data Collection Strategies

It is recommended that a process be developed and implemented for the standardised collection of post flood data. In addition to this, it is recommended that the data collected be expanded to create information that will help the community to better understand the flood event and general catchment flood behaviour. This may include the collection / determination of data such as:

- The approximate recurrence internal of the rainfall intensity and peak river / creek flows;
- The approximate recurrence interval of any major over ground flooding;
- A comparison of the storm event with previous historical events and design events. Comparison could be made against rainfall, flows or depths;
- Timings of peak flows or levels; and,
- The timing and duration of road overtopping / closures.

Following the development of the post-flood collection strategy, a post-flood information mail-out should be developed to pass this information on to the community. The purpose of presenting this data to the community is to allow them to relate their recent flood experience to other historical events and to design events.

Being able to compare their recent flood experience with predicted flows and levels from a 2% or 1% AEP event, would give them a greater understanding of what such an event would look like, and what would be required for them to be safe in such an event.

12.6 Review of Entrance Management Policy

Council has adopted an Entrance Management Plan for the Tabourie Creek entrance (refer **Section 3.1**). This Policy, prepared in 2005 set the currently adopted trigger level of 1.17m for the artificial opening of the entrance.

As a result of the implementation of some of the structural options, namely the levees and the road raising (refer **Section 12.2.3**) and the ongoing impacts from sea level rise as a result of climate change (refer **Section 5.3.4**), alternative entrance policies may be warranted in the future.

It is recommended that the Entrance Management Policy be reviewed to take these factors into account. The current policy was prepared before Council adopted the current sea level rise benchmarks, and it would be useful to incorporate this into the Entrance Management Policy.

13 Economic Assessment of Options

It is possible to quantitatively assess the economic benefits of some of the options, namely those that were hydraulically modelled, and those with known benefits. For those options, a benefit-cost ratio can be calculated.

13.1 Preliminary Costing of Options

Cost estimates were prepared for those options which allow for an economic assessment. A summary of these estimated capital costs are provided in **Table 13-1**. Details of these costings are provided in **Appendix E**. Note that the caravan park and Princes Highway road raising options were not assessed as they do not have an impact on property damages.

For other options, broad estimates were made for the purpose of comparison in the multi-criteria assessment. These are detailed in **Section 14**.

Prior to an option proceeding, it is recommended that in addition to detailed analysis and design of the option, that these costs be revised prior to budget allocation to allow for a more accurate assessment of the overall cost. Detailed rates and quantities will also be required at the detailed design phase.

Table 13-1 Costs of Quantitatively Assessed Options

Option ID	Option	Capital Cost ($)	Ongoing Costs ($)
FM 1.1	Princes Highway Creek Side Levee	580,300	2,000
FM 1.2	Portland Way Levee	174,400	2,500
FM 2.2	River and Lyra Road Raising	515,100	1,500
FM 2.3	Beach and Bridge Street Raising	524,600	2,000
FM 2.4	Bridge and Centre Street Raising with levee	927,500	2,000
FM 2.5	Combination of 2.2, 2.3 and 2.4	1,631,900	5,000

13.2 Average Annual Damage for Quantitatively Assessed Options

The total damage costs were evaluated for each of the options assessed by hydraulic modelling (quantitative assessment). The average annual damage (AAD) for each of the options is shown comparatively against the existing case in **Table 13-2**.

The results in **Table 13-2** show that the most effective option in reducing damages was the combination of levees and road raisings (FM 2.5), closely followed by the raising of Bridge and Centre Streets (FM 2.4). The construction of the levee along the rear of Princes Highway properties (FM 1.1) also resulted in a relatively high reduction in flood damages.

Whilst the AAD is reduced to various degrees for different options, this reduction needs to be offset against the capital and recurrent costs of the option. This is discussed in **Section 13.3**.

Table 13-2 Average Annual Damage for Quantitatively Assessed Options

Option ID	Option	AAD ($)	Reduction In AAD Due to Option ($)
Existing	Existing Scenario	593,441	-
FM 1.1	Princes Highway Creek Side Levee	531,108	62,333
FM 1.2	Portland Way Levee	588,048	5,393
FM 2.2	River and Lyra Road Raising	591,054	2,387
FM 2.3	Beach and Bridge Street Raising	592,452	989
FM 2.4	Bridge and Centre Street Raising with levee	515,969	77,472
FM 2.5	Combination of 2.2, 2.3 and 2.4	514,980	78,461

13.3 Benefit Cost Ratio of Options

The economic evaluation of each modelled option was assessed by considering the reduction in the amount of flood damage incurred by various events and comparing this value with the cost of implementing the option.

The existing condition (or the ‘do nothing’ option) was used as the base case to compare the performance of modelled options. The PMF, 1% AEP, 2% AEP 5%AEP, 10% AEP, 20% AEP and 50% AEP events were considered for this evaluation. Preliminary costs of each option were prepared and a benefit-cost analysis of each option was undertaken on a purely economic basis (i.e. no assessment of social or environmental benefits and impacts).

Table 13-3 summarises the overall economics for each option that was able to be economically assessed. The indicator adopted to rank options on economic merit is the benefit-cost ratio (B/C).

The B/C ratio compares damage savings from an option to option construction and maintenance costs:

- Where the B/C is greater than 1 the economic benefits are greater than the implementation costs.
- Where the B/C is less than 1 but greater than 0, there is still an economic benefit from implementing the option but the cost of implementing the option is greater than the economic benefit.
- Where the B/C is equal to zero, there is no economic benefit from implementing the option.
- Where the B/C is less than zero, there is a negative economic impact of implementing the option.

Table 13-3 Summary of Economic Assessment of Management Options

Option	AAD	Reduction in AAD	NPW of Benefit *	Capital Cost	Recurrent Cost	NPW of Option *	B/C Ratio	Rank
FM 1.1	531,108	62,333	$860,242	580,300	2,000	$607,901	1.4	1
FM 1.2	588,048	5,393	$74,427	174,400	2,500	$208,902	0.4	4
FM 2.2	591,054	2,387	$32,942	515,100	1,500	$535,801	0.1	5
FM 2.3	592,452	989	$13,649	524,600	2,000	$552,201	0.0	6
FM 2.4	515,969	77,472	$1,069,171	927,500	2,000	$955,101	1.3	2
FM 2.5	514,980	78,461	$1,082,820	1,631,900	5,000	$1,700,904	0.6	3

***** NPW – Net Present Worth is calculated using 7% interest over 50yrs.

There were two options that realised a B/C ratio greater than 1, namely FM 1.1 (Princes Highway levee) and FM 2.4 (Bridge and Centre Street raising). FM 2.5 (combination of FM 2.3, 2.4 and 2.5) was close to breaking even on benefits and costs with a B/C ratio of 0.7. The remaining options had B/C ratios less than 0.5.

The options with a high B/C ratio tended to be those that removed or reduced flooding in frequent events. The less effective options tended to focus on flooding that occurred in larger events. Those options with B/C ratio less than 1 may provide other benefits associated with flood risk to life. These benefits have been assessed in **Section 14** for all options.

13.4 Benefit / Cost of Increasing Levee Heights

The heights of levees and roads in the options assessed were set to protect properties from frequent flooding. Higher levees and roads to protect properties in larger flood events create a number of design issues:

- A greater visual impact
- A greater impact on flood behaviour in larger events
- Greater difficulty in tying raised road levels into existing roads and driveways.

Within the Tabourie Lake study area, it was found that the levees did not result in significant offsite impacts. This is likely due to the significant storage volume available in Lake Tabourie, so the minor loss of storage behind the levees does not impact peak flood levels.

Given that higher levees do not significantly impact peak flood levels, the benefits and costs of increasing the levee heights to the 1% AEP were assessed. This required a typical raise of 0.15m to 0.25m over the previous levee height. This was done only for FM 2.5 (listed below as FM 2.5a). FM 2.2, FM 2.3 and FM 2.4 were not assessed individually as raising the levees and roads for single options resulted in minor flood level increases on adjacent properties.

The results of this assessment are shown in **Table 13-4**. The impact plot is shown in **Figure 13-1**.

It can be seen that providing protection to the 1% AEP event resulted in a benefit cost ratio greater than 1. This was due a significant increase in benefits, for a minor increase in costs, due to the peak levels in the 5%, 2% and 1% being generally within 0.2m. Option FM2.5a has therefore been included in the options assessment in **Section 6**.

Table 13-4 Summary of Economic Assessment of Management Options with Increased Levee Height

Option	AAD	Reduction in AAD	NPW of Benefit *	Capital Cost	Recurrent Cost	NPW of Option *	B/C Ratio	Rank
FM 1.1	531,108	62,333	$860,242	580,300	2,000	$601,488	1.4	2
FM 1.2	550,455	5,393	$74,427	174,400	2,500	$200,885	0.4	5
FM 2.2	553,461	2,387	$32,942	515,100	1,500	$530,991	0.1	6
FM 2.3	554,859	989	$13,649	524,600	2,000	$545,788	0.0	7
FM 2.4	478,376	77,472	$1,069,171	927,500	2,000	$948,688	1.3	3
FM 2.5	477,387	78,461	$1,082,820	1,631,900	5,000	$1,684,870	0.6	4
FM 2.5a	388,521	204,920	$2,828,049	1,903,600	5,000	$1,972,604	1.4	1

***** NPW – Net Present Worth is calculated using 7% interest over 50yrs.

13.5 Impact of Climate Change on Option Feasibility

As discussed in **Section 12.2.4** climate change has the potential to both reduce the level of protection of structural mitigation options and increase the damage savings in frequent events. Given this future uncertainty, the 50 year design life assumed for structural options in the above assessment may not be realistic.

In order to better reflect the likelihood of future flooding changes, the benefit cost assessment was repeated, but for a design life of 20 years. Beyond this horizon, it is likely that the performance of the structural options will begin to be impacted by altered climate conditions. The results of this assessment are shown in **Table 13-5**.

It can be seen that the reduced design life of the structural option impacts their B/C ratio. Only FM 1.1 and FM2.5a have a ratio above 1, while FM 2.4 has a B/C ratio of 0.9. The other options have significantly higher costs than benefits.

The assessment suggest that options FM 1.1, FM 2.4 and FM 2.5a are still worth considering as part of the Floodplain Risk Management Plan as they are cost effective over the medium term.

Table 13-5 Summary of Economic Assessment of Management Options for a 20 year Design Life

Option	AAD	Reduction in AAD	NPW of Benefit *	Capital Cost	Recurrent Cost	NPW of Option *	B/C Ratio	Rank
FM 1.1	531,108	62,333	$660,357	580,300	2,000	$601,488	1.1	2
FM 1.2	550,455	5,393	$57,134	174,400	2,500	$200,885	0.3	5
FM 2.2	553,461	2,387	$25,288	515,100	1,500	$530,991	0.0	6
FM 2.3	554,859	989	$10,477	524,600	2,000	$545,788	0.0	7
FM 2.4	478,376	77,472	$820,739	927,500	2,000	$948,688	0.9	3
FM 2.5	477,387	78,461	$831,217	1,631,900	5,000	$1,684,870	0.5	4
FM 2.5a	388,521	204,920	$2,170,925	1,903,600	5,000	$1,956,570	1.1	1

14 Multi-Criteria Matrix Assessment

A multi-criteria matrix assessment approach was adopted for the comparative assessment of all options identified using a similar approach to that recommended in the *Floodplain Development Manual* (2005). This approach to assessing the merits of various options uses a subjective scoring system. The principle merits of such a system are that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute "right" answer as to what should be included in the plan and what should be omitted. Rather, it provides a method by which stakeholders can re-examine options and, if necessary, debate the relative scoring assigned.

Each option is given a score according to how well the option meets specific considerations. In order to keep the scoring simple a system was developed for each criterion as shown in **Table 14-1**.

14.1 Scoring System

A scoring system was devised to subjectively rank each option against a range of criteria given the background information on the nature of the catchment and floodplain as well as the community preferences. The scoring is based on a triple bottom line approach, incorporating economic, social and environmental criterion. The criterion and scoring system adopted is shown in **Table 14-1**, and includes:

Economic	Benefit cost ratio
	Capital and operating costs
	Reduction in risk to property
Social	Reduction in social disruption
	Reduction in risk to life
	Community acceptance
	Council support
Environmental	Fauna / Flora & Heritage constraints

14.1.1 Design Life for the Multi-Criteria Assessment

A design life of 20 years was adopted for the multi-criteria assessment to account for future uncertainty arising from climate change. The Tabourie Lake area is sensitive to future climatic conditions. As a result, the future performance of structural options will change, and property modifications such as house raising and re-building may become feasible as flood levels increase.

Consequently, a typical 50 year design life was not appropriate as it would not capture these changes.

A 20 year design life will allow the determination of risk reduction measures that are applicable and cost effective in the short to medium term.

Table 14-1 Details of Adopted Scoring System

Category	Category Weighting	Criteria	Criteria Weighting	Score				
				-2	-1	0	1	2
Economic	2	Benefit Cost Ratio	2	0 to 0.2	0.2 to 1	1	1 to 1.5	>1.5
		Capital and Operating Costs	1	Extreme >$2 million	High $500,000 - $2 million	Medium $200,000 - $500,000	Low $50,000 - $200,000	Very Low $10,000 - $50,000
		Reduction in Risk to Property [1]	1	Major increase in AAD (>$20,000)	Slight increase in AAD (<$20,000)	No Improvement	Slight decrease in AAD (<$20,000)	Major decrease in AAD ($>20,000)
Social	1	Reduction in Risk to Life	1	Widespread or significant increase in risk to life	Localise or slight increase in risk to life	No change in risk to life	Localised or slight reduction of risk to life	Widespread or significant reduction of risk to life
		Reduction in Social Disruption	1	Major increase in social disruption (road overtopping increased by >0.2m)	Slight increase in social disruption (road overtopping increased by <0.2m)	No change to social disruption	Slight reduction of social disruption (road overtopping reduced by <0.2m)	Major reduction of social disruption (road overtopping reduced by >0.2m)
		Council Support	1	Strong disagreement	Disagreement	Neutral/No response	Support	Strong support
		Community Support	1	Strong disagreement	Disagreement	Neutral/No response	Support	Strong support
		Compatible with Policies and Plans [2]	1	Completely incompatible	Slightly incompatible	Compatible	NA	NA
Environment	1	Surface Water Quality	1	Likely impacts to quality of catchment inflows or reduction in water exchange with ocean and freshwater inputs	Possible impacts to quality of catchment inflows or reduction in water exchange with ocean and freshwater inputs	No impacts on catchment inflows or water exchange with ocean and freshwater inputs	Possible improvements to quality of catchment inflows or increase in water exchange with ocean and freshwater inputs	Likely improvements to quality of catchment inflows or increase in water exchange with ocean and freshwater inputs
		Groundwater	1	Likely interception of groundwater flow contamination of groundwater quality during construction or after implementation	Possible interception of groundwater flow contamination of groundwater quality during construction or after implementation	No impact on groundwater flow or quality	Possible improvements to groundwater flow or quality	Likely improvements to groundwater flow or quality
		Fauna/Flora Impact[3]	1	Likely to impact on EECs, wetlands, seagrasses or large areas of vegetation. Restricts connectivity between areas of habitat and waterways	Possible impacts on EECs, wetlands, seagrasses or removal of isolated trees / vegetation. Restricts connectivity between degraded habitat and waterways	No impact	Restoration of small areas of habitat	Restoration of large areas of habitat
		Acid Sulfate Soils	1	Any work within Class 1 ASS area. Any excavation work within Class 2 ASS area. Excavation >1m within Class 3 ASS area. Excavation >2m within Class 4 ASS area.	Surface works within Class 2 ASS area. Excavation <1m or surface works within Class 3 ASS area. Excavation <2m or surface works within Class 4 ASS area.	Works not within areas identified as PASS	N/A	N/A
		Heritage [4]	1	Works within 10m of known heritage item(s)	Works within 30m of known heritage item(s)	No likely impact	N/A	N/A

[1] Values of likely AAD reduction assumed where actual assessment not undertaken

[2] The options have been assessed for the compatibility with Council policies and plans:

[3] Location of Endangered Ecological Communities (EECs) derived from AHA Ecological vegetation mapping (2008). Location of seagrasses derived from SCC (2012).

[4] Indigenous heritage items identified through AHIMS search.

14.2 Multi-Criteria Matrix Assessment

The assignment of each option with a score for each criterion is shown in its entirety in **Appendix F**. The score for each category (i.e. economic, environment and social) is determined by the score for each criterion, factored by a weighting as shown in **Table 14-1**.

The overall score for the option is then calculated by the weights for each of the categories.

It is noted that the economic category is given more weight than either the environment or social categories. This is due to the economic category being the most direct measure of both the effectiveness of the option on flooding as well as its affordability. Options that rank highly on environmental or social categories do not necessarily provide significant flooding benefits.

A rank based on the total score was calculated to identify those options with the greatest potential for implementation. The total scores and ranks are also shown in **Appendix F**.

Of the options investigated, the top three identified by the multi-criteria analysis were:

1. EM 1 Information transfer to SES
2. P 2 Building and development controls
3. EM 6 Local Evacuation Centre / P 1 LEP Update (equally ranked)

Of the structural options assessed, excluding the road raising options for emergency access only, the top three options identified by the multi-criteria analysis were:

1. FM 1.1 Princes Highway Levee
2. FM 2.5a Local levee and road raising combination with 1% AEP protection
3. FM 2.4 Bridge & Centre Street road raising with levee construction

The ranking of the options is proposed to be used as the basis for prioritising the components of the *Floodplain Risk Management Plan*. It must be emphasised that the scoring shown in **Appendix F** is not “absolute” and the proposed scoring and weighting should be reviewed at regular intervals to ensure they are still representative.

15 Floodplain Risk Management Plan

A Floodplain Management Plan has been prepared to present the outcomes of the Floodplain Risk Management Study. The Plan describes how the land in the study area is to be used and managed to meet the defined objectives of the Floodplain Risk Management Study. The Plan includes a summary discussion of:

- The existing danger and potential damages to both private and public assets,
- How the proposed measures (structural and non-structural, including planning controls) would reduce the flood risk,
- The type of development that is commensurate with the future estimated flood risk.

The Plan also provides a concise description and discussion of the flood hazard and problems, proposed mitigation measures, estimated costs, priority and management plan for the study area and sources of funding.

The key elements of the Floodplain Risk Management Plan include:

- **An implementation strategy** that provides an outline sequencing of the various structural and non-structural measures included highlighting both the measures priority and opportunity for implementation. Opportunities for funding of the structural measures and staging of works to meet Council's budget constraints.
- **A flood emergency management model** that includes flood extent/hazard maps at specific flood height increments. The maps identify buildings that are inundated and the stage when evacuation routes are disrupted.
- **Property Flood Information Database** that provides individual flood data for each property within the floodplain.
- **A Flood Awareness Education Program** based on the recommendations of this Floodplain Risk Management Study.

16 Conclusions

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Tabourie Lake Township.

Flooding in the Tabourie Lake Township can pose a hazard to some residents and properties near creeks and overland flowpaths. The purpose of this study was to identify and examine options for the management of flooding within the Tabourie Lake catchment.

An assessment was undertaken on the number of properties to be affected under different frequency storm events and the appropriate economic damage for that event. Table 16-1 summarises these results.

Table 16-1 Flood affected properties and damages under existing conditions

Flood Event	Properties with Over Floor flooding	Properties with Over Ground flooding	Flood Damage
50% AEP	0	0	$ 0
20% AEP	2	21	$ 214,653
5% AEP	12	60	$ 1,190,980
2% AEP	41	120	$ 3,346,099
1% AEP	42	121	$ 3,352,211
PMF	176	194	$17,224,924
Average Annual Damage			**$ 342,114**

Options to reduce or manage the effects of flooding in the catchment were investigated, and recommendations of a mix of strategies to manage the risks of flooding were developed.

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

These options included:

- Flood modification measures
- Property modification measures
- Emergency response measures

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social). Hydraulic modelling of some of the flood modification options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure.

The assessment resulted in a ranking for each option to allow for the development of an implementation strategy to be developed as part of the Floodplain Risk Management Plan. The assessment found, of the all the options investigated (including flood, property and emergency measures), the top three identified by the multi-criteria analysis were:

1. EM 1 Information transfer to SES
2. P 2 Building and development controls
3. EM 6 Local Evacuation Centre

Of the structural options assessed, excluding the road raising options for emergency access only, the top three options identified by the multi-criteria analysis were:

1. FM 2.5a Local levee and road raising combination with 1% AEP protection
2. FM 1.1 Princes Highway Levee
3. FM 2.4 Bridge & Centre Street road raising with levee construction

17 Qualifications

This report has been prepared by Cardno for Shoalhaven City Council and as such should not be used by a third party without proper reference.

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

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

The report relies on the accuracy of the survey data and pit and pipe date provided.

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

18 References

ABS. (2011, May). Retrieved September 2, 2011, from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6302.0May%202011?OpenDocument

Andreescu, & Frost. (1998, February). Weather and traffic accidents in Montreal, Canada. *Climate Research 9*, pp. 225-230.

Andrey, Y. (1993). A temproal analysis of rain-related crash risk. *Accident Analysis and Prevention 25*, 465-472.

Bewsher Consulting. (2008). *Caravan Park Flood Safety Study.* Epping, NSW: Bewsher Consulting Pty Ltd.

BMT WBM. (2010). *Tabourie Lake Flood Study.* Broadmeadow, NSW: BMT WBM.

Cardno. (1998). *Wollongong Floodplain Management Study.* Sydney: Cardno.

Cardno. (2014). *Tabourie Lake FRSMP: Delft3D Verification Report.* St Leonards: Cardno (for Shoalhaven City Council).

Haines & Thom (2014). Climate change impacts on entrance processes of intermittently open/closed coastal lagoons in NSW Australia. *Journal of Coastal Research 50,* 242-246.

Jung, Qin, & Noyce. (2009). Rainfall effect on single vehicle crash severities using polychotomous response models. *Accident Analysis and Prevention 42*, 213-224.

MacDonald International. (2010). *Evacuation Plan: Lake Tabourie Tourist Park.* Nowra, NSW: MacDonald International.

NSW Government. (2005). *Floodplain Development Manual.* Sydney: NSW Government.

NSW Government. (2005). *Floodplain management Guideline No4, Residential Flood Damage Calculation.* Sydney: DIPNR.

NSW Government. (2013). *Standard Instrument Local Environmental Plan (LEP) Program*. Retrieved 08 01, 2013, from Planning and Infrastructure: http://www.planning.nsw.gov.au/LocalPlanning/StandardInstrument/tabid/247/language/en-AU/Default.aspx

NSW Government. (2013). *Standard Instrument Local Environmental Plan (LEP) Program*. Retrieved 08 01, 2013, from Planning and Infrastructure: http://www.planning.nsw.gov.au/LocalPlanning/StandardInstrument/tabid/247/language/en-AU/Default.aspx

Peter Spurway & Associates Pty Ltd. (2005). *Tabourie Lake Entrance Management Policy & Review of Environmental Factors (Final Draft).* Bingi, NSW: Peter Spurway & Associates Pty Ltd.

SES. (2004). *Shoalhaven City Local Flood Plan: A Sub-Plan of the Shoalhaven Local Disaster Plan.* SES: Shoalhaven City.

SES. (2012, 01 09). *Business Flood Safe Toolkit*. Retrieved 01 09, 2012, from NSW State Emergency Service: http://www.ses.nsw.gov.au/community-safety/floodsafe/bus-floodsafe/about

Shoalhaven City Council. (2012). *Tabourie Lake: Revised Estuary Management Plan.* Nowra, NSW: Shoalhaven City Council.

Water Studies Pty Ltd. (1992). *User Manual: FLDamage.* Water Studies Pty Ltd.

Webb McKeown & Associates. (2008). *Lower Shoalhaven River Flood Study.* WMA.

WMAwater. (2011). *Lower Shoalhaven RIcer Floodplain Management Study and Plan: Climate Change Assessment.*