Nowra and Browns Creeks

Floodplain Risk Management Study

W4959

Prepared for
Shoalhaven City Council

April 2016

Shoalhaven City Council

Cardno
Shaping the Future

Document Information

Prepared for	Shoalhaven City Council
Project Name	Floodplain Risk Management Study
File Reference	W4959 R002 v4 FRMS.docx
Job Reference	W4959
Date	April 2016

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Document Control

Version	Date	Author	Author Initials	Reviewer	Reviewer Initials
1	10 Jun 2015	Luke Evans Sabina Lohani	LE SL	Kieran Geraghty	KG
2	11 Aug 2015	Sabina Lohani	SL	Luke Evans	LE
3	11 Sep 2015	Sabina Lohani	SL	Luke Evans	LE
4	01 Apr 2016	Sabina Lohani	SL	Luke Evans	LE

Executive Summary

Shoalhaven City Council have commissioned Cardno to undertake a Floodplain Risk Management Study for the South Nowra area and its surrounds.

Browns Creek is a major tributary of Nowra Creek and flows in a northerly direction east of the Princes Highway. It joins Nowra Creek near the intersection of the Princes Highway and Hillcrest Avenue.

The combined catchment of Nowra and Browns Creeks has an area of approximately 20km^2.

Existing elevation in the upper catchment is 190m AHD (approx.) and terrain varies from 1 in 6 in the upper catchment to a much shallower gradient of 1 in 100 in the lower part of the catchment.

Land use in the catchment varies with rural bushland, forested areas and pasture land in the upper part of the catchment, industrial and commercial land use through South Nowra and includes the western part of Nowra CBD near the Shoalhaven River.

In addition to the main creeks a number of significant overland flowpaths have been identified within the study area and result in flood risk outside of the main floodplain. Typically overland flowpath names were not available and naming has been assigned based on nearby landmarks such as road crossings.

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 ($)
20% AEP	0	13	$82,606
10% AEP	1	16	$299,818
5% AEP	3	19	$1,134,374
2% AEP	7	31	$2,005,763
1% AEP	11	47	$3,291,895
0.2% AEP	29	80	$9,548,839
PMF	144	206	$35,407,925
Average Annual Damage			$224,886

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 (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. P 2 Building and Development Controls
2. P 1 LEP Update
3. P 8 Flood Proofing Guidelines

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. Opt 1 Vegetation Management
2. Opt 5 Industrial precinct drainage with upstream basins
3. Opt 3 Upstream Basins

This ranking 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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1 Introduction

Shoalhaven City Council is responsible for local planning and land management in the Nowra and Browns Creeks catchment. Council adopted the Nowra and Browns Creeks Catchment Flood Study on 31 January 2006 and uses this to inform development and planning decisions. Council has now commissioned Cardno to develop a floodplain risk management study and plan in accordance with the process outlined in the NSW Floodplain Development Manual.

1.1 Study Context

The NSW Government's Flood Prone Land Policy is directed at reducing the impact of flooding and flood liability on individual land owners and occupiers of flood prone property, and reducing private and public losses resulting from floods, utilising ecologically positive methods wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government. To facilitate this, the Government provides funding in support of floodplain management programs and has published the NSW "Floodplain Development Manual – the management of flood liable land" (NSW Government, April 2005) (the Manual), to provide guidance to Councils in the implementation of the Policy. The Manual describes a floodplain management process comprising the following sequential stages, which are reiterated as required:

1.	Data Collection	Compilation of existing data and collection of additional data.
2.	Flood Study	Defines the nature and extent of the flood problem for the full range of flood events.
3.	Floodplain Risk Management Study	Evaluates management options for the floodplain in consideration of social, ecological and economic factors.
4.	Floodplain Risk Management Plan	Involves formal adoption by Council of preferred options following public comment.
5.	Implementation of the Plan	Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, education, flood readiness and response plans, environmental rehabilitation, ongoing data collection and monitoring).
6.	Review of Plan	Review of plan to ensure it remains current and appropriate. A review is normally carried out after 10 years.

This report addresses Stage 3 of the process.

1.2 Study Objectives

The overall objective of this study is to develop a Floodplain Risk Management Plan for the study area that address the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy, as detailed in the *Development Manual: the Management of Flood Liable Land* (NSW Government, 2005).

The assessment has been undertaken in two phases:

- Phase I - floodplain risk management study in which the floodplain management issues confronting the study area were assessed, management options investigated and recommendations made.
- Phase II – floodplain risk management plan developed from the floodplain risk management study with recommendations for how flood prone land within the study area should be managed.

2 Catchment Description

The town of Nowra is located on the Shoalhaven River approximately 160km south of Sydney on the NSW South Coast. Nowra Creek is a tributary of the Shoalhaven River and begins approximately 12km south of Nowra and flows in a northerly direction.

Browns Creek is a major tributary of Nowra Creek and flows in a northerly direction east of Princes Highway. It joins Nowra Creek near the intersection of Princes Highway and Hillcrest Avenue.

The combined catchment of Nowra and Browns Creeks has an area of approximately 20km^2.

Existing elevation in the upper catchment is 190m AHD (approx.) and terrain varies from 1 in 6 in the upper catchment to a much shallower gradient of 1 in 100 in the lower part of the catchment.

Land use in the catchment varies with rural bushland, forested areas and pasture land in the upper part of the catchment, industrial and commercial land use through South Nowra and includes the western part of Nowra CBD near the Shoalhaven River.

Significant flooding has occurred within the catchment including 1999, 1989, 1978 and 1974. The catchment area is shown in **Figure 2-1**.

3 Available Data

3.1 Previous Reports and Studies

A number of previous studies and assessments have been undertaken for the Nowra and Browns Creeks catchment. These studies have been reviewed and a summary is outlined in Table 3-1.

Table 3-1 Review of Previous Studies

Study	Description
Lower Shoalhaven River Floodplain Management Study and Plan, Climate Change Assessment (WMAwater, 2011)	This study comprised an amendment to the 2008 study to incorporate the predicted impacts of climate change. The study adopted NSW Government sea level rise estimates of 0.4m by 2050 and 0.9m by 2100, and increases in precipitation of 10%, 20% and 30% in line with DECCW Guidelines. Based on these values, the findings of the previous 2008 study were updated including planning levels, flood damages, flood mitigation options and evacuation procedures. This study provides information on climate change impacts on setting downstream tailwater levels in the hydraulic model for Nowra Creek.
Lower Shoalhaven River Floodplain Risk Management Study (Webb, McKeown & Associates, 2008)	The study built on the initial 1990 study, further investigating key flooding issues and possible solutions. The model incorporated the scenario with Shoalhaven Heads closed but scouring out as the flood progressed. Key issues identified included blockage at Shoalhaven Heads, evacuation access, urban development and expansion. An economic analysis was undertaken which estimated Average Annual Damage at $1.8m with 734 properties affected in the 100yr ARI event. A variety of management measures were discussed including flood modifications (basins, levees), property modifications (raising, voluntary purchase) and response modifications (evacuation planning). Property and emergency response initiatives were considered to be more applicable. While outside the Nowra and Browns Creeks catchment this report provides an overview of mitigation measures considered downstream of Nowra Bridge.

Study	Description
Lower Shoalhaven River Floodplain Risk Management Plan (Webb, McKeown & Associates, 2008)	The study outlines the preferred mitigation options, their benefits and how Council may implement these programs. Examples of the mitigation measures proposed include: ▪ Develop a post-flood evaluation and review program to further refine models; ▪ Implement stormwater management plan for local drainage flooding issues; and ▪ Finalise and implement Council's Shoalhaven River Entrance Management Plan for Flood Mitigation (EMPFM); and ▪ Update flood polices such as FPL's property set-backs and improve resident flood awareness.
Nowra and Browns Creeks Flood Study (Patterson Britton & Partners Pty Ltd, 2005)	The flood study identified existing flooding behaviour within the catchment and developed an XP-RAFTS hydrology model and RMA-2 hydraulic model. The study indicated both Nowra and Browns Creeks both have limited capacity resulting in breakout of flows from both over the existing floodplains. Recent flood events within the catchment have inundated roads resulting in some areas becoming isolated and impassable for several hours
Bridge Waterway Options at Central Avenue on Nowra Creek (Lyall & Associates, 2001)	This assessment investigated peak flows for a range of ARI events in the vicinity of Central Avenue bridge over Nowra Creek. It indicated the existing road would be inundated in events greater than 5 year ARI mainly due to a lack of hydraulic capacity in the channel. The bridge crossing has since been upgraded.
Nowra Creek at Whites Bridge on Albatross Road (Hyder Consulting, 2000)	This study assessed peak flood levels along Nowra Creek between Albatross Road and the Berry Street crossing. A RORB hydrologic model was developed and a HEC-RAS model of the existing creek based on surveyed cross sections. Results indicated the existing creek has the capacity to convey of a 5 year ARI storm event. This relatively low capacity is attributed to a small cross section area and low bridges and road embankments. This study highlights a constriction along the creek resulting in frequent overtopping and associated flooding.

Study	Description
Shoalhaven River Design Flood Profiles, Burrier to Nowra (NSW Public Works, 1995)	This assessment was an extension of the Lower Shoalhaven River Flood Study (1990) and determined peak flood levels for the 50 year, 100 year and PMF events for the River between Burrier and Nowra. Hydrology modelling was undertaken using WBNM with hydraulic modelling undertaken in MIKE-11. Peak flood levels were recorded for major flood events in 1974, 1975 and 1978 and were used to calibrate the MIKE-11 model. This study was an extension to the 1990 Flood Study and provides peak flood levels at the confluence of Nowra Creek and Shoalhaven River which assists in setting downstream tailwater conditions.
Flood Studies for South Nowra Industrial Estate and Nowra Creek (Lyall & Macoun Consulting Engineers ,1991)	This study identified options for controlling flood flows and measure for potential encroachment into the floodplain for an area of land within South Nowra Industrial Estate. Hydrology modelling was undertaken using RORB with hydraulic modelling undertaken using FPLAIN software. The assessment identified 100 year ARI flood levels along Nowra Creek. The report included information on historical flood marks although the models were not calibrated to known storm events. In addition, the report concluded that sections of Nowra Creek were heavily overgrown resulting in hydraulic inefficiencies and recommended channel clearance as a potential mitigation measure.
Lower Shoalhaven River Flood Study (Webb, McKeown & Associates, 1990)	The flood study for the region was undertaken in 1990 using the WBNM hydrological model, and the CELLS hydraulic model. The models were calibrated to yearly historical floods from 1974 – 1979 and the 1988 flood event. Results were provided for downstream conditions at Shoalhaven Heads for the 20 year, 50 year, 100 year and PMF events. Various levels were determined depending on whether the heads were open or closed.

3.2 Survey Information

Topographical information has been provided via ALS data undertaken in 2010 which covers the study area.

Survey information of creek cross sections and hydraulic structures within the study area is available from previous assessments undertaken and Council records. In addition, survey of Nowra Creek and key bridges and culverts was undertaken as part of the original flood study and this FRMS.

3.3 Geographic Information System Data

The following Geographic Information (GIS) Data was provided by Council for use as part of this assessment:

- Cadastre;
- Aerial photography;
- ALS data (2010) for the study area;
- Building extent polygons within Nowra;
- Watercourses within the study area;
- Stormwater network information including pit and pipe data; and
- Land use information, heritage, conservation and vegetation areas.

3.4 Site Inspection

A site visit and inspection of the catchment was undertaken on 8 June 2012 with Council and Office of Environment and Heritage (OEH) to identify key areas of interest within the catchment. Road crossings within the study area were inspected as they offered access to the main tributaries. In addition, the hydraulic structures associated with these crossings were a key concern with the modelling.

3.5 Stormwater Pit and Pipe Data

Council has provided all available data for pit and pipe assets within the study area. Upon review of this data it was found that:

- Key road crossing culverts observed during the site inspection that had no data available; and
- A significant portion of the pipes within the study area do not have invert levels recorded.

3.6 Historical Flood Information

The Nowra and Browns Creeks catchment has experienced a number of large flood events, namely 1974, 1978, 1989 and 1999. Flood level information was collected through a community survey undertaken as part of the Flood Study (2005). Information on the flood levels which occurred along Nowra Creek following the 1978 event was used to attempt to calibrate the hydraulic model. However, the reliability of the information was not adequate for verification purposes (Patterson Britton & Partners, 2005).

3.7 Historical Rainfall Data

No rainfall gauges exist within the study area. The locations of nearby rainfall gauges are indicated in Table 3-2. No stream flow gauges exist on either Nowra or Browns Creeks.

Table 3-2 Rainfall Gauges

Station Number	Station Name	Operational Period
068072	Nowra Royal Australian Navy AWS	2000 – present
068213	Nowra Boat Shed	1860 – present
068048	Nowra Treatment Works	1896 – present

3.8 Previous Modelling

3.8.1 Hydrological Modelling

The XP-RAFTS software package was used to estimate catchment runoff as part of the Flood Study (2005). A comprehensive review of the existing model was undertaken to assess the model parameters used and their suitability. Results showed general correlation between the model and the flood study report with the following minor exceptions:

- Minor differences in the % impervious applied to subcatchments between the design model and 1978 model resulting in slightly higher rainfall losses in the design model;
- Manning's n-value of 0.035 has been adopted for all pervious area and may be considered too smooth for some vegetated areas; and
- 12 hour temporal pattern adopted for 1978 event while report indicates 24 hour storm duration.

Complete results of the model review were included in the Stage 1 Report, Cardno (2012).

3.8.2 Hydraulic Modelling

Hydraulic modelling for the Flood Study (2005) was undertaken using Resource Management Associates (RMA-2) software. Cardno developed a 1D/2D hydraulic model for the study area using SOBEK and hence the existing model has not been reviewed.

Components of the existing hydraulic model that have been incorporated into the new model, such as roughness mapping, have been reviewed during establishment of the hydraulic model.

4 Consultation

4.1 Community Consultation

The community consultation undertaken as part of the FRMS has built on the consultation undertaken as part of the Flood Study (Patterson Britton & Partners, 2005). The purpose of the Flood Study consultation was to gather additional information of historical flooding in the study area.

The purpose of the more recent consultation undertaken as part of this FRMS was to inform the community about the study, identify community concerns and attitudes, to gather information from the community on potential options for the floodplain and to develop and maintain community confidence in the study results.

Community consultation was undertaken in three key phases over the course of the project:

- Resident Brochure Survey
- Community Forums
- Public Exhibition of Draft Flood Study

4.1.1 Resident Brochure and Survey

Community consultation was undertaken in October 2012. An information brochure and questionnaire were distributed to those property owners within the Nowra and Browns Creeks study area that would be subject to flooding in a Probable Maximum Flood (PMF) event. The brochure and questionnaire are included in **Appendix A**.

The brochure provided an outline of the floodplain risk management process and the objectives of the study. The survey sought information about historical flooding events and flood awareness within the community.

The brochure and questionnaire were delivered to approximately 210 property owners within the catchment area. From the distribution, 24 responses were received which represents a return of approximately 11% of direct distribution. Typical response rates for these types of surveys is in the order of 10% therefore this represents a reasonable return rate.

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

4.1.1.1 Time at Address

The resident survey enquired about the property type and length of time that residents have resided at their current address. A breakdown of property type is indicated in Table 4-1.

Table 4-1 Property Type

Property Type	Number
Residential – Owner Occupied	18
Residential – Occupied by Tenant	1
Business	4
Vacant Land	1

Of all respondents, 39% (9 respondents) have been residing at their address for less than 10 years, 22% (5 respondents) have lived at their address for between 10 to 20 years while 39% (9 respondents) have lived at their address for greater than 20 years.

Three out of four business owners that responded have been established at their current addresses for greater than 30 years.

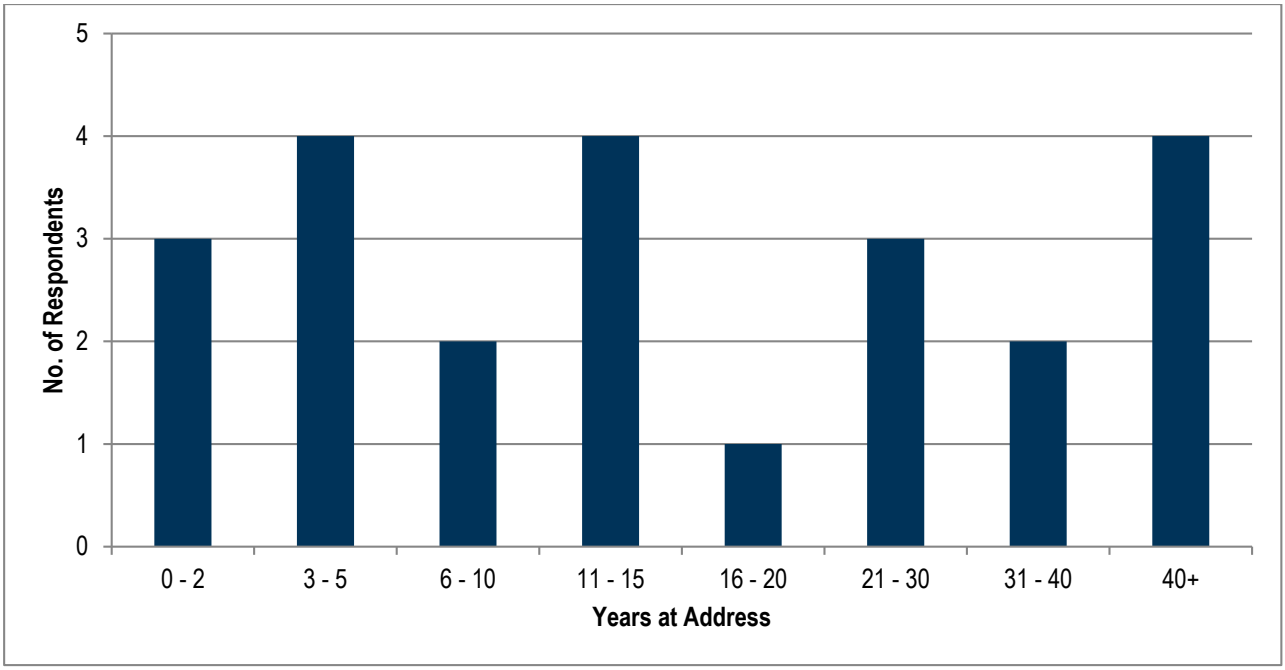

Figure 4-1 No. of Years at Address

4.1.1.2 Community Flood Experiences and Expectations

Respondents were asked to provide feedback on their previous flooding experiences and their expectation of future flooding conditions. Responses are outlined in Figure 4-2 and Figure 4-3 respectively.

Results show that 88% (21 respondents) experienced either direct flooding at their property or witnessed flooding in the study area in the past. No previous flooding experiences were reported by 12% (4 respondents).

Figure 4-3 indicates 58% of respondents expect to be directly affected by flooding at their property in the future.

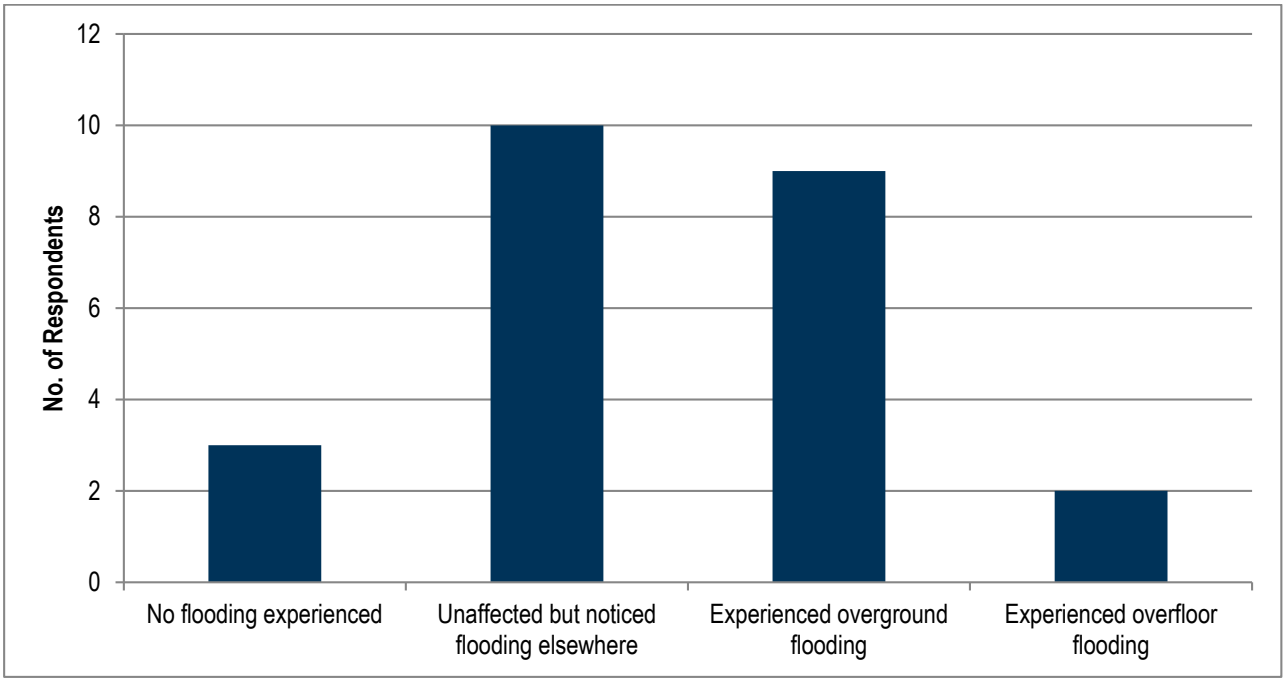

Figure 4-2 Historical Flooding Experiences

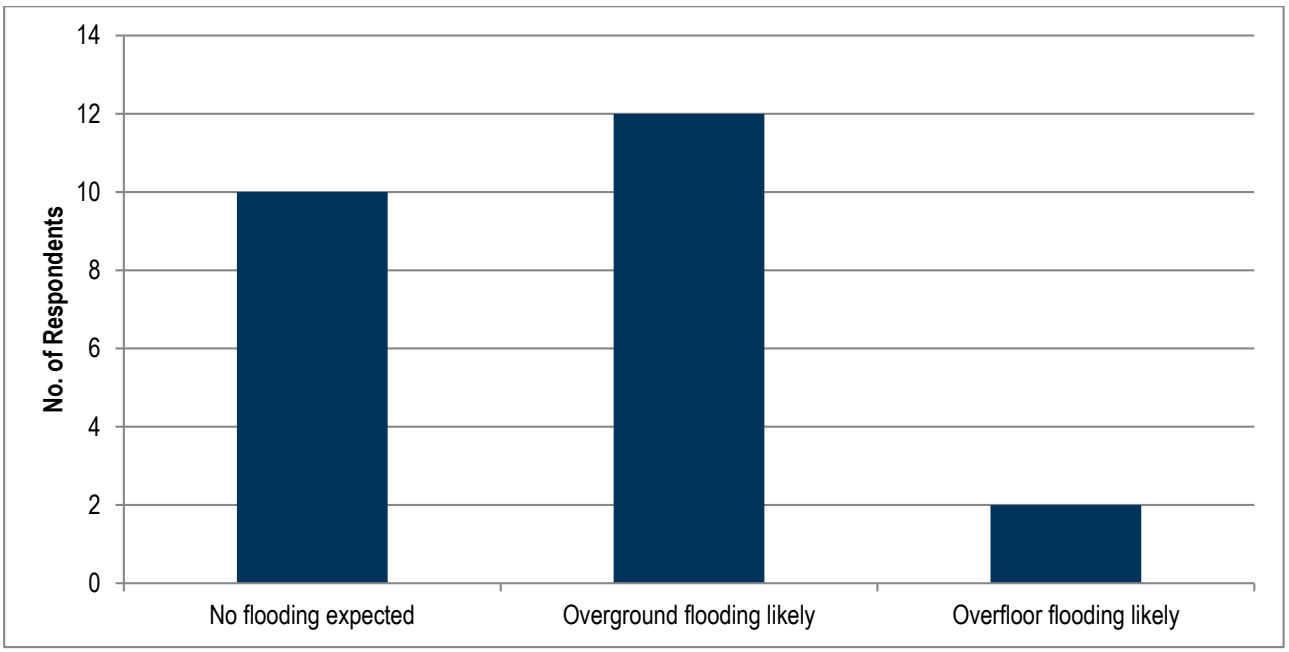

Figure 4-3 Expected Flooding Experiences

4.1.1.3 Preferred Community Communication Method

Ongoing communication and engagement with the community is an integral part of this study. Part of the questionnaire asked residents the best method for dissemination of flood related information. The results are shown below in Figure 4-4 and indicate a clear preference for mail outs with publications in the local newspaper and community meetings also ranking highly.

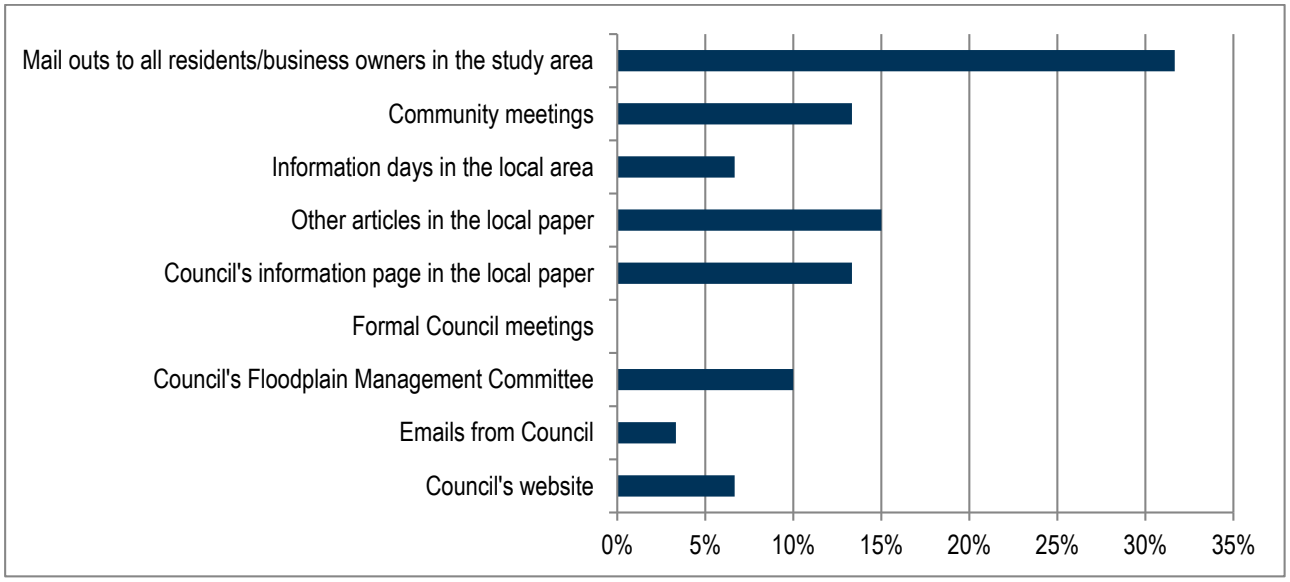

Figure 4-4 Preferred Community Communication Method

4.1.1.4 Community Preferred Flood Mitigation Options

Respondents were invited to provide feedback on their preferred flood mitigation options which are shown in Figure 4-5. Results indicate environmental channel improvements and improved flood flow paths were the most preferred options.

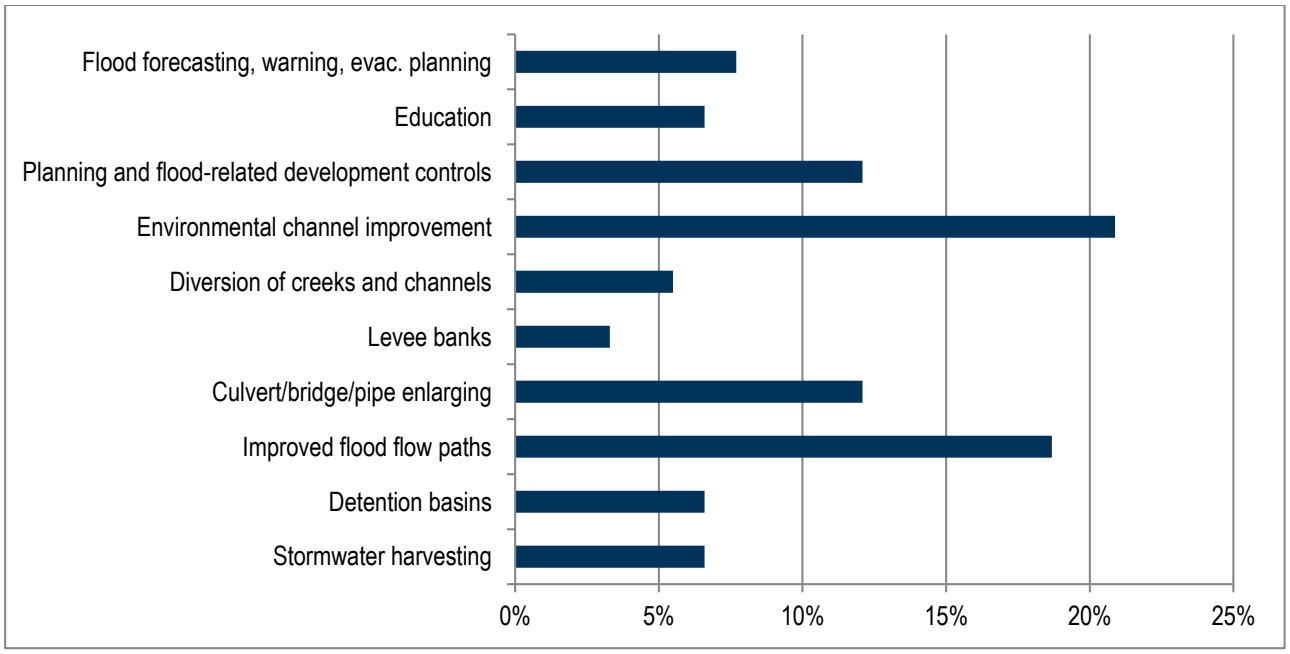

Figure 4-5 Community Preferred Flood Mitigation Options

4.1.2 Community Forums

As part of the Floodplain Risk Management Study and Plan, two community workshops were be held to present the findings of the study to residents, and to gather comments and feedback.

The first workshop was held at Council offices in Nowra on Wednesday, 29 October 2014. The workshop was undertaken to introduce the study to the community, and to hold a preliminary discussion on potential mitigation

The second workshop was held at the Council offices in Nowra on Monday, 23 March 2015. The workshop was undertaken to present to the community the results of mitigation option assessment. 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 community workshops included:

- A number of attendees commented on the loss of access along some roads. However, there was agreement that the flooding was typically of short duration and so the impact was minimal.
- There was a discussion on the various flooding mechanisms of the catchment (catchment and elevated Shoalhaven River flooding), and how individual options were capable of protecting the community from each flooding mechanism.

4.1.3 Public Exhibition Period

Following approval by the Committee, this Draft Floodplain Risk Management Study will be put on public exhibition for a minimum of four weeks. During the public exhibition period, the community and interested parties will be able to review the draft study and submit comments on the study and its outcomes. These submissions will then be considered in the finalisation of the FRMS.

5 Existing Flood Behaviour

5.1 Properties with Over floor Flooding

A detailed assessment of the flood damages and over floor flooding is provided in **Section 6** of this report. The results are summarised below in **Table 5.1**. Single storey dwellings have been highlighted, as these properties have limited opportunity for vertical evacuation. It is noted that almost all flood affected residential properties were single storey.

Table 5-1 Properties with Over floor Flooding

Flood Event (AEP)	Residential Properties		Commercial Properties	Industrial Properties
	Single Storey	Total Residential		
PMF	-	94	27	23
0.2%	8	9	10	10
1%	1	1	6	4
2%	1	1	3	3
5%	1	1	1	1
10%	0	0	1	0
20%	0	0	0	0

5.2 True Flood Hazard

Provisional flood hazard categorisation based around 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,
- Effective flood access.

In the catchment many of the above factors are not applicable in terms of affecting hazard identification. However, to provide a thorough assessment process, all of the above factors have been considered in this report, and are discussed in the following sections.

True flood hazard maps are provided for the 1% AEP event and the PMF event in **Figure 5-1** and **Figure 5-2**.

5.2.1 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.

5.2.2 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 duration storm for the developed regions of the study area is 2 hours. Some non-developed areas had longer critical durations of 3 hours and 6 hours. As these non-developed areas were zoned as environmental conservation areas, it is not expected that they would be developed in the future. As such, the 2 hour event was adopted to assess warning times across the whole catchment.

As such, the peak of the flow generally occurs at various locations within the catchment within 1 hour from the start of the rainfall. Therefore, there is little to no warning time throughout the study area.

However, it is noted that all areas within the study area were exposed to similar flood response times, and therefore it can be considered that no area within the catchment is any more at risk than another.

5.2.3 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. The latest flood event within the study area occurred in 1999. Based on the responses from the resident survey (refer **Section 4**) approximately 42% of respondents were living in the study area at the time of the 1999 flood event.

As there is no reason to suggest that a particular part of the catchment is likely to be any more prepared for a flood than another, flood readiness has not been considered in the preparation of hazard extents.

5.2.4 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 high hazard. However, 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 defining areas affected by true high hazard.

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

5.2.5 Depth and Velocity of Flood Waters

As outlined above, provisional hazard mapping is determined from a relationship between velocity and depth. 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 (2005). This provisional hazard mapping has been used as the base to determine true flood hazard.

5.2.6 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 were generally less than a couple of hours, even in the longer duration events. Those properties affected by longer periods of inundation were already selected by the provisional high hazard criteria.

5.2.7 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 due to a number of factors, including:

- The number of people requiring assistance,
- Mobility of those being evacuated,
- Time of day, and
- Lack of suitable evacuation equipment.

The duration of flooding in the catchment is relatively short, as noted above. Therefore, evacuation issues for the majority of the catchment were not considered to be an issue. The exception to this is for properties that experience over floor flooding in the 1% AEP and PMF events that do not have a second floor. This allows for limited opportunities for residents to escape the inundation within their properties. There were a total of 9 of these residential properties in the 1% AEP event and 94 in the PMF event.

These have not been included on the figures at this stage due to privacy reasons.

5.2.8 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.

For flooding experienced in the Nowra and Browns Creeks catchment, evacuation is generally not recommended. As such, effective flood access is not considered in the True Hazard mapping.

5.3 Hydraulic Categories

Hydraulic categorisation of the floodplain is used in the development of the Floodplain Risk Management Plan. The Floodplain Development Manual (2005) defines flood prone land to be one of the following three hydraulic categories:

- Floodway - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- Flood Storage - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it would result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- Flood Fringe - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area would not have any significant effect on the flood pattern or flood levels.

Floodways were determined for the 1% AEP event by considering those model branches that conveyed a significant portion of the total flow. These branches, if blocked or removed, would cause a significant redistribution of the flow. The criteria used to define the floodways are described below (based on Howells et al, 2003).

As a minimum, the floodway was assumed to follow the creekline from bank to bank. In addition, the following depth and velocity criteria were used to define a floodway:

- Velocity x Depth product must be greater than 0.25 m^2/s and velocity must be greater than 0.25 m/s; OR
- Velocity is greater than 1 m/s.

Flood storage was defined as those areas outside the floodway, which if completely filled would cause peak flood levels to increase by 0.1 m and/or would cause peak discharge anywhere to increase by more than 10%. The criteria were applied to the model results as described below.

Previous analysis of flood storage in 1D cross sections assumed that if the cross-sectional area is reduced such that 10% of the conveyance is lost, the criteria for flood storage would be satisfied To determine the limits of 10% conveyance in a cross-section, the depth was determined at which 10% of the flow was conveyed. This depth, averaged over several cross-sections, was found to be 0.2 m (Howells et al, 2003). Thus the criteria used to determine the flood storage is:

- Depth greater than 0.2m
- Not classified as floodway.

All areas that were not categorised as Floodway or Flood Storage, but still fell within the flood extent, where the depth is greater than 0.1 m, were represented as Flood Fringe.

Hydraulic categories for the 1% AEP and the PMF design events are shown in **Figure 5-3** and **Figure 5-4**.

6 Current Economic Impact of Flooding

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

Table 6-1 Types of Flood Damages

Type	Description
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 calculate 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, generic spread-sheets have been 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.

The damage analysis methodology is provided in **Appendix B**.

6.3 Results

The results from the damage analysis are shown in **Table 6-2**. Based on the analysis described above, the average annual damage for the study area under existing conditions is $224,886.

Table 6-2 Nowra & Browns Creek 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 ($)
PMF					
Residential	94	1.12	2.82	130	$ 8,423,375
Commercial	27	0.82	3.79	36	$ 15,810,490
Industrial	23	1.21	3.65	40	$ 11,174,060
PMF Total	**144**			**206**	**$ 35,407,925**
0.2% AEP					
Residential	9	0.38	0.81	33	$ 780,665
Commercial	10	0.61	1.93	25	$ 4,969,955
Industrial	10	0.59	1.15	22	$ 3,798,219
0.2% AEP Total	**29**			**80**	**$ 9,548,839**
1% AEP					
Residential	1	0.35	0.35	18	$ 115,101
Commercial	6	0.37	1.26	16	$ 1,756,434
Industrial	4	0.25	0.68	13	$ 1,420,360
1% AEP Total	**11**			**47**	**$ 3,291,895**
2% AEP					
Residential	1	0.24	0.24	10	$ 87,915
Commercial	3	0.38	1.02	13	$ 845,418
Industrial	3	0.20	0.46	8	$ 1,072,429
2% AEP Total	**7**			**31**	**$ 2,005,763**
5% AEP					
Residential	1	0.11	0.11	8	$ 78,151
Commercial	1	0.66	0.66	5	$ 533,738
Industrial	1	0.15	0.15	6	$ 522,486
5% AEP	**3**			**19**	**$ 1,134,374**
10% AEP					
Residential	0	-	-	6	$ 18,000
Commercial	1	0.20	0.20	5	$ 105,303
Industrial	0	-	-	5	$ 176,515
10% AEP Total	**1**			**16**	**$ 299,818**
20% AEP					
Residential	0	-	-	4	$ 12,000
Commercial	0	-	-	4	$ -
Industrial	0	-	-	5	$ 70,606
20% AEP Total	**0**			**13**	**$ 82,606**

7 Social Issues

Knowledge of the demographic character of an area assists in the preparation and evaluation of floodplain management options that were appropriate for the local community. For example, the data is relevant in the consideration of emergency response or evacuation procedures (e.g. information may need to be presented in a range of languages and special arrangements may need to be made for less mobile members of the community).

Demographic data for these suburbs was sourced primarily from the Australian Bureau of Statistics (ABS) 2011 Census for the Nowra Statistical Area (Level 2).

The demographic data for the Nowra area showed that:

- Over a third of people living in the Nowra and Browns Creeks catchments were aged between 20-49 years (refer **Table 7-1**). Furthermore, 75% of the population were aged below 60 years. This indicates that the community may be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures.
- English was the only language spoken in approximately 85% of homes in the Nowra and Browns Creeks catchments. The most common languages spoken at home other than English were Cantonese, Italian, Tagalog and Spanish. This suggests that language barriers (e.g. during evacuation, or for flood education), were unlikely to occur for the vast majority of the population (refer **Table 7-2**).
- The average median weekly income for individuals in the region was $1,960, compared to the NSW average of $561. This trend of well above average income for the region compared to the NSW average was also evident for family and household incomes (refer **Table 7-3**). This may have implications for the economic damages incurred on property contents during a flood event.
- In the catchments, the median house price is $291,437, and the unit price is $210,075 (refer **Table 7-4**). In NSW, the median house price is $440,000, and unit price is $445,000 (APM, 2012). This information has implications for the economic damages incurred during a flood event.

Table 7-1 Age Structure of Nowra

Age Group (Years)	Persons in Catchment	% of total persons in Catchment	% of total persons in NSW
0 - 9	1661	13%	13%
10 - 19	1685	13%	13%
20 - 29	1,752	13%	13%
31 - 39	1,499	11%	14%
40 - 49	1,688	13%	14%
50 - 59	1,673	13%	13%
60 +	3,218	24%	20%
TOTAL	**13,176**	**100%**	**100%**

Table 7-2 Languages Spoken at Home in Nowra (ABS, 2011)

Languages Spoken at Home	Number of People	% of total number of people	% of total homes in NSW
English Only	11,154	84.7	72.5
Cantonese	38	0.3	2.0
Italian	25	0.2	1.4
Tagalog	24	0.2	0.4
Spanish	30	0.2	0.5
Mandarin	17	0.1	1.6
Turkish	6	0.05	0.3
German	14	0.1	0.3
Greek	5	0.04	1.3
Dutch	6	0.05	0.1
Hungarian	4	0.03	0.1
Macedonian	3	0.02	0.4
French	3	0.02	0.3
Maltese	3	0.02	0.3

Table 7-3 Average Weekly Income for People over 15 years (ABS, 2011)

Income (For Population Aged 15 Years and Over)	Catchments	New South Wales
Average Median Individual Income (weekly)	$1,960	$561
Average Median Family Income (weekly)	$4,772	$1,477
Average Median Household Income (weekly)	$4,230	$1,237

Table 7-4 Dwelling Structure in Nowra (ABS, 2011)

Suburb	Median House Price	Median Unit Price
Nowra	$267,000	$166,400
South Nowra	$336,750	$253,750
West Nowra	$277,000	Not Available
Nowra Hill	$285,000	Not Available
Average for Catchment	**$291,437**	**$210,075**

8 Environmental Issues

8.1 Topography, Geology & Soils

8.1.1 Topography

Ridges and highpoints were the dominant landform characteristics of Nowra. The study area lies at the southern end of the Sydney Basin and its urban areas were located between the Shoalhaven Coastal Flood Plain to the east and Nowra Creek to the west. In general, land within the outer Nowra area slopes towards the eastern flood plain and the Shoalhaven River to the north. Significantly steeper terrain lies to the west of Nowra CBD towards Nowra Creek (Arup, 2011).

8.1.2 Geology

When developing floodplain risk management options it is important to understand the geology of the catchment to ensure appropriate locations for management options were selected and to assist with the planning and construction of suitable building foundations based on the geological constraints present.

Three geological formations occur within the catchment with the majority of the catchment falling within the Shoalhaven Group, as illustrated in **Figure 8-1**:

- Alluvium Formation– Quaternary channel and floodplain alluvium, gravel, sand, silt and clay;
- Nowra Sandstone Formation – Late Permian quartzose sandstone, minor siltstone plus conglomerate beds; and
- Shoalhaven Group – Permian sandstone, siltstone, shale, polymictic conglomerate, claystone, rare tuff, carbonate and evaporate. .

The geological constraints on floodplain management depend on the management options selected to be implemented. At this stage, no significant geological constraints have been identified that would impact the preliminary assessment of options in this FRMS.

8.1.3 Soils

According to the Soil Landscape Map of Kiama (Scale 1:100,000) the catchment is located on the Nowra and Shoalhaven soil landscape groups.

The Nowra soil landscape group is generally characterised by medium to coarse-grained quartz sandstones which contain rounded pebbles scattered throughout the beds. Moderately deep (50-100cm) brown podzolic soils occur on crests and upper slopes. Soloths and/or yellow earths occur mid-slope and yellow podzolic soils occur on lower slopes and drainage lines. The main limitation of this soil type relates to rock outcrops, possible shallow soils that may be hard-setting and may contain a degree of stoniness. The erodibility of the topsoil is generally low, but high for the subsoils. Erosion hazards for non-concentrated flows were moderate to high (Shoalhaven City Council, 2005).

The Shoalhaven soil landscape group is located in floodplains, levees and backwaters, and is noted to have a potential for acid sulfate soils (ASS). Alluvium is generally present – gravel, sand, silt and clay derived mainly from sandstone and shale overlying buried estuarine sediments. Moderately deep (50-100cm) prairie soils occur on levees, red earths and yellow and red podzolic soils occur on terraces and alluvial soils and gleyed podzolic (potential acid sulfate) soils occur on

the floodplain. Additional limitations of this soil landscape include flood hazard, seasonal water logging, permanently high watertable, hardsetting, strong acid and sodicity (Shoalhaven City Council, 2005). Acid Sulfate Soil investigations should be undertaken before any flood modification works are undertaken.

8.1.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) occur when soils containing iron sulfides are exposed to air and the sulfides oxidise producing sulphuric acid. This usually occurs when soils are disturbed through excavation or drainage works. The production of sulfuric acid results in numerous environmental problems.

A review of the Soil Landscape Map of Kiama (Scale 1:100,000) and the Shoalhaven City Council online acid sulfate soils mapping indicates that parts of the lower catchment with the gorge adjacent to the Shoalhaven River have a high probability of ASS within 1m of the ground surface. This is a significant environmental risk if ASS materials were to be disturbed by activities such as shallow drainage, excavation or clearing. If high risk materials were disturbed there may be a severe environmental risk. Soil investigations would be necessary to assess these areas for acid sulfate potential should any flood management actions be proposed.

However, developed areas of the catchment have no known incidents of acid sulfate soils.

8.2 Contaminated Land and Licensed Discharges

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the Contaminated Land Management Act 1997.

OEH is authorised to regulate contaminated land sites and maintains a record of written notices issued by the Environment Protection Authority (EPA) in relation to the investigation or remediation of site contamination. A search of the OEH Contaminated Land Record on 14 March 2013 found one contaminated site within the catchment area - Nowra Mobil Service Station (202 Princes Highway, Nowra South, NSW 2541) which is listed as a remediation site.

When implementing any flood modification works within the catchments, the locations of these contaminated sites should be noted, and if works are proposed to be carried out nearby, further investigation of potential impacts should be undertaken.

It is important to note that there are limitations to the Contaminated Lands Register and other areas may be contaminated that were not on the register.

A search of the Protection of the Environment Operations Act 1997 (PoEO Act) licensed premises public register on 11 March 2013 identified seven licensed premise within the catchment as shown in **Table 8-1**.

Flood modification works in the catchment should both consider the protection of these facilities from flood damages and the compatibility of the flood works with the operations of the facilities.

Table 8-1 Items Listed on the PoEO Licensed Premises Register (EPA, 2012)

Suburb / City	Organisation	Activity
Nowra	**Adbri Masonry Group Pty Ltd** C & M Brick Pty Ltd 2 Prosperity Road, Nowra, NSW, 2541	Concrete Works
Nowra	**South Coast Liquid Treatment Pty. Ltd** 13 Tom Thumb Avenue, Nowra, NSW 2541	Non-thermal treatment of hazardous and other waste
South Nowra	**Nace Civil Engineering Pty. Limited** Hw1 Princes Highway South Nowra Duplication Princes Highway Between Kinghorne Street And Forest Road, South Nowra, NSW, 2541	Road Construction
Nowra	**Nowra Brickworks (NSW) Pty Ltd** Nowra Brickworks Princes Highway, Nowra, NSW, 2541	Ceramics Production
Nowra	**Nowra Chemical Manufacturers Pty Ltd** Nowra Chemicals 5 Flinders Road, Nowra, NSW, 2541	Dangerous Goods Production
Nowra	**Randamusa Pty Ltd** Eziway Concrete 27-29 Quinns Lane, Nowra, NSW, 2541	Concrete Works
Nowra	**South Coast Concrete Crushing And Recycling Pty Limited** South Coast Concrete Crushing & Recycling Princes Highway, Nowra, NSW, 2541	Crushing grounding or separating Recovery of general waste Land-based extractive activity

8.3 Flora and Fauna

A large portion of the study area comprises cleared agricultural land and residential areas that have modified a great majority of the original native vegetation. Many of the flora and fauna species that previously occurred in these areas were no longer present. According to Shoalhaven City Council (2005), much of the fertile land associated with the Shoalhaven River Floodplain was cleared of its native vegetation in order to support intensive agricultural use such as cropping, vegetable growing and dairying. In many of these areas, only small remnants or a few paddock trees were all that remains of the previous vegetation cover. Any remnants that occur in these environments therefore often have significant conservation value. Urban areas of Nowra, particularly north of the Shoalhaven River have been built in close proximity to the natural environment.

A search of the Bionet Atlas of NSW Wildlife (OEH, 2013a) and the Commonwealth's Environmental Protection and Biodiversity Conservation (EPBC) Database on 14 March 2013 for flora species listed under the Threatened Species Conservation (TSC) Act (recorded since 2000) and the EPBC Act showed 13 known species within the catchment (refer **Appendix C** for species details). **Figure 8-2** shows that the flora species listed under the TSC Act were recorded within the central portion of the catchment. It is noted that records were only approximate and that data has been generalised meaning that several records may exist at the one location.

The EPBC database search recorded one Threatened Ecological Community (TEC) in or near the catchment (refer **Appendix C** for details).

Any proposed flood modification options or flood protection works should consider if these species or TEC would be affected.

The large number of protected species that occurs or has the potential to occur within the catchment areas should be considered in the development and implementation of any proposed flood modification options or flood protection works. Species type, abundance and distribution should be considered, and further investigation may be required if impacts are anticipated.

8.4 Heritage

8.4.1 Aboriginal Heritage

'Traditional Custodians' is the term to describe the original Aboriginal or Torres Strait Islander people who inhabited an area. Traditional custodians today are descendants of the original inhabitants and have ongoing spiritual and cultural ties to the land and waterways where their ancestors lived. The traditional custodians of the land in the catchment are the Wodi Wodi people (north of the Shoalhaven River). Along with the Wandi Wandian people (south of the Shoalhaven River) these peoples form part of the wider Aboriginal Nation known as the Yuin Nation (DLG, n.d.).

The study area is within the Nowra Local Aboriginal Land Council (NLALC). A preliminary investigation of Aboriginal heritage was undertaken by searching the online Aboriginal Heritage Information Management System (AHIMS) database in March 2013 for known or potential Aboriginal archaeological or cultural heritage sites within or surrounding the study area. The AHIMS search results are provided in **Table 8-2** and shown on **Figure 8-2**. There are seven listed Aboriginal artefacts and sites within the catchment. It is recommended that a more detailed heritage assessment be undertaken prior to implementation of any management actions to appropriately manage the potential impacts of any proposed flood mitigation works on these sites.

Table 8-2 Items Identified under the NPWS Aboriginal Heritage Information Management System (OEH, 2013b)

Site ID	Site Name	Site Types
52-5-0090	Nowra	Shelter with Deposit
52-5-0110	Nowra	Shelter with Art
52-5-0029	Nowra	Shelter with Deposit
52-5-0030	Nowra	Axe Grinding Groove
52-5-0032	Nowra	Shelter with Art
52-5-0034	Nowra;Hidden Valley	Shelter with Art
52-5-0033	Nowra; Bundanon Punt	Axe Grinding Groove,Shelter with Art,Shelter with Deposit

The following qualifications apply to an AHIMS search:

- AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to OEH;
- Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which were not recorded on AHIMS;
- Recordings were provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and
- The criteria used to search AHIMS were derived from the information provided by the client and OEH assumes that this information is accurate.

All Aboriginal sites are protected under the National Parks and Wildlife Act 1974 (NP&W Act) and therefore any management options that impact upon Aboriginal sites must include this in their design. Known Aboriginal sites should be left undisturbed if possible, however if a management option requires their destruction, an Aboriginal Heritage Impact Permit (AHIP) must be sought from OEH. Under the NPW Act it is a requirement that any developments show "due diligence" with regard to Aboriginal heritage in the area

Land rights and Native Title are two different avenues in which traditional land owners can gain access to land or claim compensation for previous dispossession of their land.

Under the Aboriginal Land Rights Act 1983 (ALR Act) local Aboriginal land councils can claim Crown lands provided the lands are vacant and not otherwise required for an essential public purpose. A search on the Land Claims Register, maintained by the Office of the Registrar ALR Act database (ORALRA), on 14 March 2013 found no Native Title claims in the catchment.

8.4.2 Non-Indigenous Heritage

There are three different types of statutory heritage listings of non-Aboriginal origin; local, state or national heritage items. A property is a heritage item if it falls into a listings category. The category an item falls into depends on whether it is considered to be significant to the nation, state or a local area. The significance of an item is a status determined by assessing its historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic value.

A desktop review of non-Aboriginal heritage was undertaken for the catchment. Searches were undertaken of the following databases:

- Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List);
- State Heritage Register;
- NSW Heritage Office – State Heritage Register; and
- RailCorp S170 Heritage and Conservation Register.

Within the catchment, no heritage items were recorded on any of the above databases or registers.

The Shoalhaven Local Environment Plan (SLEP) 1985 lists 111 heritage items under Schedule 7 and the Draft SLEP 2009 lists 81 heritage items under Schedule 5.

The provisions that must be followed in relation to heritage items in the catchment areas are outlined under Part 3 Division 4A of the SLEP 1985 and under Part 5, Clause 5.10 of the 2014 SLEP. Due to the extensive heritage items located within the catchment area that are listed in the SLEP 1985 and the 2014 SLEP, it is recommended that a more detailed heritage assessment is undertaken prior to implementation of any management options, as there are development restrictions and procedures that need to be followed.

9 Policy and Planning Review

The Nowra and Browns Creeks catchment is located in the Shoalhaven Local Government Area (LGA) where development is controlled through the Shoalhaven Local Environment Plan (LEP) and various Development Control Plans (DCPs). The LEP is a planning instrument which designates land use and development in the LGA, while DCPs regulates development with specific guidelines and parameters.

9.1 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 required the LEP to be updated.

Shoalhaven Council has prepared the Shoalhaven LEP 2014. The LEP incorporates a section on flood affected land. The objectives include the following:

- 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.

9.2 Current Land Use Zoning

The zoning of the study area is shown in **Figure 9-1**, and these zones are described in **Table 9-1** as per the Standard LEP Instrument (NSW Government, 2013).

Table 9-1 Catchment Land Uses (based on NSW Government, 2013)

Zone	Land Use	Description
Business Zones	B1 Neighbourhood Centre	▪ To provide a range of small-scale retail, business and community uses that serve the needs of people who live or work in the surrounding neighbourhood. ▪ To ensure that development is of a scale that is compatible with the character of the surrounding residential environment.
	B3 Commercial Core	▪ To provide a wide range of retail, business, office, entertainment, community and other suitable land uses that serve the needs of the local and wider community. ▪ To encourage appropriate employment opportunities in accessible locations. ▪ To maximise public transport patronage and encourage walking and cycling.
	B4 Mixed Zone	▪ To provide a mixture of compatible land uses. ▪ To integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.
	B5 Business Development	▪ To enable a mix of business and warehouse uses, and bulky goods premises that require a large floor area, in locations that are close to, and that support the viability of, centres. ▪ To allow a diversity of activities that do not significantly conflict with the operation of existing or proposed development.
Environmental 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.
	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

Zone	Land Use	Description
	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.
Industrial	IN1 General Industrial	▪ To provide a wide range of industrial and warehouse land uses. ▪ To encourage employment opportunities. ▪ To minimise any adverse effect of industry on other land uses. ▪ To support and protect industrial land for industrial uses. ▪ To allow a diversity of activities that do not significantly conflict with the operation of existing or proposed development. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area.
	IN2 Light Industrial	▪ To provide a wide range of light industrial, warehouse and related land uses. ▪ To encourage employment opportunities and to support the viability of centres. ▪ To minimise any adverse effect of industry on other land uses. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area. ▪ To support and protect industrial land for industrial uses. ▪ To allow a diversity of activities that do not significantly conflict with the operation of existing or proposed development.
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
	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

Zone	Land Use	Description
	R3 Medium Density Residential	▪ To provide for the housing needs of the community within a medium density residential environment. ▪ To provide a variety of housing types within a medium density residential environment. ▪ To enable other land uses that provide facilities or services to meet the day to day needs of residents. ▪ To provide opportunities for development for the purposes of tourist and visitor accommodation where this does not conflict with the residential environment.
	R5 Large Lot Residential	▪ To provide residential housing in a rural setting while preserving, and minimising impacts on, environmentally sensitive locations and scenic quality. ▪ To ensure that large residential lots do not hinder the proper and orderly development of urban areas in the future. ▪ To ensure that development in the area does not unreasonably increase the demand for public services or public facilities. ▪ To minimise conflict between land uses within this zone and land uses within adjoining zones.
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
	RE2 Private Recreation	▪ To enable land to be used for private open space or recreational purposes. ▪ To provide a range of recreational settings and activities and compatible land uses. ▪ To protect and enhance the natural environment for recreational purposes.

Zone	Land Use	Description
Rural	RU1 Primary Production	▪ To encourage sustainable primary industry production by maintaining and enhancing the natural resource base. ▪ To encourage diversity in primary industry enterprises and systems appropriate for the area. ▪ To minimise the fragmentation and alienation of resource lands. ▪ To minimise conflict between land uses within this zone and land uses within adjoining zones. ▪ To conserve and maintain productive prime crop and pasture land. ▪ To conserve and maintain the economic potential of the land within this zone for extractive industries.
	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.
	RU3 Forestry	▪ To enable development for forestry purposes. ▪ To enable other development that is compatible with forestry land uses. ▪ To encourage the recreational use of forest resources where such use is compatible with timber production. ▪ To recognise the role of forest resources in providing habitat corridors and in maintaining water quality.
Special Purpose	SP1 Special Activities	▪ To provide for special land uses that are not provided for in other zones. ▪ To provide for sites with special natural characteristics that are not provided for in other zones. ▪ To facilitate development that is in keeping with the special characteristics of the site or its existing or intended special use, and that minimises any adverse impacts on surrounding land.
	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.
	SP3 Tourist	▪ To provide for a variety of tourist-oriented development and related uses. ▪ To enable compatible residential and recreational uses. ▪ To provide for dwelling houses that form an integral part of tourist-oriented development.

9.2.2 Flood Affected Land Use Zones

A number of land uses were affected by flooding in the 1% AEP event and the PMF event, as shown in **Figure 9-2**.

These zones, in order of largest area of inundation, are listed below:

- E2 – Environmental Conservation 71.7 ha
- IN1 – General Industrial 38.9 ha
- RE1 – Public Recreation 36.9 ha
- B5 – Business Development 28.0 ha
- R1 – General Residential 12.2 ha
- RU3 – Forestry 11.6 ha
- SP2 – Infrastructure 8.6 ha
- R2 – Low Density Residential 2.5 ha
- E3 – Environmental Management 2.4 ha
- SP1 – Special Activities 2.0 ha
- RU2 – Rural Landscape 1.3 ha
- IN2 – Light Industrial 0.9 ha
- R3 – Medium Density Residential 0.1 ha

9.3 Development Control Plans

Development Control Plans (DCPs) were prepared by Council and apply to specific types of development or areas of land and provide detailed development guidelines and controls. DCP's outline specific controls and parameters that apply to development proposals in Shoalhaven.

In accordance with changes to the planning system in NSW, 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

This chapter provides controls for development 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 and policies applicable to the LGA is included, as well as the requirements of management of flood prone land, technical reporting requirements and flood proofing guidelines.

Additionally, this chapter includes site specific locations for which a Floodplain Risk Management Plan has been prepared.

The chapter states that development of flood-prone land within the Shoalhaven LGA area is governed by this chapter.

The lower portion of the floodplain lies within the Lower Shoalhaven River floodplain and as such some area specific controls apply as per Schedule 5 of the DCP. These include:

- The assessment of the impact of fill to be undertaken based on 2050 flood behaviour to reflect current climate change scenarios; and,
- A merits based approach to assessing development applications above the existing FPL but below the 2050 and/or 2100 FPLs.

Chapter G11 – Subdivision

The chapter covers subdivisions within the Shoalhaven LGA.

The chapter states that a flood assessment should be undertaken for properties within the floodplain. It is also recommends reference to the NSW Floodplain Development Manual 2001 be updated to the current NSW Floodplain Development Manual 2005.

The chapter refers to Chapter G9 for setting floor levels within flood prone land.

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

As part of the chapter, the following performance criteria were 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 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.

9.4 Recommended Flood Controls

As a result of the investigation into planning controls, a number of recommendations were proposed to increase the effectiveness of the planning controls. The existing controls are set out in *Schedule 6 – Flood Related Development Controls –DCP2014 G9* which applies to all areas in the Shoalhaven LGA without an implemented Flood Management Plan. Site specific conditions are in addition to, or override, the conditions within DCP2014 were relevant.

Recommended changes to existing controls are summarised in Table 9-2.

Table 9-2 Review of Existing Flood Planning Controls

Existing Control	Comments
Floor Levels	
For the majority of developments, floor planning levels are set at 1% AEP flood level + 0.5m freeboard Variations on this overarching control are for minor developments where the above generic floor planning level is preferred, however, if this cannot be achieved the existing habitable floor level or higher is acceptable Additionally, carparks in High Hazard Flood Storage or Flood Fringe areas need to be high enough to ensure a velocity – depth of less than 0.3 m^2/s for a 1% AEP Critical infrastructure which lie in Low Hazard Floodway / Flood Storage / Flood Fringe areas only have to set floor levels up to 5% AEP flood levels	The existing flood planning levels seem appropriate for the catchment, with the exception of car park freeboard. Entrance to carparks should be no lower than 100 year ARI flood level plus 0.5m. All above ground car parks should be designed taking into account vehicle stability up to the PMF event. Vehicle stability can be assessed in accordance with the NSW Floodplain Development Manual (2005) Three options are available: ▪ The floor planning level of the car park is sufficient to prevent the instability of vehicles due to flooding; ▪ The car park is flood proofed to prevent the instability of vehicles due to flooding; and ▪ Bollards are provided to prevent cars being swept away.
Structural Soundness	
Depending on the land use category the building must be able to withstand forces of floodwaters including debris and buoyancy forces up to the PMF, 0.2% AEP or 1% AEP. Most land use categories are also required to show that the structure would not become floating debris during a 1% AEP flooding scenario. Control Number 4. Certification of building foundations by a chartered geotechnical practitioner is required in some circumstances.	The additional control (no. 4) seems to contradict the first three controls relating to the building being able to withstand forces of floodwaters for the 1% AEP or greater events. It is recommended that this control should either be clarified or removed.

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.	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 behavior; 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.
Flood Evacuation Plan	
All residential and commercial developments (including minor development) within the high hazard areas is required to have a flood evacuation plan that ensures the timely, orderly and safe evacuation of people from the area and that it would 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.	Evacuation plans should also be prepared for properties that experience long duration flooding.

Existing Control	Comments
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.	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.

9.5 Proposed Industrial Redevelopment

Council are planning to rezone a region in South Nowra to industrial to allow for increased industrial development within the region. The proposed development area is shown in **Figure 9-3**.

A preliminary layout and master drainage plan has been prepared for the site and is shown in **Figure 9-3**. In order to control the additional runoff from the increased impervious area, it is proposed to construct a series of swales to drain the site to a number of shared basins to retard the flow before releasing it to Nowra and Browns Creeks.

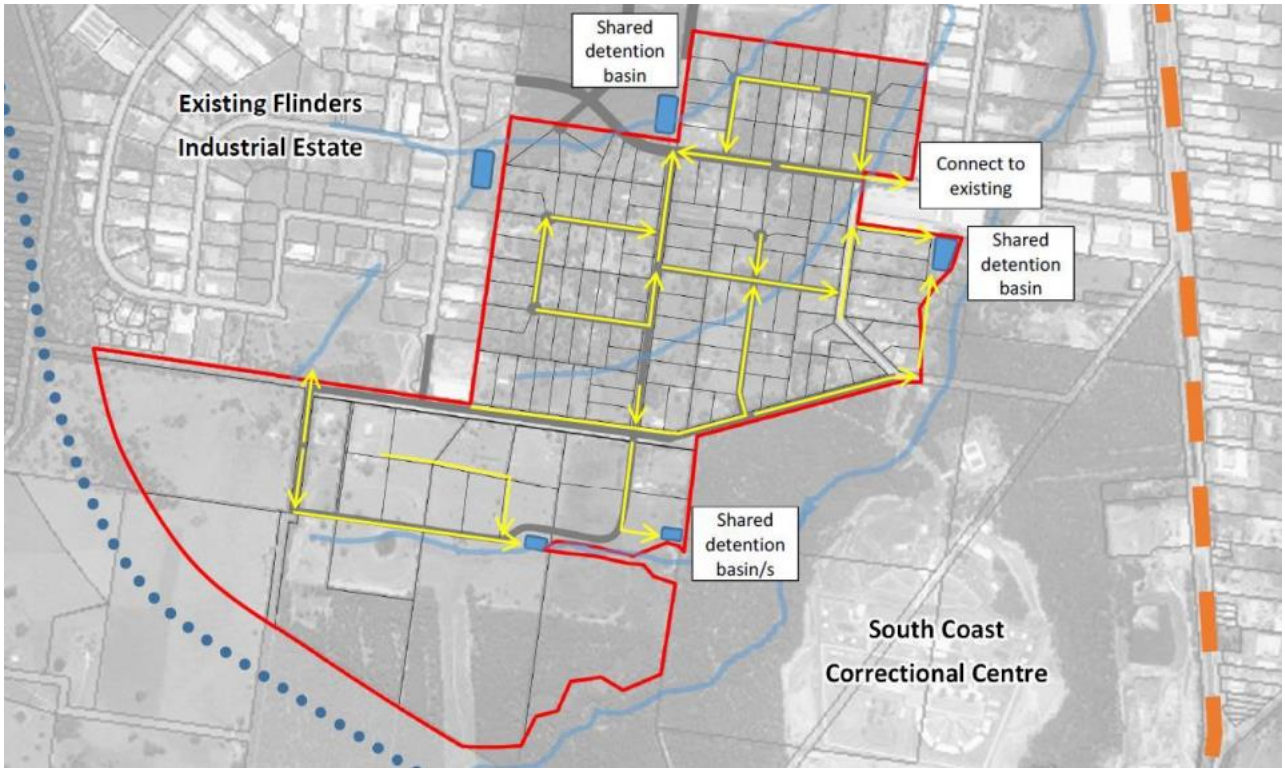

Figure 9-3 Drainage Concept Plan for Proposed South Nowra Industrial Development

To assess the impacts of the proposed rezoning and development of the site, the flood model was updated to incorporate:

- A revised roughness layer to account for the increased impervious area. Roughness was reduced to 0.015 across the site to represent a fully impervious, fully developed site.
- The proposed major drainage network of open swales and detention basins, as shown in **Figure 9-3**. The landform for the site had not been finalised at the time of the assessment, so it was assumed that the terrain fell towards the nearest drainage line. The basins had not been sized at the time of the assessment, so it was assumed that the additional basins would be of a similar size to the existing basin on the site, with a volume of approximately 7,500 m^3.
- The initial and continuing losses were changed to 1mm and 0mm respectively for the site to represent a fully impervious, fully developed industrial area.

The revised model was run for the full range of design events to assess the post-development flood behaviour of the region. The results are shown in **Figure 9-4**.

The results show that the full development of the site with a predominately impervious industrial development resulted in downstream increases for both Nowra Creek and Browns Creek for events larger than the 10% AEP. Increases of up to 0.6m were observed in Browns Creek, and of up to 0.4m on Nowra Creek in the 1% AEP. The impacts peaked upstream of Centre Avenue, and had largely dissipated by Flinders Road.

In order to prevent adverse flood impacts downstream, it is recommended that additional mitigation options be investigated in addition to the currently proposed basins. Possible mitigation that may be implemented, either individually or in combination include:

- Increasing the size of the common detention basins. The basins were currently sized to a similar volume as the existing basin on the site. Providing additional detention would assist in reducing downstream levels.
- WSUD options such as permeable pavements and on site detention could be implemented at the lot scale in order to reduce site runoff.
- Vegetated regions could be retained within the proposed development. This would not only reduce the impervious area of the site, and consequently the site runoff, but would also be beneficial in terms of water quality.

It is stated within Chapter G9 of the DCP2014 that any proposed development cannot increase the level or flow of floodwaters or stormwater runoff on surrounding land. Therefore the development, as currently proposed, would need to further manage floodwater / stormwater runoff so as to meet the requirements of the DCP.

10 Flood Planning Level

10.1 Background

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

A variety of factors require consideration in determining an appropriate FPL. Of key consideration in the development of an FPL, is 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.

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;
- Land availability and its needs;
- FPL for flood modification measures (levee banks etc);
- Changes in potential flood damages caused by selecting a particular flood planning level;
- Consequences of floods larger than that selected for the FPL;
- Environmental issues along the flood corridor;
- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Possibility of creating a false sense if security within the community;
- Land values and social equity;
- Potential impact of future development on flooding;
- Duty of care.

These issues are dealt with collectively in the following sections.

10.2 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 flood 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.

10.3 Likelihood of Flooding

As a guide, **Table 10-1** 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 10-1** 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 10-1 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

10.4 Current FPL

Based on Chapter G9 of DCP2014, Council currently utilises the following flood planning levels:

- For existing residential developments, based on the 1% AEP flood level, floor levels have a minimum freeboard of 0.5m;
- For new residential developments, based on the 1% AEP flood level incorporating a 0.23m sea level rise, floor levels have a minimum freeboard of 0.5m;
- For subdivisions, based on the 1% AEP flood level incorporating a 0.36m sea level rise, floor levels have a minimum freeboard of 0.5m;
- For existing industrial and commercial development, based on the 1% AEP flood level, floor levels have a minimum freeboard of 0.5m;
- For new industrial and commercial development, based on the 1% AEP flood level incorporating a 0.23m sea level rise, floor levels have a minimum freeboard of 0.5m; and,
- Council strongly recommends that any part of a building which extends below the minimum floor level be flood proofed in accordance with Appendix J NSW Floodplain Manual 2005

10.5 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.

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. Chapter G9 restricts building within the floodway, and recommends against filling in flood storage areas. In general, DCP2014 limits development in flood prone regions.

Given this, and other controls within the DCP (Section 9.3), this is not considered to be a significant issue within the catchment, as all proposed development is required to demonstrate how it meets the requirements of the DCP.

10.6 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 10-2**. 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 10-2 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 2% 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 10-2 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

10.7 Incremental Height Difference 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 10-3** for selected events. These were 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 were only calculated where flood levels were reported in the 5% AEP event.

Table 10-3 Relative Differences Between Design Flood Levels

Event (AEP)	Difference to PMF (m)	Difference to 0.2% AEP (m)	Difference to 1% AEP (m)	Difference to 2% AEP (m)
0.2%	0.62	-	-	-
1%	0.86	0.24	-	-
2%	0.96	0.34	0.10	-
5%	1.09	0.47	0.23	0.13

Table 10-3 indicates a significantly larger difference in flood level of the PMF event compared to other events. The smallest change is between the 2% and 1% AEP events (0.10m), suggesting that, the adoption of the 1% AEP event would provide an increased level of risk reduction over the 2% AEP event without a significant effect on flood planning levels.

The adoption of the PMF event as the flood planning level would result in more significant increases in levels over the 1% AEP event and would therefore present an issue for the setting of flood planning levels in the catchment.

10.8 Consequences of adopting the PMF as a Flood Planning Level

Analysis of the flood damage indicates that 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 even indicate that the use of the PMF as the FPL would result in higher levels and as a result higher economic costs and inconvenience to the community. In addition, the incremental AAD per building from the 1% AEP to the PMF is relatively low.

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 DCP.

Given the risk of exposure outlined in **Table 10-1**, it is recommended that emergency response facilities be located outside of the floodplain and any other likely critical facilities be limited to areas outside of the floodplain. Other critical facilities, such as schools and day care centres are suggested to have a floor level at the PMF level. Given the significant difference in peak levels between large flood events it is also recommended that any critical infrastructure currently within the PMF should develop evacuation strategies to plan for these events.

10.9 Environmental and Social Issues

The FPL can result in housing being placed higher than it would otherwise be. 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.

10.10 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.

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.

10.11 Freeboard Selection

As outlined in **Section 10.1**, 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:

- Changes in the catchment,
- Changes in the creek/channel vegetation,
- Accuracy of model inputs (e.g. accuracy of ground survey, accuracy of design rainfall inputs for the area)

Model sensitivity:

- 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 blockage.

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 ~ +/-0.15m

Based on this analysis, the total sum of the likely variations is in the order of 0.5m.

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

10.12 Flood Planning Level Recommendations

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

- For existing residential developments, new residential developments and for subdivisions, based on the 1% AEP flood level, floor levels have a minimum freeboard of 0.5m;
- For existing and new industrial and commercial development, based on the 1% AEP flood level, floor levels have a minimum freeboard of 0.5m;
- Council strongly recommends that any part of a building which extends below the minimum floor level be flood proofed in accordance with Appendix J NSW Floodplain Manual 2005

Commercial and/or Industrial properties have adopted higher frequency flood events such as the 5% AEP planning level based on the perception of risk. These occupiers can make informed commercial decisions on their ability to bear the burden of economic loss through flood damage, while residential lots don't generally provide an income to offset losses. Additionally, inventory, machinery and other assets can be stored above flood levels to lessen economic loss during a flood event.

However, as there were a relatively low number of commercial and industrial sites in the study area that were affected by floods, the adoption of the 1% AEP +0.5m as the FPL for commercial and industrial properties is appropriate for the study area.

For critical infrastructure, such as hospitals, police stations, aged care and schools, the PMF should be adopted as the FPL. It is important that these facilities, which are either difficult to evacuate or are essential during an emergency, remain flood free.

The Flood Planning Area (FPA) arising from this recommended FPL is shown in **Figure 10-1**.

The true hazard classification for the FPA is shown in **Figure 10-2**.

The hydraulic category classification for the FPA is shown in **Figure 10-3**.

11 Flood Emergency Response Arrangements

11.1 Flood Emergency Responses Documentation

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

11.1.1 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 the following aspects:

- Roles and responsibilities in emergencies,
- Preparedness measures,
- Conduct of response operations,
- 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.

11.1.2 Shoalhaven Flood Emergency Sub 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 South Nowra is a flood prone region of the catchment. The Flood Plan lists flood evacuation points for flood affected regions. For Nowra, these locations are:

- Nowra Showgrounds, West Street;
- Shoalhaven Entertainment Centre, 44 Bridge Road;

- Senior Citizens Centre, Graham Place; and
- Police Boys Club, Park Road.

11.2 Emergency Service Operators

The Nowra and Browns Creeks floodplain lies within the Illawarra / South Coast region of the State Emergency Service (SES). The SES maintains a Local Operations Headquarters at 92 Albatross Rd, Nowra. The Illawarra / South Coast region office is located at 6-8 Regent St, Wollongong.

The access road from the Local Operations Centre to the floodplain is the Princes Highway, which may be flood affected during large storm events.

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 locations of key emergency services for study area are outlined in **Table 11-1**.

Table 11-1 Emergency Service Providers Locations

Emergency Service	Adopted Value
Shoalhaven Hospital	2 Shoalhaven Street, Nowra
Ambulance Station	West Bunberra St, Bomaderry
Nowra Police Station	88 Plunkett St, Nowra
Nowra Fire Station	Unit 1/34 Norfolk Avenue, Nowra
Rural Fire Service	92 Albatross Rd, South Nowra

11.3 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.

11.3.1 Access Road Flooding

Summarised in **Table 11-2** below are the key access routes out of, and through, the study area. The crossings are shown in **Figure 11.1**.

It is noted that roads outside of the study area may also be flood affected during storm events, so that even if roads within the study area were flood free, access may still be lost between adjacent townships.

Table 11-2 Flooding of Key Access Roads

Location	ID	20% AEP Depth (m)	10% AEP Depth (m)	5% AEP Depth (m)	2% AEP Depth (m)	1% AEP Depth (m)	0.2% AEP Depth (m)
Corner Bice Rd and Berry St	A	0.58	0.84	1.11	1.38	1.58	2.02
Corner Albatross Rd and Albert St	B	0.33	0.61	0.89	1.17	1.37	1.80
Albatross Rd at Nowra Creek	C	0.30	0.49	0.78	1.10	1.32	1.79
Hillcrest Ave at Browns Creek	D	-	0.24	0.41	0.73	1.03	1.81
Browns Rd at Browns Creek	E	0.30	0.36	0.44	0.53	0.60	0.76
Quinns Lane at Browns Creek	F	0.28	0.34	0.43	0.52	0.60	0.77
Old Southern Road at Browns Creek	G	0.56	0.63	0.72	0.82	0.90	1.09
Flinders Road	H	-	-	-	-	0.03	0.11
Jellicoe Street West	I	-	-	-	-	0.27	0.34
Jellicoe Street East	J	-	-	-	-	0.25	0.68
Central Ave West	K	-	-	-	0.21	0.23	0.26
Central Ave East	L	-	-	-	-	0.81	1.19

11.3.2 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 were 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.

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 11.2**. 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.

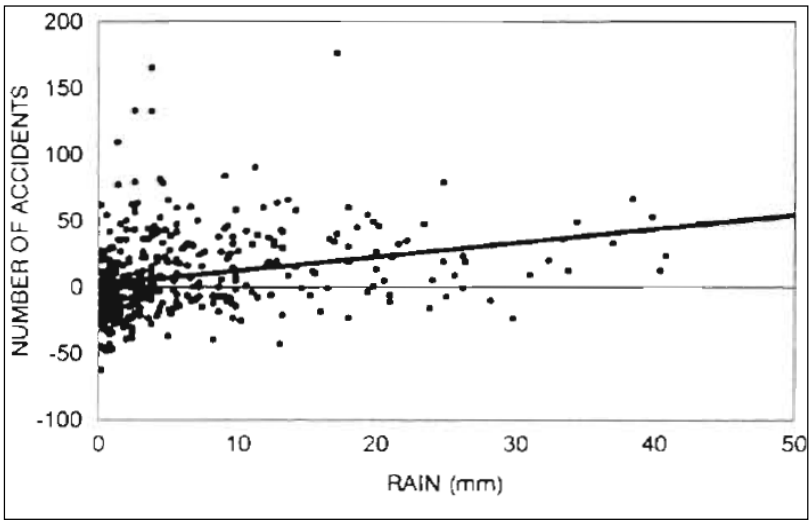

Figure 11.2 Accidents per day vs daily rainfall (Andreescu & Frost, 1998)

The rainfall intensity temporal distribution for the 1% AEP 2 hour event and 1% AEP 9 hour event are shown in **Figure 11.3** and **Figure 11.4** respectively. It is noted that these are exclusive of climate change impacts on rainfall intensities.

The figure shows that rainfall intensities were generally greater than 10mm/hr for both durations, with peaks of 159mm/hr, 293mm/hr and 209mm/hr at 25 minutes, 35 minutes and 40 minutes into the storm respectively for the 2 hour event, and 58mm/hr and 96mm/hr at 3 hours and 5 hours into the storm respectively for the 9 hour event.

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).

However, average rainfall intensities for both the 1% AEP 2 hour event and 9 hour event were well in excess of the values identified in the literature as beginning to have an effect on driving risk.

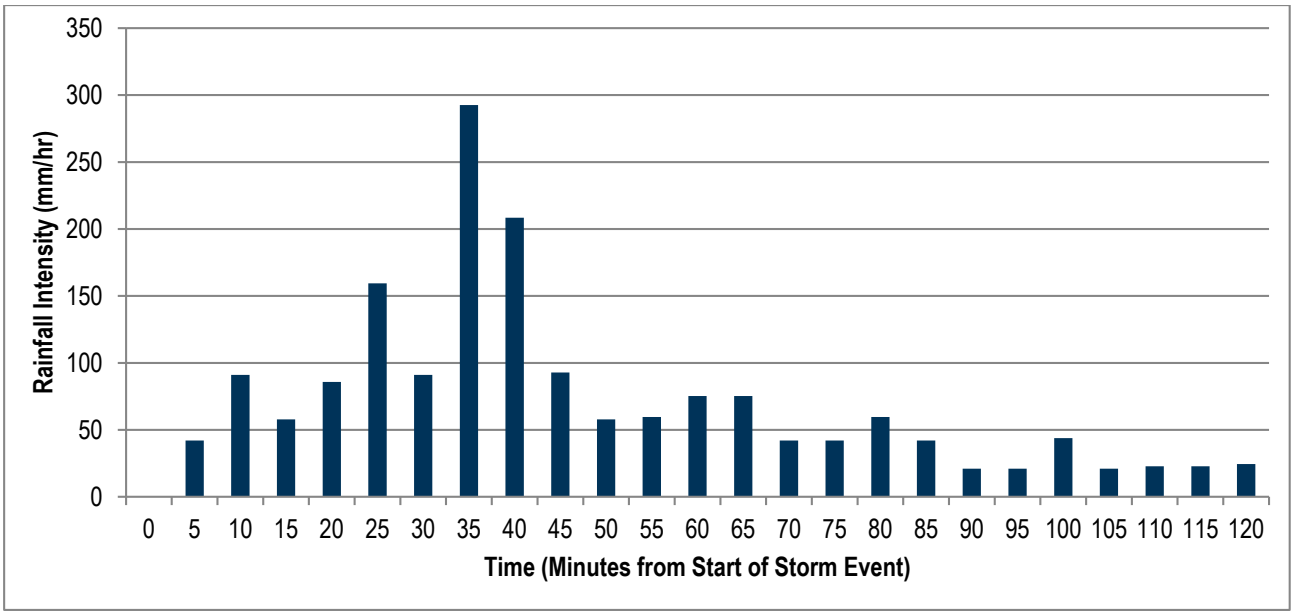

Figure 11.3: 1% AEP 2hr Temporal Rainfall Distribution

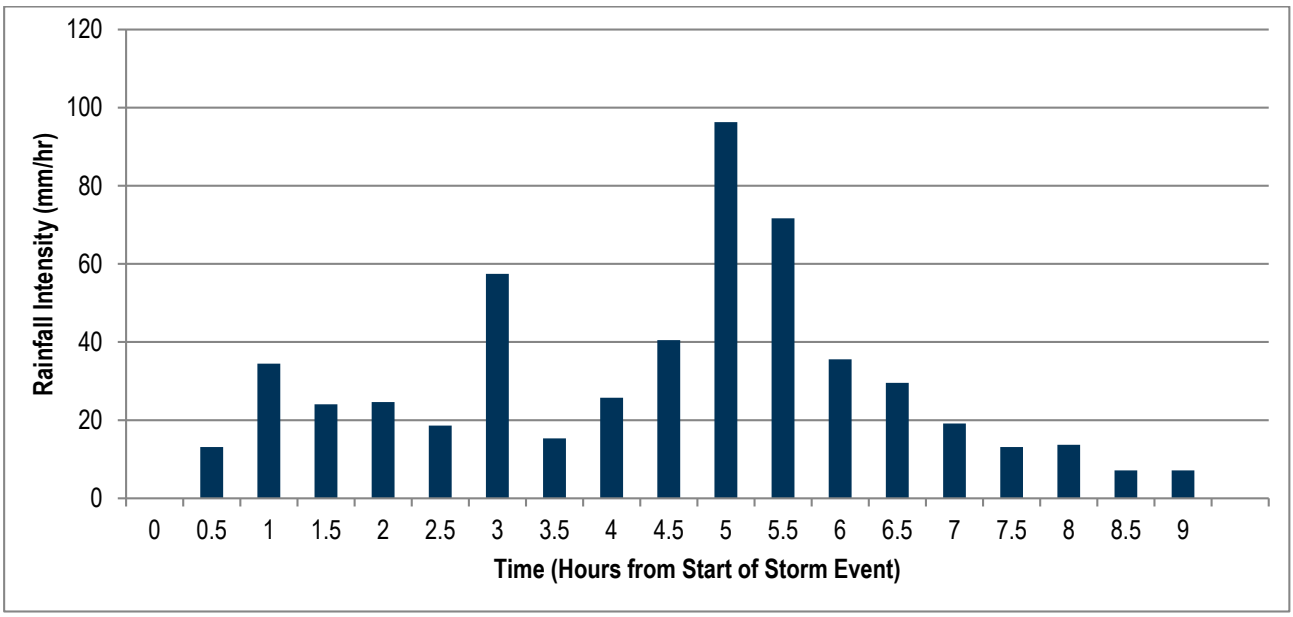

Figure 11.3: 1% AEP 9hr Temporal Rainfall Distribution

From the above, it is not recommended that people attempt to drive during a significant rain event. As the most intense rainfall would 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 would 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.

11.4 Flood Emergency Response

11.4.1 Catchment Response Time

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.*

The majority of sub-catchments within the study area were small, with relatively steep upstream areas. This results in the majority of locations within the study area having fast catchment response times where flash flooding is predominant.

Therefore, for the purposes of considering response to flooding in this study it is concluded that the rate of rise for all floodplains within 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 evacuate compared to shelter-in-place as a flood response strategy.

11.4.2 Flood Warning

There is no official flood warning system for the 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 peak of the flood and the causative rain. However, sources of real-time flood intelligence during times of flooding are:

- Bureau of Meteorology (BoM):
- 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.
- BoM Severe Weather Warnings: For the management of coastal erosion and inundation, BoM would 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 would advise SES Region Headquarters which would issue SES Livestock and Equipment Warnings.
- Evacuation Warnings by radio, door-knocks and telephone:

11.4.3 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 the:

- Time required to notify a region;
- 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. It is not dissimilar to the expected sequence of events for shelter-in-place with the exception that residents evacuate to higher ground rather than elevated buildings.

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 would 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 were shorter.

11.4.4 Community Response to Flooding

11.4.4.1 Short Duration Flooding

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 flood emergency response. There are two main forms of flood emergency response that may be adopted by people within the floodplain:

- Evacuation: The movement of residents out of the floodplain before their property becomes flood affected;
- Shelter-in-place: The movement of residents to a building that provides vertical refuge on the site or near the site before their property becomes flood affected. Council are not currently pursuing a shelter in place option at this time. Council will continue to liaise with the SES to identify strategies to manage existing flood risk in areas where minimal to no warning time is available.

The evacuation potential of the study area in the event of flooding is considered to be limited due to the flash flooding nature of the catchments within the LGA. Based on the SES evacuation timeline approach, there is insufficient time to co-ordinate a regional evacuation process, however there is potential for localised evacuation of sites near the edge of the floodplain.

This conclusion is in accordance with the following relevant sources:

- The AFAC guideline states that evacuation is the most effective strategy, provided that evacuation can be safely implemented, however it may be worse than not evacuating at all. It suggests determination of whether there are barriers to evacuation posed by available warning time, availability of safe routes, and resources available, with evacuation potential found to be minimal.
- Review of flood fatalities in Australia has found that the vast majority (75.7%) of fatalities occurred outside when people have entered flood waters in a vehicle or on foot, with only 12.4% of fatalities occurring in a house (Haynes et al, 2009). Conversely, it should also be noted that flooding in the Lockyer Valley showed the hazard associated with shelter-in-place, with 13 of the 19 fatalities being people sheltering in buildings that were either completely inundated or collapsed under the force of the flood flows (Rogencamp and Barton, 2012)

11.4.4.2 Long Duration Flooding

Longer duration storms allow for the possibility of pre-flood responses. These responses include:

- Sand bagging;
- Elevation of property contents;
- Lashing down potential flood hazards;
- Moving vehicles to high ground; and,
- Evacuation.

Flood warning systems utilise rainfall / stream gauges to provide advance warning of approaching flood waters. The warning system may be useful for flood response to inform access routes and to provide emergency responders with an indication of priority areas. However, a warning system would have a limited benefit for resident warnings due to the relatively short timeframe between issuing the warning and the arrival of flood waters.

These warnings could be via alerts issued by the monitoring authority of the gauge. Alternatively, the alerts may be automatically generated by a certain gauge trigger level, and distributed via SMS to high risk locations, and others who have requested the alerts.

This warning would allow residents to install temporary flood proofing (sand bags), relocate items / property to higher ground, and secure items which may come loose during the flood event.

Advance warning from the BOM via a severe weather warning would also allow high risk properties the opportunity to evacuate.

In the case of evacuation, it is important to assess the benefits, and to determine who is likely to be able to take advantage of this option. It must also be determined if they would be any safer doing so, than staying within their property.

Two key concerns with evacuation are:

- The depth and duration of floodwaters over key access roads,
- Driving conditions occurring during the evacuation period (noting that evacuation to higher ground or evacuation centres would primarily be via private vehicle).

Although a flood warning system may provide some advance warning of flooding, the system would not be able to differentiate between short and long response flooding. If the flood is a short duration event, with a quick catchment response, the warning may result in residents leaving their home shortly before or during the peak of the flood, placing themselves at risk.

As such, it is suggested that the flood response should focus on a 'remain in place' policy, and that the community be educated as to the appropriate actions to take in a flood event.

12 Community Education and Awareness

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

12.1 Current Community Awareness of Flood Behaviour and Risk

The community survey and workshops as described in Section 4 showed that 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. 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.

12.2 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 would be a period of time with no rainfall events, over which period peoples' appreciation of flood risks may begin to wane.

12.3 Education and Awareness Program

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

12.3.1 Short Term

12.3.1.1 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.

12.3.1.2 Develop a Post-Flood Data Collection Strategy

The collection of post-flood data was recommended as part of the Broughton Creek Floodplain Risk Management Study. In addition to this, it is recommended that the data collected be expanded to create information that would 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 interval of the rainfall intensity and peak river / creek flows;
- The approximate exceedance probability 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.

12.3.2 Medium Term

12.3.2.1 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.

12.3.2.2 Develop a Flood Information Package for New Residents

The documents prepared for the Flood Safe initiative would 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.

12.3.2.3 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.

12.3.3 Long Term

12.3.3.1 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.

The SES has also prepared a broadsheet and associated questions for Year 9 geography students which discusses flooding of the Nepean River Floodplain.

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.

It is also recommended that Council contact schools to investigate opportunities for students to be informed of flood hazards and appropriate responses. For example, schools run fire drills frequently to ensure students know how to respond during fires. It may be possible to expand this emergency response training to include a discussion on flood risks and responses. Alternatively, opportunities could be investigated to make presentations concerning flooding to students studying waterways, the environment or natural disasters as part of their school curriculum.

12.4 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.

12.4.1 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.

12.4.2 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 would 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.

13 Floodplain Risk Management Options

13.1 Managing Flood Risk

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 may be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 13-1**.

Table 13-1 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 options aimed at preventing / avoiding or reducing the likelihood of flood risks. These options reduce the risk through modification of the flood behaviour in the catchment.
- **Property modification measures** – Property modification measures are focused on preventing / avoiding and reducing consequences of flood risks. Rather than necessarily modify the flood behaviour, these options aim to modify properties (both existing and future) so that there is a reduction in flood risk.
- **Emergency response modification measures** – Emergency response modification measures aim to reduce the consequences of flood risks. These measures generally aim to modify the behaviour of people during a flood event.

13.2 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 13-2** and shown in **Figure 13-1** and **Figure 13-2**.

These options were taken to the first community workshop and discussed with the community. From this workshop, five options were developed for assessment with the hydraulic model, namely:

- Opt1 Vegetation Management (F12), results shown on **Figure 13-3**;
- Opt2 Culvert Augmentations (F19, F20, F25), results shown on **Figure 13-4**;
- Opt3 Upstream Detention Basins (F14, F22), results shown in **Figure 13-5**;
- Opt4 Channel Formalisation with Upstream Detention Basins (F13, F14, F22), results shown in **Figure 13-6**;
- Opt5 Industrial Precinct Drainage with Upstream Detention Basins (F24, F25, F27, F14, F22), results shown in **Figure 13-7**;

The costs and performance of these options is discussed in **Section 14**.

Upstream basins were found to be required for Option 4 and Option 5 above in order for the options to be feasible. Without the basins, the options resulted in downstream / adjacent impacts on nearby properties. Consequently, downstream works on Browns Creek and within the industrial area should not be undertaken independently as they would require offsite works to ensure that there are no adverse impacts.

13.2.1 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 described above. Although consent is not required, most flood mitigation works would require further environmental assessment.

The determining authority, in this case Shoalhaven City 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, Council would be required to take out further permits, licenses and approvals such as:

- Flood mitigation works which emit into a water body would 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.

Table 13-2 Nowra & Browns Creek Flood Mitigation Options

Option ID	Details	Expected Benefit
F1	Culvert upgrade to increase capacity of Osbourne St crossing of Nowra Creek	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F2a	Bridge upgrade to increase capacity of Berry St crossing of Nowra Creek, at corner of Bice Rd	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F2b	Bridge upgrade to increase capacity of Berry St crossing of Nowra Creek, at corner of Bice Rd, with raising of the road level	As above, but road raising would ensure that road is raised above 100yr / PMF flood level.
F3a	Bridge upgrade to increase capacity of Berry St crossing of Nowra Creek, at corner of Albatross Rd	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F3b	Bridge upgrade to increase capacity of Berry St crossing of Nowra Creek, at corner of Albatross Rd, with raising of the road level	As above, but road raising would ensure that road is raised above 100yr / PMF flood level
F4a	Combination of 1, 2a and 3a works	Given the close proximity of the crossings, individual works may only be of limited benefit. This option would assess the combined effect.
F4b	Combination of 1, 2b and 3b works	Given the close proximity of the crossings, individual works may only be of limited benefit. This option would assess the combined effect.
F5	Localised levees along Albatross Rd and Berry Street	Prevent flood waters entering properties adjacent to Nowra Creek between Albatross Rd and Osbourne St. Levees may be at the 20, 50 or 100yr ARI level.
F6	Construction of by-pass flowpath from Nowra Creek to Tributary 5	As above, but road raising would ensure that road is raised above 100yr / PMF flood level.
F7a	Bridge upgrade to increase capacity of Albatross Rd crossing of Nowra Creek	The constriction would control to some extent the flooding US. Widening of this section would increase the capacity, and reduce upstream flood levels and extents
F7b	Bridge upgrade to increase capacity of Albatross Rd crossing of Nowra Creek, with raising of the road level	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F8	Widening of local constriction on Nowra Ck between Princes Highway and Albatross Rd	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F9	Culvert upgrade to increase capacity of Princes Highway Crossing of Browns Creek	As above, but road raising would ensure that road is raised above 100yr / PMF flood level
F10a	Culvert upgrade to increase capacity of Hillcrest Avenue Crossing of Browns Creek	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F10b	Culvert upgrade to increase capacity of Hillcrest Avenue Crossing of Browns Creek, with raising of the road level	As above, but road raising would ensure that road is raised above 100yr / PMF flood level
F11a	Culvert upgrade to increase capacity of Quinns Ln Crossing of Browns Creek	Increasing the capacity of the channel through the removal of debris and invasive species should reduce water levels along the channel and reduce the degree to which the flood extents impact adjacent properties.

Option ID	Details	Expected Benefit
F11b	Culvert upgrade to increase capacity of Quinns Ln Crossing of Browns Creek, with raising of the road level	Increasing the capacity of the channel should reduce water levels along the channel and reduce the degree to which the flood extents impact adjacent properties.
F12	Vegetation management within Browns Creek. Removal of any invasive species that may affect the channel capacity. Removal of any dead trees or large debris that is obstructing flow.	Reduction of flood levels downstream (DS), extent of influence would be dependent on basin size
F13	Formalising of the Browns Creek flowpath	Reduction of flood levels DS, extent of influence would be dependent on basin size
F14	Detention Basin US of Old Southern Rd	Reduction of flood levels DS - extent of influence would be dependent on basin size. This option may be less effective than Opt14 and Opt15 as it is located further up the catchment, and would intercept less water. If a feasibility study for the detention basin is conducted in the future, discussions with the land owner will need to occur at the outset to determine available land. During the public exhibition of the draft FRMSP the owner indicated that only some of the land, east of the creek line, would be available to implement this option.
F15	Detention Basin US of Western Rd	Reduction of flood levels DS, extent of influence would be dependent on basin size. This option may be less effective than Option 14 and Option 15 as it is located in the very upper part of the catchment and thereby would intercept less flow
F16	Detention Basin US of Princes Highway	The filling of lots would raise the ground levels above the flood level, in order to allow development to occur.
F17	Detention Basins on local creeks US of BTU Rd	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F18	Filling of lots along Browns Creek	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F19	Culvert upgrade on Flinders Rd	Reduced flood levels and extents in the surrounding upstream (US) area, and a reduction in overtopping flows.
F20	Culvert upgrade on Jellicoe St	Reduction of flood levels DS - extent of influence would be dependent on basin size
F21	Culvert upgrade on Central Ave	The pipe would drain the water logged land between the industrial sites, with the pipe discharging into Nowra Creek
F22	Detention Basin US of Nowra Hill Rd	The easement would drain the water logged land between the industrial sites, with the easement discharging into Nowra Creek
F23	Construction of pipe to drain lots west of Bellview St	Flows towards Tributary 2 would be diverted through a pipe / culvert prior to reaching the industrial lots, reducing flooding in this region. The flow would be divert to Nowra Creek, US of Central Ave
F24	Construction of easement to drain lots west of Bellview St	The Tributary 2 flows would be diverted through an easement before reaching the industrial lots, reducing flooding in this region. The flow would be divert to Nowra Creek, US of Central Ave. In order to connect this easement to the existing easement, a corner of the Resource Recovery Centre lot would need to be acquired by Council in order to provide continuity between these easements. This acquisition has been included in the option.
F25	Regrading southern side of Central Ave to divert Tributary 2 flows	Increasing the capacity of the channel through the removal of debris and invasive species should reduce water levels along the channel and reduce the degree to which the flood extents impact adjacent properties.
F26	Road raising	Raising of Central Avenue to provide flood free access during the 1% AEP event.
F27	Formalisation of tributary through industrial precinct	Removal of flooding from adjacent industrial lots

13.3 Property Modification Options

A number of property modification options were identified for consideration in the floodplain. These are:

- LEP update P 1
- Building and Development controls P 2
- House Raising P 3
- House Rebuilding P 4
- Voluntary Purchase P 5
- Land Swap P 6
- Council Redevelopment P 7
- Flood Proofing P 8

These options are discussed in detailed below. Some options would be eligible for funding assistance from OEH. Other options would be independently funded by Council. Options for which OEH funding is available are House Raising (P3) and voluntary purchase (P5).

13.3.1 P 1 – LEP Update

Local environment plans are prepared by councils to guide planning decisions for local government areas. Through zoning and development controls, they allow councils to supervise the ways in which land is used.

The Shoalhaven LEP is discussed in **Section 9**.

13.3.2 P 2 – Building and Development Controls

The key document for flood related controls in the Shoalhaven LGA is DCP2014, and recommended updates to this document are discussed in **Section 9.3**.

13.3.3 P 3 – House Raising

House raising is a possible option to reduce the incidence of over floor flooding in properties. However, whilst house raising can reduce the occurrence of over floor flooding, there are issues related to the practise, including:

- Difficulties in raising some houses, such as slab on ground buildings. In some slab on ground situations it may be possible to install a false floor, although this is limited by the ceiling heights.
- The potential for damage to items on a property other than the raised dwelling are not reduced – such as gardens, sheds, garages, etc.
- Unless a dwelling is raised above the level of the PMF, the potential for over floor flooding still exists – i.e. there would still be a residual risk
- Evacuation may be required during a flood event for a medical emergency or similar, even if no over floor flooding occurs, and this evacuation is likely to be hampered by floodwaters surrounds a property

- The need to ensure the new footings or piers can withstand flood-related forces.
- Potential conflict with height restrictions imposed for a specific zone or locality within the local government area
- Potential heritage constraints

The OEH *Guidelines for voluntary house raising schemes* (OEH, 2013a) sets out issues for consideration in determining whether a house raising scheme is viable. The Guidelines state that the following should be considered in determining the feasibility of voluntary purchase:

- The full range of flood events and impacts;
- The hydraulic category of the area (typically not suitable in floodways);
- The hazard category (generally limited to low hazard areas);
- Identification of houses' suitability for raising; and
- Cost effectiveness of the scheme.

For a single storey slab on ground property, the flooding damage that occurs for over-floor flooding of around 0 to 0.5m of depth is around $50,000. **Table 13-3** provides the approximate Annual Average Damage (excluding over ground only damage) for over-floor flooding commencing in different AEP events for individual residential properties. It assumes that over-floor flooding damage is constant at $50,000 for each over-floor event. This effectively provides a typical AAD for an individual property, and can be used as a guide.

Table 13-3 also demonstrates that properties with over-floor flooding in less frequent events were not exposed to flood damages as frequently, and hence the annualised damage for that property is not as significant. Properties that were exposed to over-floor flooding commencing in the 10% AEP event experience annualised damages of approximately $5,000 with a NPV (over 30 years) of approximately $68,800.

Table 13-4 shows the reduction in AAD from different house raising scenarios. In order for the scheme to be equitable, the house raising should only occur by raising floor levels up to the next AEP flood level. If it were to occur for a higher level, then it is arguable that the properties experiencing over-floor flooding in the next AEP event would be disadvantaged. In order to overcome this equity issue, it may be possible to apply a sliding scale subsidy which applies to all properties which were affected by over-floor flooding in events more frequent than the 1% AEP event.

As there were 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 study area.

Table 13-3 Estimates of AAD and NPV for Different Over-Floor Flooding Scenarios

Event in which over-floor flooding commences	Number of Properties with over-floor flooding	AAD per Property	NPV (50yrs) per Property
100% AEP	0	$50,000	$690,000
50% AEP	0	$25,000	$345,00
20% AEP	0	$10,000	$137,600
10% AEP	1	$5,000	$68,800
2% AEP	7	$1,000	$13,800
1% AEP	11	$500	$6,900
0.2% AEP	29	$100	$1,380
PMF	144	$0	0

Table 13-4 Reduction in AAD Resulting From Difference House Raising Scenarios *

Option (Change of AEP)	Number of Properties	Reduction in AAD (per property)	Reduction in AAD (Overall)	NPV of Reduction	Estimated Cost of Raising #
Up to 2%	0	0	0	0	0
2% to 1%	12	$500	$6,000	$82,800	$480,000
1% to 0.5%	22	$250	$5,500	$75,900	$880,000
0.5% to PMF	33	$250	$8,250	$113,900	$1,320,000

* Estimated based on a "typical" property with over floor flooding damage of $50,000

Assuming a cost of $40,000 to raise each property

13.3.4 P 4 – House Rebuilding

Under a re-building scheme, the property owner would have the option of utilising the subsidy for house raising described above for re-construction instead. In a number of cases, the ability to raise properties can be difficult and therefore rebuilding may be the only option. The advantage of this option is that the new structure can also be built in a flood compatible way (such as including a second storey for flood refuge).

One of the issues associated with this option is that there is still a significant cost for the property owner to redevelop their land. In addition, this provides an inequitable situation for those properties that are subject to the subsidy and those that are not. It can have the effect of skewing the property development market, where those properties subject to the subsidy are made more attractive for development than those properties that are not.

Similar to the house raising option, the fact that no properties experience over floor flooding in frequent events, make this option unviable in the catchment.

13.3.5 P 5 – Voluntary Purchase

An alternative to the construction of flood modification options and for properties where house raising is not possible is the use of voluntary purchase of existing properties. This option would free both residents and emergency service personnel from the hazard of future floods. This can be achieved by the purchase of properties and the removal and demolition of buildings. Properties could be purchased by Council at an equitable price and only when voluntarily offered. Such areas would then need to be rezoned to a flood compatible use, such as recreation or parkland, or possibly redeveloped in a manner that is consistent with the flood hazard.

However, this option should be considered after other, more practical options have been investigated and exhausted.

The OEH *Guidelines for voluntary purchase schemes* (OEH, 2013b) sets out issues for consideration in determining whether a voluntary purchase scheme is viable. The Guidelines state that the following should be considered in determining the feasibility of voluntary purchase:

- Flood hazard classification and associated risk to life;
- Hydraulic classification in relation to location in a floodway;
- The benefits of floodway clearance; and
- Economic, social and environmental costs and benefits.

There are no properties in the study are that meet these criteria. As such, voluntary purchase is not considered a viable option for the study area.

13.3.6 P 6 – Land Swap

An alternative to pure voluntary purchase is the consideration of a land swap program whereby Council swaps a parcel of land in a non-flood prone area, such as an existing park, for the flood prone land with the appropriate transfer of any existing facilities to the acquired site. After the land swap, Council would then arrange for demolition of the building and have the land rezoned to open space.

No sites fitting the above criteria were found, and as such, this option is not considered viable.

13.3.7 P 7 – Council Redevelopment

This option also provides an alternative to the Voluntary Purchase scheme. While Council would still purchase the worst affected properties, it would redevelop these properties in a flood compatible manner and re-sell them with a break even objective.

As no properties were identified as suitable for voluntary purchase, this option is not considered viable for the study area.

13.3.8 P 8 – 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 shall be 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 / industrial 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 objects that are likely to float and cause damage
- Re-locate waste containers, chemical and poisons well over floor level
- Install any available flood proofing devices, such as temporary levees and emergency water sealing of openings

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 floodplain.

13.4 Emergency Response Modification Options

A number of emergency response modification options are suitable for consideration within the 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

These options are discussed in detail below.

13.4.1 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. Information of this transfer would be detailed in the Flood Emergency Plan, to be prepared as part of the next stage of the study.

13.4.2 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, as discussed in **Section 11.**

13.4.3 EM 3 – Flood Warning System

The critical duration and response times for the majority of the study area limit the implementation of a flood warning system. As discussed in **Section 11** the short duration flooding experienced in local systems is not well suited to flood warning systems. Severe weather warnings are likely to be the only assistance for these areas.

13.4.4 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 their evacuation, if required, during the flood event.

A strategy to manage and improve public awareness and education is discussed in **Section 12**.

13.4.5 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. 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 gauges be installed at road crossings which are subject to inundation in frequent events and which experience overtopping in the 2% AEP event.

13.5 Data Collection Strategies

This would involve the preparation of a flood data collection form and the use of this form following a flood event. This would allow for more information to be gathered concerning the nature of flooding within the catchment, building on the knowledge from the Flood Study.

14 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. This calculation is described below.

14.1 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 14-1**. Details of these costings are provided in **Appendix D**.

For other options, broad estimates were made for the purpose of comparison in the multi-criteria assessment. These are detailed in **Section 15**.

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 would also be required at the detailed design phase.

Table 14-1 Costs of Quantitatively Assessed Options

Option ID	Option	Capital Cost	Ongoing Costs
Opt1	Vegetation Management	$719,300	$20,000
Opt2	Culvert Augmentation	$746,600	$5,000
Opt3	Upstream Basins	$1,386,200	$10,000
Opt4	Channel formalisation with upstream basins *	$6,065,500	$20,000
Opt5	Industrial precinct drainage with upstream basins #	$2,574,000	$15,000

* Channel works only cost = $4,679,300

Industrial works only cost = $1,187,800

14.2 Average Annual Damage Assessment of Options

The total damage costs were evaluated for each of the options assessed by hydraulic modelling. The average annual damage (AAD) for each of the options is shown comparatively against the existing case in **Table 14-2**.

The results in **Table 14-2** show that the most effective option in reducing damages was Option 5, industrial precinct drainage with upstream basins, followed by Option 1 vegetation management. Option 3, the upstream basins option, also had a relatively substantial reduction in damages. Channel formalisation with upstream basins only resulted in a minor reduction in damages, while the culvert augmentation option results in increased impact on 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 which is investigated below.

Table 14-2 Average Annual Damage for Quantitatively Assessed Options

Option ID	Option	AAD	Reduction In AAD Due to Option
Existing	Existing Scenario	$224,886	-
Opt1	Vegetation Management	$158,612	$66,274
Opt2	Culvert Augmentation	$236,047	-$11,161
Opt3	Upstream Basins	$176,213	$48,673
Opt4	Channel formalisation with upstream basins	$210,305	$14,581
Opt5	Industrial precinct drainage with upstream basins	$125,442	$99,444

14.3 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.

Table 14-3 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 provides an insight into how the damage savings from an option, relate to its cost of construction and maintenance:

- 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 14-3 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
Opt1	$158,612	$66,274	$914,631	$719,300	$20,000	$995,315	0.9	1
Opt2	$236,047	-$11,161	-$154,030	$746,600	$5,000	$815,604	-0.2	5
Opt3	$176,213	$48,673	$671,724	$1,386,200	$10,000	$1,524,207	0.4	3
Opt4	$210,305	$14,581	$201,229	$6,065,500	$20,000	$6,341,515	0.0	4
Opt5	$125,442	$99,444	$1,372,401	$2,574,000	$15,000	$2,781,011	0.5	2

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

It is noted that only Option 1 vegetation Management had a benefit cost close to one. All the other options have benefit cost ratios less than this, indicating that construction costs substantially outweighed damage reductions.

The primary reason for this is that the frequency of inundation for most properties which experience over floor flooding is quite low – generally only in events larger than the 2% AEP. As a result, the annualised damage savings of these events are relatively small. For instance, a saving of $100,000 in 1% AEP damages is reduced to a difference of $1,000 once the damages have been annualised.

14.4 Economic Assessment of Desktop Assessed Options

Where a desktop assessment was utilised for options (as opposed to hydraulic modelling), a detailed economic analysis was not undertaken. Instead, a judgement on the economic benefits of the options was made. This is described in **Section 15.**

15 Multi Criteria Assessment

Evaluating what constitutes an appropriate strategy for floodplain management is a significant analytical and policy challenge. Urban areas impacted by flooding are valued in a number of ways by communities, organisations and individuals. Impacts associated with flooding include risk to assets and risk to life. Such challenges have led to the exploration of alternative policy analysis tools, one being Multi Criteria Assessments (MCA). The goal of MCA is to attempt to directly incorporate multiple values held by stakeholders into the analysis of management alternatives while avoiding the reduction of those values into a standard monetary unit. In so doing, one can consider different floodplain management options in the context of economic criteria as well as other criteria such as social, political or environmental aspects. Stakeholders can also assign explicit weights to those values to reflect their preferences and priorities. Therefore, MCA provides opportunities for the direct participation of stakeholders in the analysis.

A Multi Criteria Assessment approach has been adopted for the comparative assessment of all floodplain management options identified within the Shoalhaven LGA using a similar approach to that recommended in the Floodplain Development Manual (2005). This approach uses a subjective scoring system to assess the merits of various options. The principal 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.

15.1 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 adopted 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	Meeting of flow and water quality objectives
	Fauna / Flora

The scoring system is shown in **Table 15-1** for the above criteria.

Table 15-1 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	Major increase in AAD	Slight increase in AAD	No Improvement	Slight decrease in AAD	Major decrease in AAD
Social	1	Reduction in Risk to Life	1	Major increase in risk to life	Slight increase in risk to life	No change in risk to life	Slight reduction of risk to life	Major reduction of risk to life
		Reduction in Social Disruption	1	Major increase in social disruption	Slight increase in social disruption	No change to social disruption	Slight reduction of social disruption	Major reduction of social disruption
		Council Attitude	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	1	Completely incompatible	Slightly incompatible	Neutral	Compatible	Completely Compatible
Environment	1	Compatible with Water Quality and Flow Objectives	1	Completely incompatible	Slightly incompatible	Neutral	Compatible	Completely Compatible
		Fauna/Flora Impact	1	High negative impact	Slight negative impact	No impact	Some benefit	Considerable benefit

* Values of likely AAD reduction assumed where actual assessment not undertaken

15.1.2 Economic Assessment Overview

The economic assessment involved an appreciation of:

- Benefit Cost Ratio;
- Capital and Operating Costs; and
- Reduction in Risk to Property.

Capital and operating costs for options were quantitatively assessed for the hydraulically modelled options, whilst a judgement of the likely capital and recurrent costs was made for the remaining options by experienced engineers.

It is noted that the Benefit Cost Ratio incorporates both the capital & operating costs, and the reduction in the Risk to Property. However, these are included to provide an overall measure of both the affordability of an option (the magnitude of the cost) as well as the overall benefit of the option. The Benefit Cost Ratio, while providing a representation of the economic efficiency of the option, does not provide this information.

15.1.3 Social Impact Assessment

The social impact assessment involved an appreciation of:

- Reduction in Social Disruption;
- Reduction in Risk to Life;
- Council Attitude; and
- Community Support.

In general, there is a high level of flood awareness in the community. The nature of the population in the area is such that the population is fairly stable with some growth expected. However, regardless of the awareness in the area, the social disruption due to flooding (via the effects of property inundation, loss of access and traffic disruption) remains present. Similarly, while there is an understanding of the potential for flooding, the reduction in the risk to life is an important criterion to be taken into account. This criterion is highly subjective as it is difficult to assess the behaviour of persons under extreme conditions such as flooding.

The community support for a particular option was derived by converting the community responses received in the consultation period into a numerical score.

The attitudes of Shoalhaven Council to different options were subjectively assessed based on discussions with representatives over the course of the study.

15.1.4 Environmental Assessment

The environmental impact assessment involved an appreciation of both:

- Compatibility of the option with Water Quality and Flow Objectives, and
- Fauna/flora impact.

It is important to recognise that the watercourses of the area need to be managed in a sustainable way, in recognition of the modified nature of the system.

The assignment of each option with a score for each criterion is shown in its entirety in **Appendix E**. 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 15-1**.

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 E**.

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

1. P 2 Building and Development Controls
2. P 1 LEP Update
3. P 8 Flood Proofing Guidelines

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

1. Opt 1 Vegetation Management
2. Opt 5 Industrial precinct drainage with upstream basins
3. Opt 3 Upstream Basins

This ranking 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 E** is not “absolute” and the proposed scoring and weighting should be reviewed at regular intervals to ensure they are still representative.

16 Floodplain Risk Management Plan

The results of the Floodplain Risk Management Study were used to form the Nowra and Browns Creeks Floodplain Risk Management Plan (Cardno, 2015), which has been prepared as a supplementary document to this, this Floodplain Risk Management Study.

17 References

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