Kangaroo Valley

Floodplain Risk Management Study

W4960

Prepared for
Shoalhaven City Council

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Cardno
Shaping the Future

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Executive Summary

Cardno have been commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Kangaroo Valley Township.

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

The Kangaroo River is a tributary of the Shoalhaven River, on the south coast of New South Wales. The river originates from within the Budderoo National Park, from where it flows across the western escarpment, through the township of Kangaroo Valley, and discharges into Lake Yarrunga. Lake Yarrunga is formed by Tallowa Dam, constructed immediately downstream of the confluence of the Kangaroo River and the Shoalhaven River.

The land use of the catchment is predominately forest and pasture, with isolated areas of urban development. The terrain is varied; steep ranges surround the catchment on the northern, eastern and southern sides, formed by the eastern escarpment. In the centre of these ranges are open alluvial flats.

The study area of the Kangaroo Valley Floodplain Risk Management Study and Plan is located mid-way along the Kangaroo River on the central flats, comprising the area of the Kangaroo Valley Township, within the Shoalhaven City Council LGA.

The Kangaroo River is the major flowpath in the study area. It runs east to west through the study area, and has one crossing within the study area; Hampden Bridge, located downstream of the Kangaroo Valley township.

In events as small as the 20% AEP event, the Kangaroo River breaks its northern banks and inundates the floodplain in the centre of the study area. The southern bank rises higher than the northern bank and prevents overtopping in events smaller than the 10% AEP. In events greater than the 10% AEP event, the river breaks its southern banks, which impacts properties between the river and Moss Vale Rd.

PMF flood levels are significantly higher than the other design events assessed, with depths up to 6m higher in the PMF than the 1% AEP in some locations. These depths are such that even second stories on properties will not provide flood refuge in the PMF event. It is therefore important that other strategies are put in place, such as education and community awareness measures and the provision of flood refuges, to address this risk to life.

The other major system in the study area is Barrengarry Creek which enters the study area in the north, and joins with the Kangaroo River immediately downstream of the Kangaroo Valley township

In events above the 0.2 EY event, it breaks over the eastern bank, and contributes to flooding within the central floodplain. In larger events, flooding along the reach within the study area is largely governed by flooding in the Kangaroo River; the central floodplain is fully inundated, and the levels along Barrengarry Creek are controlled by the large volume of flood water passing down the Kangaroo River.

Two small tributaries join the Kangaroo River upstream of the Township; Nugents Creek and Jarretts Creek. The upper reaches of the creeks are typically well contained within the creek banks for events up to the 2% AEP. Flooding within the

downstream extents of the creek however are controlled by the Kangaroo River, and backwater flows break creek banks in events as small as the 10% AEP event.

Two additional tributaries join the Kangaroo River within the Township; Town Creek and Myrtle Creek. Similar to the Nugents and Jarretts Creeks, upstream reaches are typically contained within the creek banks, whilst downstream reaches are controlled by flood levels in the Kangaroo River.

An assessment was undertaken on the number of properties to be affected under different frequency storm events, as well as an estimate of the appropriate economic damage for that 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
0.5 EY	0	0	0
0.2 EY	0	0	0
10% AEP	14	21	$1,805,800
2% AEP	34	31	$4,317,800
1% AEP	54	36	$7,091,500
PMF	115	94	$26,827,100
Average Annual Damage			**$216,165**

* Over ground flooding only reported for those properties that do not have over floor flooding

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

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

These options included:

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

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

The assessment 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 3 Building and Development Control Plans

2. EM 4 Public Awareness and Education
3. EM 3 Flood Warning System

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

1. FM 1.3 Caravan Park Levee
2. FM 3.1 Kangaroo Valley Vegetation Management
3. FM 3.2 Creek Formalisation

However, an analysis of the benefits and costs arising from the structural options showed that none of the options delivered a benefit-cost ratio above one. The caravan park levee had the highest ratio of 0.7, while all the other options had ratios of 0.5 or below, showing that the costs of implementing the option were at least twice as high as the resultant reduction in damages. Consequently, aside from of the caravan park levee, no other structural options are considered viable.

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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* Figures are located in body of report. Other figures are attached separately.

Glossary

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

Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding

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

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

Abbreviations

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

1 Introduction

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Kangaroo Valley catchment.

The study has been undertaken to define the existing flooding behaviour and associated hazards of the study area, and to investigate possible mitigation options to reduce flood damage and risk. The tasks were undertaken alongside community consultation to ensure that community concerns were addressed.

This report details the flood damages assessment, the environmental, social and policy review, and the investigations undertaken into potential flood mitigation options. The findings of this report will be used to develop the Floodplain Risk Management Plan.

1.1 Study Context

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

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

This document addresses aspects of Stage 4 of the process.

1.2 Floodplain Risk Management Study Report Objectives

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

The specific objectives of the Floodplain Risk Management Study are:

- To undertake effective community consultation and participation throughout the project
- To identify and describe the various potential flood problems and specific future flooding issues
- To assess whether the flood provisions in Council's existing environmental planning policies and instruments are consistent with each other, the Floodplain Development Manual and the findings of the flood analyses incorporating climate change impacts and sea level rise
- To identify and assess potential management measures for existing developed areas

- To assess the benefits and cost of the potential management measures and whether they might produce adverse effects in the floodplain
- To examine ways in which the creek and floodplain environment may be enhanced by preparing a strategy that will create a valuable corridor of vegetation without having a detrimental effect on flooding
- To identify modifications required to current policies in the light of investigations.
- To assess flood risks to or associated with existing infrastructure and opportunities to manage future infrastructure replacement so as to maximise flood tolerance and mitigation potential.

2 Catchment Description

The Kangaroo River is a tributary of the Shoalhaven River, on the south coast of New South Wales. The river originates from within the Budderoo National Park, from where it flows across the western escarpment, through the township of Kangaroo Valley, and discharges into Lake Yarrunga. Lake Yarrunga is formed by Tallowa Dam, constructed immediately downstream of the confluence of the Kangaroo River and the Shoalhaven River.

The land use of the catchment is predominately forest and pasture, with isolated areas of urban development. The terrain is varied; steep ranges surround the catchment on the northern, eastern and southern sides, formed by the eastern escarpment. In the centre of these ranges are open alluvial flats.

The study area of the Kangaroo Valley Floodplain Risk Management Study and Plan is located mid-way along the Kangaroo River on the central flats, comprising the area of the Kangaroo Valley Township, within the Shoalhaven City Council LGA.

The Kangaroo River catchment area and the study area are shown in **Figure 2-1**.

The township of Kangaroo Valley is located on the southern side of Kangaroo River. The main road, Moss Vale Road, crosses the Kangaroo River at Hampden Bridge, west of the township.

The key features of the study area are shown in **Figure 2-2**.

The township is located on the southern side of the Kangaroo River, with most development located on the high ground at the foot of the adjacent ranges. Commercial areas are predominately along Moss Vale Road, with residential properties located on the hills to the south. A number of dairy farms are located across the central alluvial plain.

The township has experienced historical flooding, with significant events occurring in 2005, 1999, 1991, 1990, 1978 and 1975. Roads have been reported cut during flood events, in some instances by depths of over 2m.

3 Available Data

3.1 Previous Reports and Studies

A number of previous studies have been conducted concerning the Kangaroo Valley region, and the wider Kangaroo River catchment. These studies have been reviewed as part of this study and relevant information incorporated. Previous studies are summarised in **Table 3-1**.

Table 3-1 Summary of Previous Studies and Reports

Study / Report	Description
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. The study determined downstream conditions at Shoalhaven Heads for 20yr, 50yr, 100yr and PMF. Different levels were determined depending on if the heads were open or closed.
Flood and Risk Management Study Report for the River Crossing in Kangaroo Valley (Water Resources Consulting Services, 1994)	The report focuses on the road crossings of Upper Kangaroo River, Kings Creek and Gerringong Creek. The site is approximately 10km upstream of the Kangaroo Valley Township, and outside of the current study area.
Shoalhaven River Design Flood Profiles – Burrier to Nowra (NSW Public Works, 1995)	The study was conducted to extend the modelling undertaken in the Lower Shoalhaven River Flood Study, which investigated the Shoalhaven River downstream of Nowra. Modelling was undertaken for the 2% and 1% AEP events using WBNM and MIKE11, and the models were calibrated to historical events from 1974, 1975, 1976, 1978 and 1988.
Chapter N1 of the Shoalhaven DCP 2014 (SCC, 2014)	The DCP covers the Village area of Kangaroo Valley and the smaller settlement of Barrengarry. The DCP has been prepared to guide development in the region.
Kangaroo River – Tallowa Dam Flood Investigations (SMEC, 2006)	The study was undertaken to investigate the effect on Kangaroo River flood levels of changing the operational parameters of Tallowa Dam. The proposed change was increasing the Full Supply Level by 7m to 63.34mAHD. The assessment was carried out in RAFTS and MIKE11, and assessed behaviour for events between the 50% AEP and 1% AEP events. The study found that levels at Hampden Bridge increased by 0.05m in the 1% AEP event and 0.33m in the 20% AEP due to the increased dam level.

Study / Report	Description
Lower Shoalhaven Floodplain Risk Management Study (Webb, McKeown & Associates, 2008a)	The study built on the initial 1990 study, further investigating key flooding issues and possible solutions. The model used had Shoalhaven Heads closed, but scouring out as the flood progressed. Key issues identified included blockage at Shoalhaven Heads, evacuation access, and urban development and expansion. It also stated that Broughton Creek and Bolong Rd Bridge had insufficient capacity to manage flood waters. An economic analysis was undertaken which estimated AAD at $1.8M, with 734 properties affected in the 100yr 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 response initiatives were considered to be more applicable.
Lower Shoalhaven Floodplain Risk Management Study and Plan (Webb, McKeown & Associates, 2008b)	The study outlines which of the mitigation options put forward above are most likely to have benefits, and how council could implement these programs. An example of the mitigation measures proposed are: ▪ Develop a post-flood evaluation and review program to further refine models ▪ Implement stormwater management plan for local drainage flooding issues ▪ Finalise and implement Council's Shoalhaven River Entrance Management Plan for Flood Mitigation (EMPFM) ▪ Update flood polices such as FPL's property set-backs, and improve resident flood awareness
Kangaroo Valley Flood Study (SMEC, 2009)	The flood study developed a RAFTS hydrological model and a MIKE11 hydraulic model to define the flooding behaviour in the study area. The models were calibrated to historical events from 1975, 1978, 1990, 1999 and 2005. For design events, a stage-discharge curve at Tallowa Dam was adopted as the downstream condition. The study found that roads within the study area were subject to overtopping, with some locations experiencing overtopping depths of greater than 2m in the 1% AEP event. The report noted that the rate of rise of flooding within the area is generally quick.

Study / Report	Description
Lower Shoalhaven River Floodplain Management Study & Plan: Climate Change Assessment (WMAwater, 2011)	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 DECC Guidelines. Based on these values, the findings of the previous study (Webb McKeown & Associates, 2008) were updated including planning levels, damages, flood mitigation options and evacuation procedures.

3.2 Survey Information

3.2.1 Terrain

Terrain information for the study was provided through two sources:

- *Sewage scheme survey data* – terrain and feature survey covering the Kangaroo Valley Township. The survey was conducted as part of the proposed sewage scheme works. The survey was undertaken in 2004, and provided by Council as an AutoCAD .dwg file (kv-detail21June04.dwg)
- *ASCII Grid* – the flood study prepared an ASCII grid of the study area for use in the hydraulic model. This grid was prepared from Aerial Laser Survey (ALS), and was confirmed through surveyed cross sections during the flood study. The ALS was undertaken in 2006, and the generated terrain grid was used to create cross sections for the Mike11 model. The cross sections were verified by on-site survey of selected cross sections. The terrain data was provided as a MapInfo Vertical Mapper grid (DTM tin.tab) and AutoCAD drawings of the surveyed cross sections.

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

3.2.2 Structures

The MIKE11 model constructed for the flood study (refer **Section 3.7**) contained detailed information on all the bridges and crossings within the study area. The data was confirmed through comparison with Council GIS data, and during the site visit.

3.2.3 Pits and Pipes

Pit and pipe data, including easements and open drains, were provided as GIS layers from Council. This data has been reviewed and is largely complete and suitable for use in the study.

Detailed culvert surveys were also provided for 11 culverts crossing Kangaroo River and its tributaries.

The drainage information and the location of the detailed culvert survey are shown in **Figure 3-2**.

3.2.4 Additional Survey

No significant changes have occurred in the catchment since the above survey data was collected. The structure and drainage data was sufficiently complete and the terrain information has been confirmed by surveyed sections. As such, no additional survey was required to be undertaken.

3.3 GIS Data

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

- Cadastre;
- Aerial;
- Catchment boundary;
- 5m contours;
- Heritage overlay;
- Land use; and,
- Zonings.

3.4 Site Inspection

A site inspection was conducted on 8 June 2012. During the site inspection, key hydraulic features were investigated across the study area, as well as the opportunity for flood risk mitigation options.

3.5 Historic Flood Information

The study area has experienced a number of large flood events, with the most recent being in 2005 and 1999. Previous studies include flood levels at certain locations for a range of historic events, and Council has provided survey of flood marks taken within the floodplain.

The flood mark locations provided are summarised below in **Table 3-2**.

Table 3-2 Recorded Historical Floodmarks

Flood Event	Easting	Northing	Flood Height
1991	256,702.866	1,154,777.065	72.654
1991	256,721.770	1,154,851.570	73.335
1991	256,715.404	1,154,797.629	72.503
1990	256,618.831	1,154,806.712	73.234
1990	256,973.016	1,154,788.735	74.748
1990	257,014.202	1,154,767.536	74.102
1990	256,178.863	1,155,486.077	70.263
1990	256,100.4563	1,155,536.480	71.145

3.6 Historic Rainfall Data

There are a number of rainfall stations, both daily and pluviograph, and stream flow gauges within and around the study area. Identified rainfall and stream flow gauges are shown in **Figure 3-3** and summarised in **Table 3-3**. Isohyetal maps were produced for historical events as part of the previous flood study (SMEC, 2009).

Table 3-3 Rainfall and Stream Flow Gauges

Station Type	Station Number	Station Name	Operational Period
Pluviograph	568128	Barren Ground	1968 - present
Pluviograph	568092	Belmore Falls (Glen Erchless)	1971 - present
Pluviograph	568076	Brogers No.2	1968 - present
Pluviograph	568078	Budderoo	1973 - present
Pluviograph	568124	Fitzroy Falls Dam	1972 - present
Pluviograph	568132	Kangaroo Valley (Brookes Plateau)	1977 - present
Pluviograph	68117	Robertson (St.Anthonys)	1962 - 2005
Stream gauge	215217	Kangaroo Valley Pumping St	1977 - present
Stream gauge	215223	Clinton Park	1966 - present
Stream gauge	215010	Kangaroo Valley	2005 - present
Stream gauge	215219	Bendeela Pumping Stn	2005 - present
Stream gauge	215220	Hampden Br	2005 - present
Stream gauge	215215	D/S Tallowa Dam	1976 - present
Stream gauge	215212	Tallowa Dam	1976 - present

3.7 Previous Modelling

The flood study undertaken in 2009 (SMEC, 2009) developed hydrological and hydraulic models to assess the flood behaviour of the study area. Hydrological modelling was undertaken using the RAFTS software package, and the hydraulics using the MIKE 11 software package.

3.7.1 Hydrology

A RAFTS model was prepared during the Flood Study investigations to model the site hydrology. The model was calibrated to five historical events.

A review of this model revealed that aspects of the modelling could be improved. These updates will be undertaken during the Stage 2 investigations and the RAFTS model re-calibrated and re-validated.

3.7.2 Hydraulics

The Flood Study developed a 1D MIKE11 model. The model extends from approximately 2km upstream of the Kangaroo Valley Township to Tallowa Dam. The model was calibrated to five historical events, and was used to define the flood behaviour for the PMF event and the 0.5%, 1%, 2%, 5%, 10% and 20% AEP design events.

As part of this study, the 1D model has been updated to a 2D model in the vicinity of the Kangaroo Valley Township.

4 Consultation

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

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

4.1 Community Information Brochure / Questionnaire

Community consultation was undertaken in August 2012. An information brochure and questionnaire were distributed to those properties owners within the Kangaroo Valley Township. The brochure and questionnaire are attached in **Appendix A**. The brochure provided an outline of the floodplain risk management process and the objectives of the study. The questionnaire sought information about historical flooding events and flood awareness within the community.

The brochure and questionnaire were delivered to approximately 250 property owners within the catchment area. Approximately 160 of these properties are within the PMF flood extent. A summary was also advertised in the local newspaper, informing residents of the study and advising that the survey was being undertaken.

From the distribution, 27 responses were received, representing a return of approximately 10% of direct distribution. This rate of return is typical for these types of surveys.

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

4.1.1 Years at Address

One of the questions in the survey related to the length of time that residents had resided at their current address. The majority of respondents were owner occupiers (70% / 19) with the remainder being tenanted, businesses, or other uses.

Of the 27 respondents, 63% (17) have been at their address for over 10 years, 48% (13) have lived at their address for over 20 years. Of the respondents, 70% (19) were living in Kangaroo Valley at the time of the 2005 flood event.

Figure 4-1 provides an overview of the periods of residency.

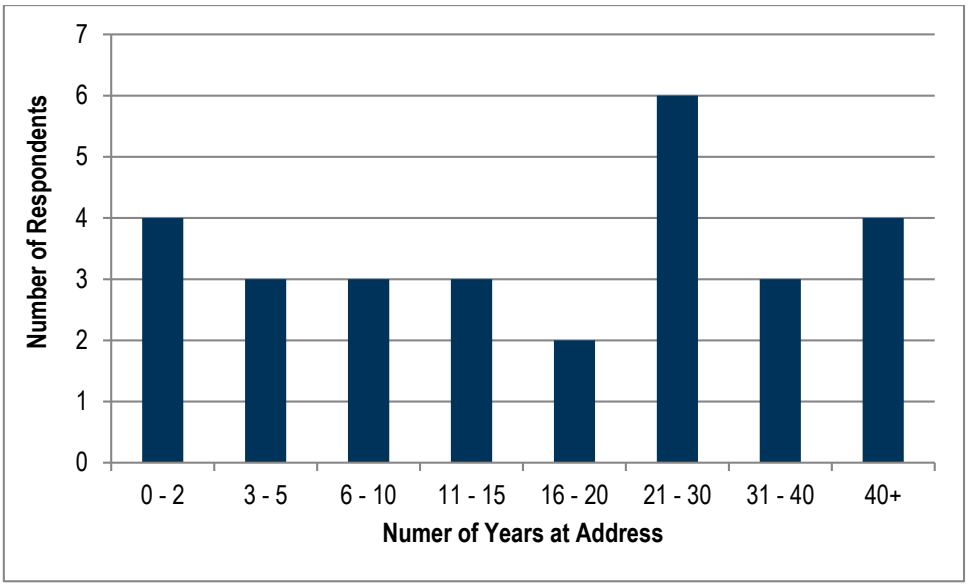

Figure 4-1: Years respondents have spent at current address

4.1.2 Community Flood Experiences and Expectations

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

The results show that 65% (18) of respondents have experienced flooding in the past with the majority of these being cases of over ground flooding. 7% (2) of respondents reported having experienced over floor flooding. No previous flooding experiences were reported by 35% (9) of the respondents.

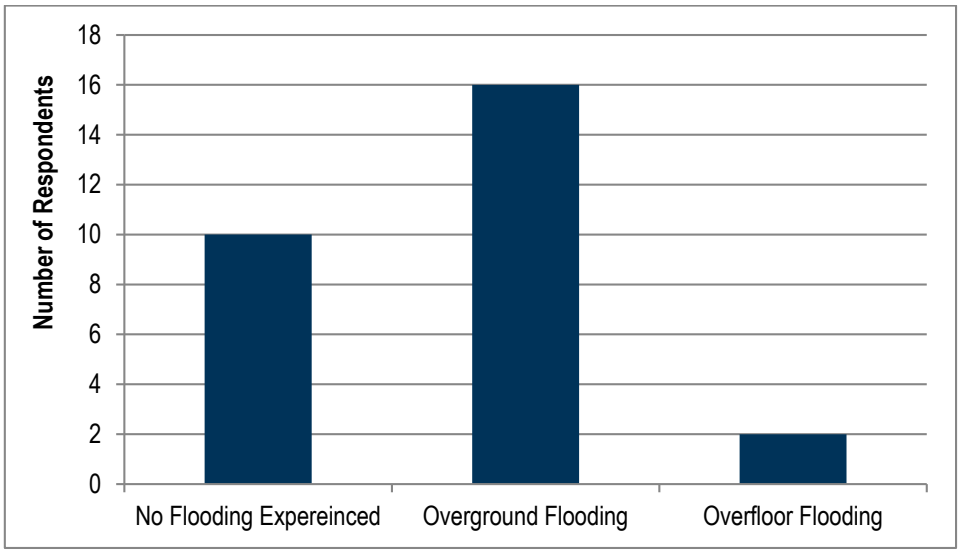

Figure 4-2: Historic Flooding Experiences

The results for the expected future flooding are nearly identical, with the same proportion of respondents expecting to experience over ground flooding. There was a slight increase in the expected rate of over floor flooding.

This suggests that respondents are basing their assumptions of future flooding risk on previous experience, and may have a reasonable level of flood awareness.

However, it is always important for ongoing flood education, as newer residents are unlikely to have experienced significant flooding and may not fully appreciate the risks.

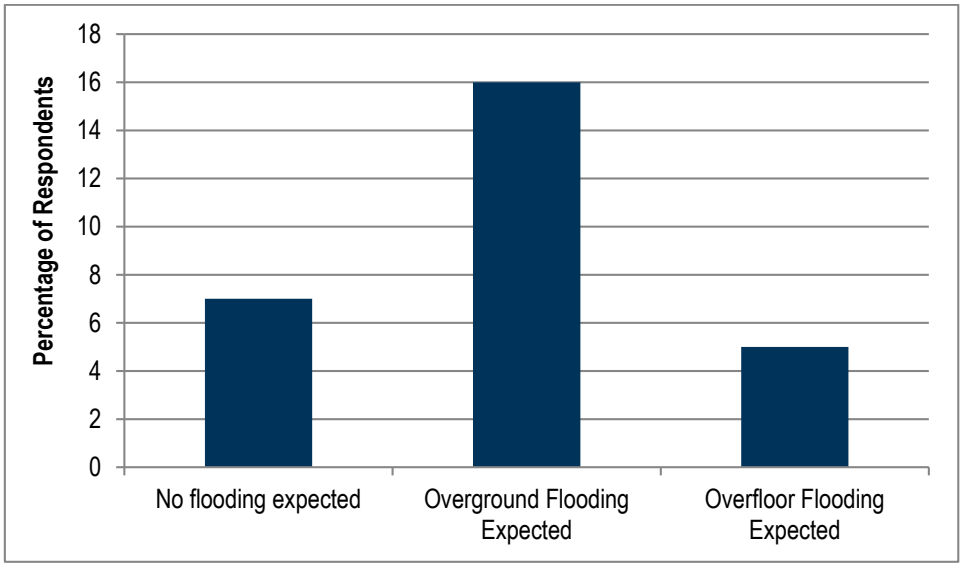

Figure 4-3: Expected Future Flooding Experience

4.1.3 Community Preferred Communication Avenue

Ongoing communication with the community is an important part of the study. Part of the questionnaire asked residents the best method for passing on flood study related information. The results are shown below in **Figure 4-4**.

The most popular method of communication by a large margin was mail outs. Information days and newspaper articles were also highly ranked. It is noted that these responses may contain some bias, as the data was gathered from a mail out survey.

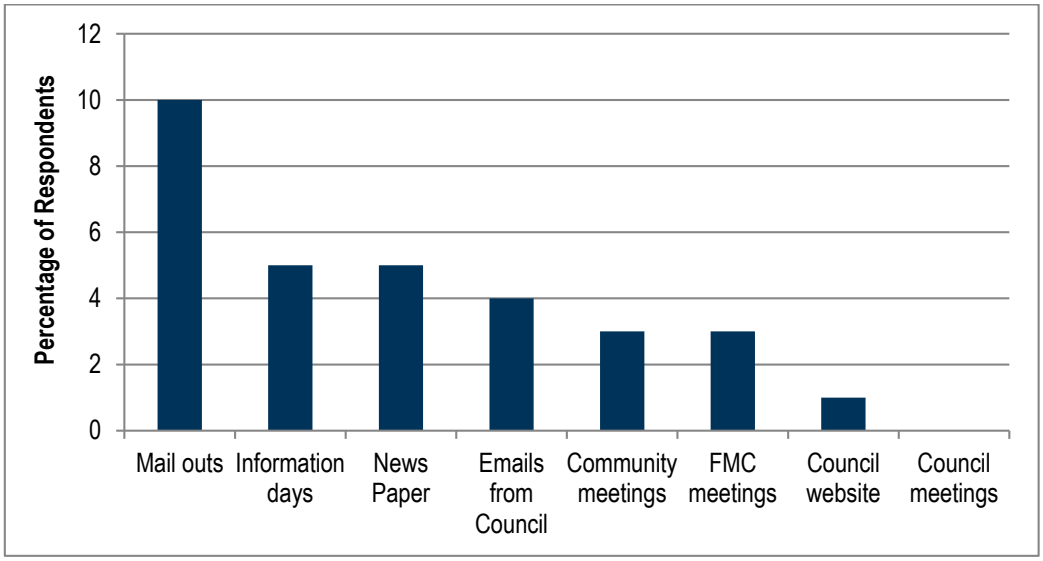

Figure 4-4: Preferred Communication Method

4.1.4 Community Preferred Flood Mitigation Options

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

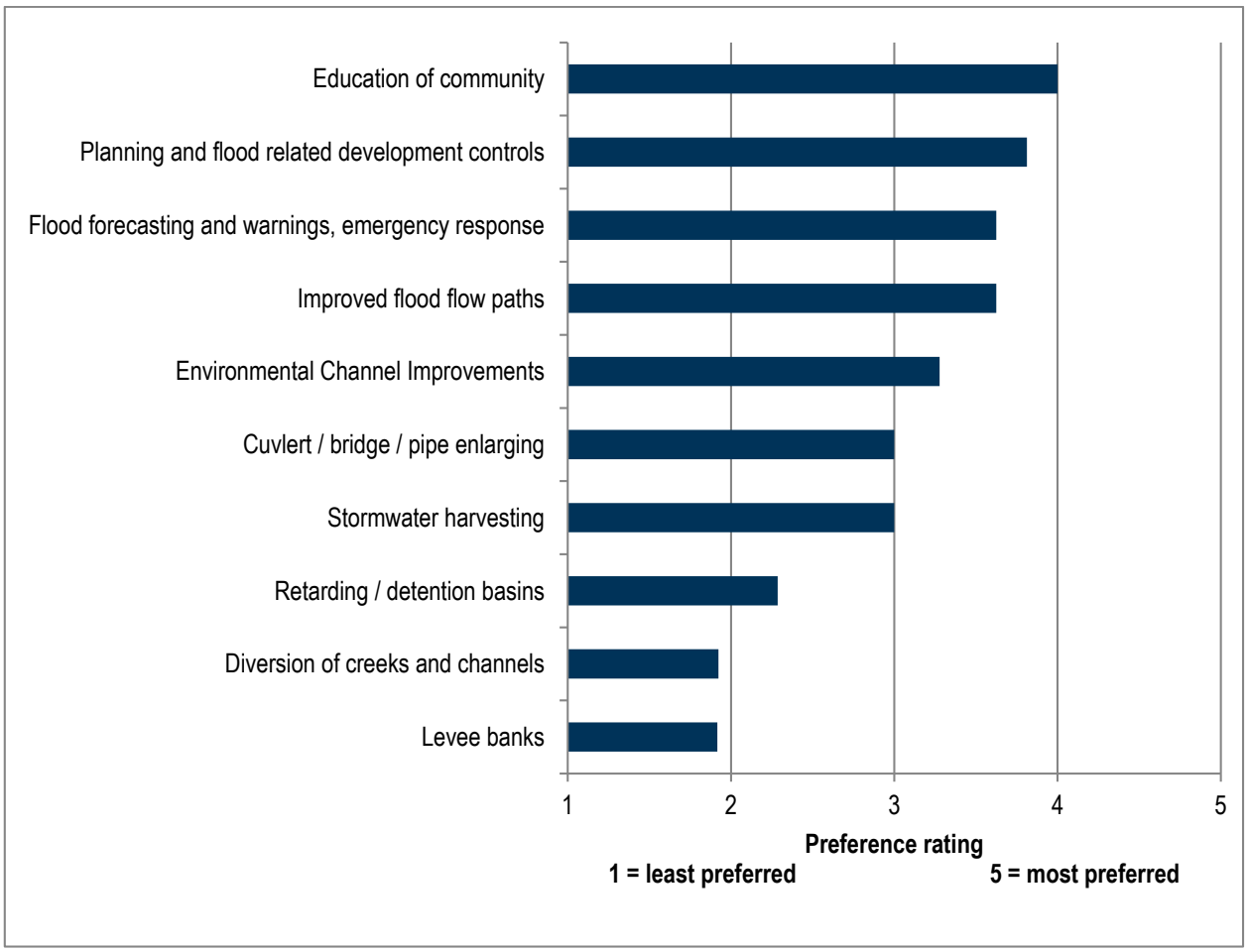

Figure 4-5: Community Preferred Flood Mitigation Options

The community showed a preference for non-structural options, with education, planning controls and improved warning and emergency response ranking highest. Channel improvements and environmental management (weed management, clearing debris) also ranked highly.

The structural options, retarding / detention basins diversions and levee banks, were the least preferred.

4.2 Community Forum

A community forum was undertaken on the 16th June 2014 to discuss the results of the revised flood study as well as the identification of preliminary flood mitigation options.

The forum was well attended by the community, with a total of 26 people attending.

Some of the key comments and feedback that was provided by the community during the meeting included:

- An understanding that structural options to reduce flooding impacts would be limited, given the flooding behaviour of the study area.
- A number of questions were raised as to how the study would impact development opportunity for residents. Based on this feedback it was decided to hold a separate presentation by Council staff during the public exhibition to discuss the impact on development opportunity of the study results.
- A community preference was expressed for planning and control revision and improving emergency responses over structural options.

A response was also provided from the Kangaroo Valley Community Association Inc. in response to the workshop. The Association provided the following comments in their response;

- The township is isolated due to flows overtopping roads in 5% AEP events. The consequences and durations of overtopping occurring during larger events is an important consideration in any emergency response plans;
- Other areas of the catchment outside of the current study boundary, notably the upper Kangaroo River, Bendeela Road and Sawyers Creek, are also subject to flooding, with consequent flood risks;
- That the valley is naturally subject to flooding, and that mitigation options are limited; and,
- Further restrictions on development beyond those in Chapter G9 Shoalhaven DCP 2014 should be adopted for the township.

Community comments on the options presented have been incorporated into the study both through identification of options and the assessment of the options.

4.3 Public Exhibition

The Floodplain Risk Management Study and Plan reports were placed on exhibition in October and November of 2015, and a community workshop was held during this period on 19 November 215.

They key comments and discussions from the workshop were:

- The community re-iterated their preference for planning and development control options and improved emergency response over structural option.
- It was discussed that the township would be required to be largely self-reliant in a large flood event, as the SES and other emergency responders would be unable to reach the township due to the loss of access roads.
- The community expressed strong support for some form of flood warning tied to the Hampden Bridge gauge.

5 Existing Flood Behaviour

As part of the study, the nature and extent of the existing flooding within the Kangaroo Valley catchment was defined.

Details and discussion on the existing flooding behaviour within the catchment, including provisional hazard and hydraulic categories, are provided in **Appendix D**.

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 are single storey.

The results in **Table 5.1** indicate that over floor flooding within the study area only occurs in events above the 10% AEP event.

Table 5-1 Properties with Over floor Flooding

Flood Event (AEP)	Residential Properties		Commercial Properties *	Industrial Properties
	Single Storey	Total Residential		
PMF	54	66	24	0
0.5%	24	31	3	0
1%	18	22	1	0
2%	9	12	1	0
10%	0	0	0	0
20%	0	0	0	0

* The caravan park has been counted as a single commercial premise

5.2 True Flood Hazard

Provisional flood hazard categorisation based around the hydraulic parameters (**refer Appendix D**), 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 Kangaroo Valley 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 study area is generally the 12 hour duration event for the 1% AEP event and the PMF. The smaller creek systems have shorter critical durations, but these do not have as much impact on properties as the longer duration systems, such as the Kangaroo River. However, as discussed in **Section 11**, the shorter duration, non-critical storms in the Kangaroo River and Barrengarry Creek still result in significant flooding. As such, the adoption of the 6 hour event to assess warning times was adopted across the whole catchment.

As such, the peak of the flow generally occurs at various locations within the catchment within 1 to 2 hours from the start of the rainfall. Therefore, there is little to no warning time throughout the study area.

Consequently, residents will not have any advance warning of the flood occurring, and will be responding to actual flood risk, such as loss of road access, or water entering the property or house. This lake of warning time forces residents to make important decisions – to evacuate or shelter in place – while dealing with the flood risk. This scenario increases both risk and hazard to residents.

However, it is noted that all areas within the study area are 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. While floods have occurred in Kangaroo Valley in 2005, 1999, 1990 and 1975, none of these floods could be classed as significant. The largest of these, in 1975, was in the order of a 10% AEP event.

Based on the responses from the resident survey (refer **Section 4**) approximately 70% of respondents were living in Kangaroo Valley at the time of the 2005 flood event.

This experience with relatively small flood events may result in the community underappreciating the actual flood risk posed by major floods. This is highlighted in the community responses. While 5 of the 28 respondents expect over floor flooding to occur at their properties in the future, over 60% of the respondents (17 of 28) would actually experience over floor flooding in a 1% AEP event.

However, 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 are no properties with flow behaviour within these constraints which are 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 and presented in **Appendix D** of this report. 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 are generally less than a couple of hours, even in the longer duration events. Those properties affected by longer periods of inundation are already selected by the provisional high hazard criteria.

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 are not considered to be an issue (refer **Section 11**). The exception to this is for properties that experience over floor flooding in the 100 year ARI 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 are a total of 18 of these residential properties in the 1% AEP event and 54 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.

Effective flood access is particularly important for those properties noted above, that experience over floor flooding but do not have a flood free second storey available for refuge.

All properties that experience over floor flooding are categorised as high hazard regions in the provisional hazard mapping.

5.3 Flood Emergency Response Planning Classification of Communities

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

The classifications are shown in **Figure 5-3**.

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

The Flood Emergency Response Planning Classifications are:

- High Flood Island – region not inundated by the PMF, but which is surrounded by floodwaters
- Low Flood Island – region is first surrounded, and then impacted by flooding in the PMF
- High Trapped Perimeter – region is not inundated by the PMF but access may be restricted
- Low Trapped Perimeter – region is first isolated, and then impacted by flooding in the PMF

- Overland Escape Route – region and access impacted by PMF. People can escape rising flood waters by moving overland to higher ground
- Rising Road Access – regions where access roads rise steadily to flood free ground and allow egress as flood waters rise
- Indirectly Affected Areas – regions that are outside the flood limit that retain access throughout the event

6 Current Economic Impact of Flooding

6.1 Background

The economic impact of flooding can be defined by what is commonly referred to as flood damages. Flood damages are categorised as 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 G**.

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 Kangaroo Valley floodplain under existing conditions is $216,165.

Table 6-2 Kangaroo Valley 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	66	5.24	9.80	71	$ 12,045,634
Commercial	23	2.53	6.56	23	$ 11,921,448
Caravan Park	26	6.53	8.11	0	$ 2,860,000
PMF Total	115			94	$ 26,827,083
0.5% AEP					
Residential	31	2.24	3.88	34	$ 4,496,052
Commercial	2	1.02	0.74	2	$ 296,403
Caravan Park	21	1.13	2.31	0	$ 2,299,000
0.5% AEP Total	54			36	$ 7,091,455
1% AEP					
Residential	22	1.19	2.97	29	$ 3,097,781
Commercial	0			2	$ -
Caravan Park	12	0.95	1.46	0	$ 1,220,000
1% AEP Total	34			31	$ 4,317,781
2% AEP					
Residential	12	0.81	2.00	20	$ 1,684,705
Commercial	0			1	$ -
Caravan Park	2	0.56	0.58	0	$ 121,000
2% AEP Total	14			21	$ 1,805,705
10% AEP					
Residential	0			0	$ -
Commercial	0			0	$ -
Caravan Park	0			0	$ -
10% AEP	0			0	$ -
20% AEP					
Residential	0			0	$ -
Commercial	0			0	$ -
Caravan Park	0			0	$ -
20% AEP Total	0			0	$ -

* Over ground flooding only reported for those properties that do not have over floor flooding

7 Social Issues

A knowledge of demographic character assists in the preparation and evaluation of flood risk management options that are appropriate for the local community. Demographic data is important in the consideration of emergency response or evacuation procedures; for example 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.

The demographic characteristics of the Kangaroo Valley study area presented in this chapter include those areas comprising of the Kangaroo Valley Township, within the Shoalhaven City Council Local Government Area (LGA). Population data was sourced primarily from the Australian Bureau of Statistics (ABS) 2011 Census.

In summary, the data revealed that:

- Approximately 50% of the population are aged between 40-69 years (**Table 7-1**); with 37% of those residents in the 60-69 age range. Furthermore, only 38% of the population was under 40 years old. These results show a community with a slightly older age who may be more at risk during flood events.
- English was the only language spoken in approximately 91% of homes in the Kangaroo River catchment. Other languages spoken at home other than English included Greek, Italian, German, Polish and Spanish (**Table 7-2**).
- The average median weekly income for individuals in Kangaroo Valley was $499 compared to the NSW average of $561. This trend of being below average income for the region compared to the NSW average was also evident for family and household incomes (**Table 7-3**). This may have implications for the economic damages incurred on property contents and the ability for residents to recover after a flood event. However, this may also be indicative of the older demographic of the population and the retired or semi-retired status of individuals.
- In 2012 the median house price in Kangaroo Valley was $352,500, and the median unit price was $320,000 (**Table 7-4**). In NSW, the median house price was $440,000, and unit price was $445,000 (APM, 2012). This information may be utilised in the calculation of economic damages incurred during a flood event in the catchment.

Table 7-1 Age Structure of the Catchment (ABS, 2011)

Age Group (Years)	Persons in Kangaroo Valley	% of Total in Kangaroo Valley	% of Total Persons in NSW
0-4 years	39	4.6	6.6
5-9 years	57	6.8	6.3
10-14 years	66	7.8	6.3
15-19 years	49	5.8	6.4
20-29 years	45	5.3	13.3
30-39 years	65	7.2	13.9
40-49 years	123	14.6	14.0
50-59 years	142	16.8	12.9
60-69 years	159	18.9	10.0
70-79 years	71	8.4	6.1
80-84 years	24	2.9	2.2
85 years and over	6	0.7	2.0
TOTAL	846	100	100

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

Languages Spoken at Home	Persons in Kangaroo Valley	% of Total Persons in Kangaroo Valley	% of Total Persons in NSW
English Only	770	91.4	72.5
Greek	11	1.3	2.0
Italian	5	0.6	1.4
German	4	0.5	0.4
Polish	4	0.5	0.5
Spanish	3	0.4	1.6

Table 7-3 Average Weekly Income for people 15 and Over (ABS, 2011)

Income (For Population Aged 15 Years and Over)	Kangaroo Valley	New South Wales
Average Median Individual Income (weekly)	$499	$561
Average Median Family Income (weekly)	$1,276	$1,477
Average Median Household Income (weekly)	$989	$1,237

Table 7-4 Median House and Unit Prices for 2012 (RealEstate, 2013)

Suburb	Median House Price	Median Unit Price
Kangaroo Valley	$352,500	$320,000

8 Environmental Issues

8.1 Topography, Geology and Soils

8.1.1 Topography

Kangaroo Valley lies between the Southern Highlands escarpment and the Cambewarra range that separates it from the coastal plain. The topography of the area ranges from steep slopes to wider valley floor, with heights from 55m AHD in the base of the valley floor to approximately 680m AHD on the upper slopes.

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 are selected and to assist with the planning and construction of suitable building foundations based on the geological constraints present.

The geology of the Shoalhaven is dominated by Permian age sandstones and siltstones. The majority of the study area lies within the Shoalhaven Group, as illustrated in **Figure 8-1**. The Shoalhaven Group comprises Permian sandstone, siltstone, shale, polymictic conglomerate, claystone, rare tuff, carbonate and evaporite.

The geological constraints on floodplain management depend on the management options selected. 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

Soils in the area are generally defined by the underlying geology ranging from sandstone escarpments down to alluvial floodplains. According to the Soil Landscape Map of Kiama (Scale 1:100,000) a range of soils may be encountered in the study area, as shown in **Figure 8-2**, including the following:

- Barrengarry landscape;
- Ellerslie landscape;
- Pulpit Rock; and
- Nowra landscape.

Particularly relevant soil landscapes are likely to be the Ellerslie and Nowra Landscapes as they are situated on the lower parts of the study area where development has occured.

The Ellerslie landscape unit is characterised by shallow soils consisting of sandy and silt loams, very stiff to hard clays and extremely weathered rock developed in units associated with the underlying rock materials. The erosion hazard is rated as high to extreme. Other limitations of the landscape include low wet bearing strength and the potential for localised mass movement.

The Nowra landscape group is generally characterised by medium to coarse-grained quartz sandstones which contain rounded pebbles scattered throughout the beds. Moderately deed (50-100cm) brown podzolic soils occur on crests and upper slopes. Soloths and/or yellow earths occur midslope 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 are moderate to high.

8.1.4 Acid Sulfate Soils

Acid sulfate soils (ASS) occurs 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 shows that no ASS is known to occur within the study area.

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.

The Office of Environment and Heritage (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 20 July 2013 found no records of contaminated sites within the catchment area. It is important to note that there are limitations to the Contaminated Lands Register and other areas may be contaminated that are not on the register.

A search of the Protection of the Environment Operations Act 1997 PoEO licensed premises public register on 20 July 2013 identified two licenced premise within the catchment as shown in **Table 8-1**.

Flood modification works within the vicinity of these sites 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

Suburb/City	Name and Address	Activity
Kangaroo Valley	Eraring Energy, Bendeela and Kangaroo Valley Hydro Electric Power Stations, Jacks Corner Road, Kangaroo Valley, NSW, 2577	Generation of electrical power otherwise than from coal, diesel or gas
Kangaroo Valley	The Scots College, The Scots College Glengarry, 369 Jacks Corner Road, Kangaroo Valley, NSW, 2577	Sewage treatment processing by small plants

8.3 Flora and Fauna

A large portion of the Kangaroo River catchment comprises cleared agricultural land and parkland, which has modified a great majority of the original native vegetation. Many of the flora and fauna species previously occurring in these areas are no longer present. The land use in the catchment is predominately forests and pastures with increasing regions of crops (for example, vineyards).

The Bionet Atlas of NSW Wildlife (OEH, 2013) was searched for flora & fauna species listed under the TSC Act (records since 2000) using a 5x5km polygon around the study area and the Commonwealth's Environment Protection and Biodiversity Conservation (EPBC) Database was searched for flora species listed under the EPBC Act within the Kangaroo Valley Township. Both databases were searched on 26 July 2013 and showed a combined total of 210 known flora species and 431 fauna species within 5km of the Kangaroo Valley Township that are listed under one or both of the Acts. **Figure 8-3** shows that there is only one recorded threatened flora species within the study area (Irenepharsus trypherus). Fauna species are distributed across the entire study area, with a slightly higher concentrated area of fauna in the southwest region.

The EPBC database search recorded one Threatened Ecological Community (TEC) in or near the catchment – Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion.

The large number of protected species that occurs or has the potential to occur within the catchment area should be considered in the development and implementation of 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

The local Aboriginal people in the Shoalhaven region were first sighted by Europeans in 1770, but it wasn't until 1797 that direct contact first occurred, when survivors from a shipwreck at Point Hicks in Victoria were making their way northward. By 1801, when Europeans landed at Jervis Bay, smallpox was already rife on the South Coast and the population of Aboriginal people had reduced in size. Over the next two decades, Aboriginal camps in the Shoalhaven were significantly impacted by European appropriation of land, but Aboriginal people remained present throughout the 1830s with some assisting the Europeans explore and find suitable pasture land.

The catchment is within the Illawarra Local Aboriginal Land Council (ILALC) and 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 July 2013 for known or potential Aboriginal archaeological or cultural heritage sites inside or within 1km of the study area. The AHIMS search results are provided in **Table 8-2** and shown on **Figure 8-4**. Given that several heritage items were found to be present, it is recommended that a more detailed heritage assessment be undertaken prior to the 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 System

Site ID	Site Name	Site Type
52-5-0027	Watts Hill	Artefact, Grinding Groove
52-4-0118	Lake Yarrunga 4	Artefact
52-5-0427	Budderoo track Grooves	Grinding Groove
52-5-0560	Nellies Glen/2	Water Hole
52-5-0561	Blue Pool	Water Hole
52-5-0625	Kangaroo Valley Artefact Scatter Duplicate copy of 52-5-0435	Artefact
52-5-0668	G2B A30	Artefact, PAD
52-5-0695	G2BA13	Conflict
52-5-0645	Kangaroo Valley 2	Artefact, PAD
52-5-0666	G2B A31	Artefact, PAD
52-5-0697	G2B A13	Conflict

PAD = Potential Archaeological 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 are not recorded on AHIMS;
- Recordings are 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 are 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 (NPW 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

8.4.1.1 Land Rights and Native Title Claims

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 15 July 2013 found no Native Title claims in the catchment.

8.4.2 Non-Aboriginal Heritage

There are three different types of statutory heritage listings of non-Aboriginal origin; local, state or national heritage items. A property is also considered 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 on the following databases to investigate the non-Aboriginal cultural heritage within this area:

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

Eight heritage items have been recorded in the Australian Heritage Database (shown on **Figure 8-4**):

- Church of the Good Shepherd Rectory (former), Rectory Park Way, Kangaroo Valley;
- Hampden Bridge, Moss Vale Road, Kangaroo Valley;
- Kangaroo Valley Pioneer Settlement, Moss Vale Road, Kangaroo Valley;
- Kangaroo Valley Police Station and Courthouse (former), Moss Vale Road, Kangaroo Valley;
- Kangaroo Valley Soldiers Memorial, Moss Vale Road, Kangaroo Valley;
- Kangaroo and Lower Shoalhaven Rivers, Moss Vale Road, Kangaroo Valley;
- Public School, 140 Moss Vale Road, Kangaroo Valley; and
- Red Rocks Nature Reserve, Nugents Creek Road, Kangaroo Valley (part of the Cambewarra Range Nature Reserve).

No heritage items were recorded in the State Heritage Register or the RailCorp S170 Heritage and Conservation Register for the catchment.

Within the Kangaroo Valley Township, the Shoalhaven Local Environment Plan (SLEP) 2014 lists 34 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 SLEP 2014. Due to the extensive heritage items listed in the SLEP 2014 that are located within the catchment area, it is recommended that a more detailed heritage assessment is undertaken prior to implementation of any management options.

9 Policies and Planning

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

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 instigated a process of updating the LEP. The Shoalhaven Local Environment Plan (SLEP) 2014 was finalised on 8 April 2014, and adopted 22 April 2014.

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

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

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

9.1.1 Current Land Use and Zoning

The Kangaroo Valley catchment is comprised predominately of rural land or bushland, with isolated centres of urban development, such as the Kangaroo Valley Township. The land use within the Kangaroo River catchment is controlled by the SLEP 2014. 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).

9.1.2 Flood Affected Land Use Zones

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

Zones within the 1% AEP event flood affected area are predominately RU1 Primary Production alongside the Kangaroo River and Barrengarry Creek. Local creek flooding, due to both catchment flows and backwater from the Kangaroo River affect residential properties (RU5 Village, R5 Large Lot) as well as public recreation areas. The peak 1% AEP extent also marginally extends across the SP2 Special Use Zone of the Kangaroo Valley Public School.

Table 9-1 Kangaroo Valley Catchment Land Uses (taken from NSW Government, 2013)

Zone	Land Use	Description
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
	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.
Residential	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

Zone	Land Use	Description
Rural	RU1 Primary Production Zone	▪ 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 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.
	RU5 Village	▪ Rural land to provide for a range of uses, services and facilities that are associated with a rural village.
Special Purpose	SP2 Infrastructure	▪ Infrastructure land that is highly unlikely to be used for a different purpose in the future, for example cemeteries and major sewage treatment plants ▪ Also appropriate for major state infrastructure or strategic sites such as major hospitals and large campus universities/TAFEs.
Waterways	W1 Natural Waterways	▪ To protect the ecological and scenic values of natural waterways ▪ To prevent development that would have an adverse effect on the natural values of waterways in this zone ▪ To provide for sustainable fishing industries and recreational fishing

9.2 Development Control Plans

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

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

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

Chapter G9 – Development on Flood Prone Land

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

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

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

The DCP requires the potential impacts of climate change to be addressed through the application of the following:

- For new building applications below 4m AHD, the impact of a 0.4m sea level rise is to be included when determining the flood planning level. This can be done by adding 0.4m to identified flood levels or through a flood assessment report which includes 0.4m sea level rise increase in design flood calculations.
- For applications for subdivision on land below 4m AHD, the impact of a 0.9m sea level rise is to be included in their design. This can be done by adding 0.9m to identified flood levels or through a flood assessment report which includes 0.9m sea level rise increase in design flood calculations.
- Throughout the DCP various AEP flood events are referred to as well as the flood planning level. It is up to the applicant to use the appropriate climate change conditions for these AEP flood events and the flood planning level. For example, if the document says “1% AEP flood event” this means the 2050 1% AEP flood event if the application is for a new development or it means the 2100 1% AEP flood event if the application is for a new subdivision.

Schedule 5 provides flood related development controls for site specific areas. These controls have been developed within the individual Floodplain Risk Management Plans for each area. It is expected that the recommendations of this FRMS&P would be considered for inclusion in the DCP.

Chapter G11 – Subdivision

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

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

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

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

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

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

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

- Dwellings and ancillary structures do not adversely impede the flow of floodwaters on flood liable land;
- The floor level of habitable rooms in a dwelling are above the relevant flood criteria including a suitable free board (i.e. flood planning levels);
- The design of all buildings and construction elements must resist the impacts of flood waters;
- Access is provided to the dwelling during time of localised flooding to assist evacuation; and
- Site works and building structures meet the standards of Councils Flood Policy, and relevant NSW Floodplain Development Manual guidelines. Applicants should also refer to DCP 106.

9.3 Planning Policies – Growth Management Strategy

Shoalhaven City Council have developed a draft Growth Management Strategy to provide leadership and planning direction for future development within the LGA to cater to a growing population.

The document provides a broad overview of planning aims and restrictions for urban areas within the LGA, which includes Kangaroo Valley. A key purpose of the Strategy is to provide residents with greater certainty to residents and landowners in the region as to the amount and type of growth they may expect to occur in the future.

For the Kangaroo Valley region, the Strategy lists Kangaroo Valley as a region with growth potential. It is noted under *Section 7.4.4 Constraints and Considerations* that the region is subject to flooding, and that flood behaviour and flood risks will place constraints on the type and extent of future developments.

The Strategy also summarises (in *Section 7.4.7 Proposed Investigations*) the types of studies that would be required in order to support any future rezoning or redevelopment, including ecological, heritage, fire risk, traffic and water quality. The draft does not include a flood risk assessment.

It is recommended that the minimum requirements listed in *Section 7.4.7* be updated to include a flood risk assessment for any proposed rezoning or redevelopment within the Kangaroo Valley Township.

9.4 South Coast Sea Level Rise Assessment

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

- 100mm for 2030;
- 230mm for 2050; and
- 350mm for 2100.

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

9.5 Recommended Changes to Development Controls for Kangaroo Valley

As a result of the investigation into planning controls, a number of recommendations are proposed to increase the effectiveness of the planning controls. These are set out in **Table 9-2**.

Table 9-2 Review of Existing Flood Planning Controls

Existing Control	Comments
Climate Change The required inclusion of sea level rise in the DCP (0.4m or 0.9m) does not correlate with the now adopted values of 0.1m, 0.23m and 0.35m.	**General to LGA** The DCP should be updated to reflect the most recently adopted sea level rise projections and to provide guidance to the applicant as to how and when they should be applied.
Minor Development For proposed dwelling extensions where it is impractical to raise the floor level, applications for extensions of the building at the existing level will be treated on their individual merits up to a maximum cumulative total increase in habitable floor area of: • $50m^2$ for residential and rural residential dwellings; and • $100m^2$ for dwellings associated with bona fide large area rural enterprises such as dairying	**General to LGA** It is recommended that this be allowed where it does not have an adverse impact on flooding.
Subdivision The DCP requires proposed subdivisions within the low hazard extent to provide reliable emergency vehicle access and pedestrians during a 1% AEP flood event (i.e. Access Controls 1 and 2). Subdivision is not suitable for High Hazard areas. There are no controls for subdivision outside of the Flood Planning Area.	**Floodplain Specific** Due to the limited road access to the Kangaroo Valley Township, there are areas with restricted access during a flood event. These areas have been identified in **Section 11**. Although some of these areas are not flood affected in a 1% AEP event, and some properties are outside of the PMF (i.e. not directly flood affected), they still face issues associated with emergency access (e.g. medical emergency) during a flood event. As such, it is recommended that the following control for access be applied to the areas identified as having restricted access: 1. Reliable emergency vehicle access is required for ambulance, SES, fire brigade, police and other emergency services during a 1% AEP flood event

Existing Control	Comments
Flood Evacuation Plan All residential and commercial developments (including minor development) within the high hazard areas are required to have a flood evacuation plan that ensures the timely, orderly and safe evacuation of people from the area and that it will not add significant cost and disruption to the community or the SES. A flood evacuation plan is also required for carparks within the flood planning area.	**Floodplain Specific** Due to access issues associated with flooding on main access roads within the Kangaroo Valley Floodplain and the relatively short period of time available to alert residents, initiate and execute evacuation, shelter in place may provide a more suitable response to flooding. It is recommended that any new development within the Kangaroo Valley Floodplain be required to prepare a flood evacuation plan and if the requirements of the DCP for effective evacuation cannot be met, that a suitable local evacuation location above the PMF be identified either within the residence or nearby. The duration of flooding should also be considered when determining whether shelter-in-place is an appropriate response to flooding.
Management and Design Special provisions apply to certain uses regarding storage of hazardous and valuable goods above the 1% AEP Flood Level, bunding to the FPL around hazardous chemical storage areas and animal refuge provisions above the 1% AEP Flood Level.	**General to LGA** Council may want to consider increasing the design level for the storage of hazardous and valuable goods and animal refuge to the flood planning level (1% AEP + 0.5m). This would provide consistency with Councils other controls.

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

10 Flood Planning Level Review

10.1 Background

The Flood Planning Level (FPL) for the majority of areas across New South Wales has typically been based on the 1% AEP +0.5m, in line with Planning Circular PS 03-007 (refer section 10.2).

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

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

- Risk to life,
- Long term strategic plan for land use near and on the floodplain,
- Existing and potential land use,
- Current flood level used for planning purposes,
- 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 the flood planning level,
- 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 of 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 +0.5m as the FPL for residential development. The need for another FPL to be adopted would be based on an assessment local flood behaviour, flood history, associated flood hazards or a particular historic flood.

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 the Shoalhaven DCP 2014 Council currently utilises the following FPLs:

- 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 Development 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. DCP 106 Amendment 1 restricts building within the floodway, and recommends against filling in flood storage areas. In general, DCP 106 Amendment 1 limits development in flood prone regions.

Given this, and other controls within the DCPs (Section 9.3), this is not considered to be a significant issue within the catchment.

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 Consequence of Adopting the PMF as a Flood Planning Level

Analysis of the flood damages (**Section 3**) 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 event indicate that the use of the PMF as the FPL would result in significantly higher floor levels, over 4m above ground level in some locations. As a result, construction would result in 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 DCPs.

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 (refer **Table 10-3**) it is also recommended that any critical infrastructure currently within the PMF should develop evacuation strategies to plan for these events.

10.8 Incremental Height Differences Between Events

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

Based on the existing flood behaviour, the average incremental height difference between events is shown in **Table 10-3** for selected events. These are determined based on the flood levels determined at each of the properties within the catchment as part of the flood damages analysis. Note that differences are only calculated where flood levels are reported in the 2% AEP event.

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 (0.38m), while the difference between the 1% AEP and the PMF averages 4m.

As a result of the significantly higher PMF depths over the other design events, an FPL based on any event other than the PMF will still leave residents with a significant residual risk that would need to be managed through planning or emergency response arrangements.

Table 10-3 Relative Differences Between Design Flood Levels

Event (AEP)	Difference to PMF (m)	Difference to 1% AEP (m)	Difference to 2% AEP (m)
1%	4.05	-	-
2%	4.43	0.38	-
5%	5.24	1.19	0.81

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 Climate Change

A climate change assessment was undertaken for Kangaroo Valley assessing changes in both sea level rise and rainfall intensity. This assessment is provided in **Appendix F**.

As a result of the study area being located upstream of Tallowa Dam, sea level rise has no impact on the study area.

It was found that changes in rainfall intensity have the potential to result in flooding impacts within the study area. An increase in rainfall intensity of 20% was found to increase average overfloor property flooding depths by 1m. There was a significant variation across the study area however. The lower 25% of properties had increases of 0.3m, while the top 25% of properties had increases over 1.3m.

10.11 Risk

As discussed in **Section 11**, residents in Kangaroo Valley, with respect to flooding, experience:

- Minimal to no warning times;
- An inability for emergency agencies to access the township during flood events due to the loss of access roads into the township form nearby centres; and,
- A quick response time of flooding, with access roads and properties in the township being inundated within 2 hours of the river breaking its banks.

Furthermore, while residents are aware that the river experiences flooding, no significant flooding has occurred in the recent memory of residents, so the risks posed by these major flooding events are underrepresented.

These risks are compounded by a PMF level that is significantly higher than other design events (see **Section 10.8**).

This suggests that the FPL alone is not able to sufficiently ensure that residents are safe during flood events. As a result, further emergency management procedures will be required to be implemented by the community in responding to flood events.

10.12 Critical Infrastructure

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.

10.13 Freeboard Selection

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

The freeboard may account for factors such as:

- 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 a 10% change in model parameters, refer Appendix E)

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.

10.14 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 Development 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 are a relatively low number of commercial and industrial sites in the study area that are 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 assessment also highlighted that the study area is at risk of higher flood levels as a result of climate change. Given a typical design life of 50 years (and that the effective service life of buildings can be commonly longer than this), new buildings constructed now will still be operating beyond 2050. As a result of the variability in climate change impacts across the study area, Council's current approach of revising the 1% AEP condition to include climate change is considered appropriate for the study.

It should be noted that an FPL set at the 1% AEP + 0.5m level will still result in significant over floor flooding in the PMF event, in the order of 5 – 6m overtopping depths. These depths are such that even second stories on properties will not provide flood refuge in the PMF event. It is therefore important that other strategies are put in place, such as education and community awareness measures and the provision of flood refuges, to address this risk to life.

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

A true hazard map of the FPA is shown in **Figure 10-2**.

The hydraulic categories of the FPA are shown in **Figure 10-3**.

11 Emergency Response Arrangements

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

11.1 Emergency Response Documentation

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 Local Flood Plan

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

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

The Flood Plan notes that Kangaroo Valley is a flood prone region of the catchment, notes that landslides are of concern in the region during flood events, and lists the Bendeela Picnic and Camping ground, located downstream of the study area, as a location of concern.

The Flood Plan lists flood evacuation points for flood affected regions. For Kangaroo Valley, this location is the Showgrounds on Moss Vale Road.

It is recommended that the results of the Floodplain Risk Management Study and Plan be provided to the SES to allow them to update the plan as required.

11.2 Emergency Service Operators

The Kangaroo Valley 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 Kangaroo Valley is Moss Vale Road, which is flood affected during large storm events within the study area and is likely to be affected elsewhere.

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

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

The role of the SES in flash flood areas such as local creeks is generally at the clean-up stage. For longer duration flooding, the SES can assist in evacuation and protection of properties. Within the Kangaroo Valley catchment, the SES may be able to assist with floods arise from the Kangaroo River, but not the local creeks.

The locations of key emergency services for Kangaroo Valley are outlined in **Table 11-1**. There is no fire station in Kangaroo Valley. The nearest fire stations are located in Berry and Nowra.

Table 11-1 Emergency Service Providers Locations

Emergency Service	Location
Shoalhaven Hospital	2 Shoalhaven Street, Nowra
Kangaroo Valley Police Station	175 Moss Vale Road, Kangaroo Valley

11.3 Access and Movement During Flood Events

Any flood response suggested for the study area must take into account the lack 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 (if available) 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 Kangaroo Valley Township. The crossings are shown in **Figure 11.1**. The table shows the time it takes for them to overtop by greater than 0.2m in the 1% AEP, for the 12hr critical duration, and how long they are overtopped for.

The table shows that most roads remain open for a significant period of time, and only remain overtopped for relatively short periods of time during long duration storm events.

In short duration events, the roads both overtop and reopen quickly, due to the short, intense nature of the rainfall and flooding.

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 are flood free, access may still be lost between adjacent townships.

Table 11-2 Flooding Time of Key Access Roads

Location	ID	Time to loss of access (hours)				Time of lost access (hours)			
		6hr Storm	9hr Storm	12hr Storm	24hr Storm	6hr Storm	9hr Storm	12hr Storm	24hr Storm
Jarrets Creek crossing	A	3	4	7	-	0.5	0.5	1	-
Tennis Complex	B	4	5	8	16	3	3.5	5	5
Myrtle Creek crossing	C	4	6	8	15	3	4	>6	5.5

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 are to be recommended.

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

A review was therefore undertaken on driver safety related to rainfall events.

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.

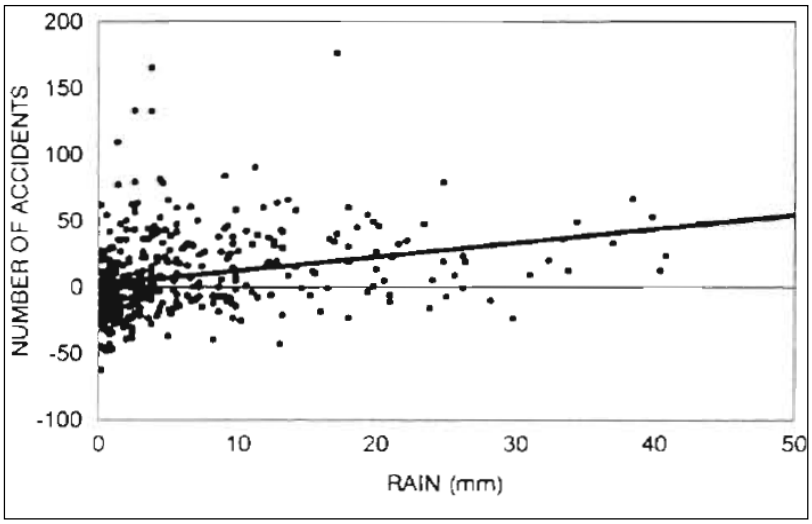

Figure 11.2 Accidents per day vs daily rainfall (Andreescu & Frost, 1998)

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

The rainfall intensity temporal distribution for the 1% AEP 12 hour event is shown in **Figure 11.3**. It is noted that these are exclusive of climate change impacts on rainfall intensities.

The figure shows that rainfall intensities are generally greater than 10mm/hr, with peaks of 15mm/hr, 15mm/hr, 52mm/hr and 37mm/hr at 1 hour, 4 hours, 7 hours and 9 hours into the storm respectively.

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 the 1% AEP 12 hour event are well in excess of the values identified in the literature as beginning to have an effect on driving risk.

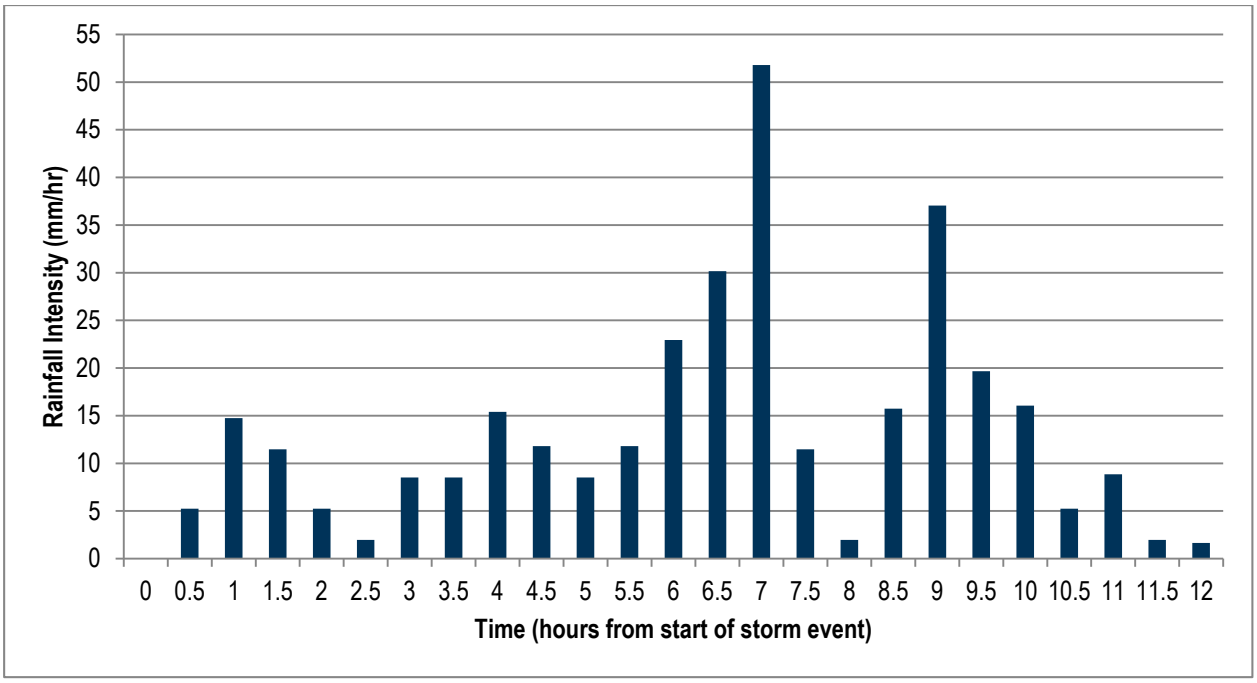

Figure 11.3: Kangaroo Valley 1% AEP 12hr Temporal Rainfall Distribution

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

11.4 Flood Emergency Response

11.4.1 Flooding Behaviour

Flooding of Kangaroo Valley is primarily driven by the Kangaroo River. Smaller tributaries pass through the Township, but they typically result in nuisance flooding only, and do not cause significant damage.

The results show that there is a significant difference in in peak water levels between design events, as illustrated in **Figure 11-4**. The figure shows a large increase in peak levels between the 10% AEP event and 2% AEP event, and a second large difference between the 0.5% AEP event and the PMF event. The figure also shows that in the larger flood events, there is little lateral expansion of the flood extent, despite the increased levels, as a result of the sharp rise in terrain at the edge of the floodplain.

The critical duration of the Kangaroo River is 12 hours, with the peak of the flood occurring 6.5 hours after the start of the storm.

Within the study area, the Kangaroo River causes flooding issues throughout the Township, particularly for those on the north side of Moss Vale Road, adjacent to the river. Backwatering from Kangaroo River flooding also affects access at multiple locations along Moss Vale Road.

While longer duration storms result in the peak flooding within this system, it is also important to also consider the severity of short duration events. Peak water levels for a range of durations are shown for key locations in **Table 11-3**.

The results show that whilst the 12hr event is critical in these locations, shorter duration events are still capable of resulting in significant peak water levels, and associated smaller warning and evacuation times. As such, it's important to make provisions for short duration responses in these regions as well.

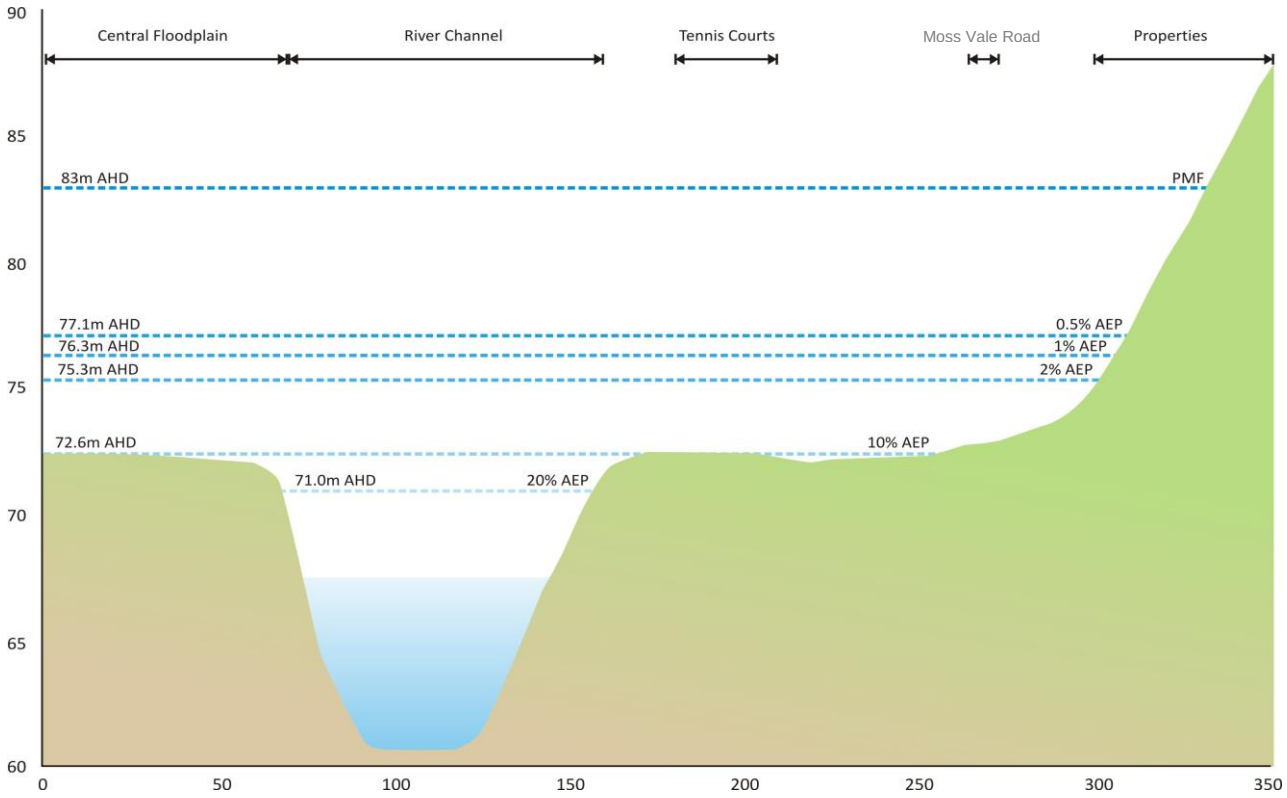

Figure 11.4: Comparison of Typical Flood Levels in Design Events

Table 11-3 Severity of storm durations for the 1% AEP event

Location	ID	Peak overtopping depth (m)				Time to loss of access (hours)			
		6hr Storm	9hr Storm	12hr Storm	24hr Storm	6hr Storm	9hr Storm	12hr Storm	24hr Storm
Jarrets Creek crossing	A	0.2	0.2	0.3	-	0.5	0.5	1	-
Tennis Complex	B	2.5	3.1	3.9	3.4	3	3.5	5	5
Myrtle Creek crossing	C	1.4	1.7	2.1	1.8	3	4	8	5.5

Shown below in **Table 11-4**, are the numbers of residential and commercial properties affected by over floor flooding in each AEP event. The table also notes how many of these affected properties have second stories which can offer flood refuge.

Relatively few properties are affected until larger events (2% AEP and greater) are experienced. However, the majority of properties lack a second storey to take refuge in, which increases the hazard level of these properties in flood events. It should also be noted that even properties with second stories will have these second floors flooded during the PMF event.

Table 11-4 Residential & Commercial Properties affected by over floor flooding

AEP	Total Properties with over floor flooding	Single story properties with over floor flooding	Double storey properties with over floor flooding
20%	0	-	-
10%	0	-	-
2%	12	7	5
1%	22	17	5
0.5%	33	27	6
PMF	89	74	15

11.4.2 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.*

As noted in Section 5.2.2, the response time of the catchment for the design flood events was less than 6 hours.

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.

11.4.3 Flood Warning

Flood warning within the study area is currently limited. An option assessed as part of this study was the installation of a flood warning system tied to the water level gauge at Hampden Bridge. Having the gauge located in the township reduces the warning time available compared to upstream gauges, but it ensures that warning of township flooding is given regardless of where the rainfall event occurs.

The trigger level adopted should be determined in consultation with the community. Lower trigger levels will provide more warning time, but will result in the alarm being triggered more frequently. Given the relatively short evacuation distances required (as all evacuation will be local, within the township), significant warning times are not required.

As a starting point for discussion with the community, a trigger level set just prior to the Kangaroo River breaking its banks at the township would provide 1 to 1.5 hours warning before access along Moss Vale Road was lost.

11.4.4 Flood Response

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.

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:

- 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; and,
- Evacuation: The movement of residents out of the floodplain before their property becomes flooded.

Each of these options have particular requirements given the nature of flooding within the study area, and associated advantages and disadvantages.

Each option is discussed below. It is recommended that the discussion form the basis for a conversation with both the SES and the community, in order to arrive at an effective and supported means of managing the residual flood risk in the study area.

11.4.4.1 Shelter in Place

The use of shelter in place requires a place within the building to be above the PMF level. Given the significant difference between the PMF and the other design events, a key concerns with the use of shelter in place within Kangaroo Valley is that it would require buildings to be constructed with 3 storeys, in order to ensure that the top flood is above the PMF. The top flood may be a loft or attic space rather than a complete floor. Such a space would have to accessible during a flood event, which would necessitate safe, flood proof internal access.

Furthermore, controls to achieve this would require Council to be able to enforce flood related development controls outside of the flood planning area, which would require special approval under PS 07-003.

The primary advantage of shelter in place is that it does not require any special understanding of flood response on behalf of the residents. People would naturally move higher in the property as flood levels raise.

It should be noted that shelter in place would only be suitable for new buildings. Existing properties that are flood effected would not be able to adopt a shelter in place response to flooding as many do not have habitable space above the PMF level.

11.4.4.2 Evacuation

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

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

As evacuation will be undertaken on a local scale, significant warning time would not be required, as residents will be able to evacuate relatively rapidly. A warning time of an hour would give residents sufficient time to relocate some household objects, pack some belongings, and walk to the refuge centre. This warning could be provided by a warning linked to the water level gauge at Hampden Bridge (refer **Section 11.4.3**).

In order for an evacuation strategy to be effective, a flood refuge will need to be constructed somewhere in the township that is above the PMF level, and of a suitable size to shelter those residents whose properties are flood affected in the PMF event.

11.4.5 High Flood Risk Locations

11.4.5.1 Schools

The Kangaroo Valley Primary School and Preschool are flood free in the 1% AEP event but is flood affected in the PMF event. Access to both the east and the west along Moss Vale Road is lost in both these events. There is high ground immediately behind the school.

As the school is flood free in all but the most extreme flood events, it is recommended that children remain at the school, and not seek to return home via roads that are prone to overtopping. In extreme flood events, refuge can be taken immediately behind the school, on the adjacent high ground. This is an option of last resort, and would require a sufficiently large and weather proof structure to be constructed as a refuge. The school has rising access during large flood events, so evacuation can be implemented when it is observed that over floor flooding of the school may be experienced.

11.4.5.2 Kangaroo Valley Glenmack Park Caravan Park

The Kangaroo Valley Glenmack Park caravan park is located on Moss Vale Road, on the eastern side of the Kangaroo Valley Township. Regions of the park are located on low-lying land adjacent to the Kangaroo River.

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

- The frequency with which it experiences over ground and over floor flooding;
- The possibility of a number of people being concentrated at the property during a flood event;

- The likelihood that patrons will be from outside the catchment, and may not appreciate the flood risks during a storm event; and,
- A lack of vertical evacuation and shelter in place options.

Protection options were investigated for the site, and a levee was found to be a feasible mitigation option for events up to the 1% AEP event (refer to **Section 13** for further information). An evacuation strategy would still be required for a response to flood events larger than the 1% AEP event.

A Flood Emergency Response Plan is required for the development as part of DCP 123 (refer **Section 0**)

11.4.5.3 Tourists

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

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

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

11.5 Recovery

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

11.6 Development of a Flood Response Plan

Building on the above investigation into the flood risks, a Flood Response Plan will be developed as part of the project, and provided as a supplementary document.

The Flood Response Plan will be developed for use during a flood event. The Emergency Response Plan will include details on:

- Available access along key roads in flood events,
- Trigger levels for rainfall / creek levels which would initiate an evacuation response,
- Detailed, property specific, flood summaries to inform property owners of expected flood levels for given storms, and appropriate responses.

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 will 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 undertaken (refer **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.

The questionnaire results showed that 70% of respondents were living in Kangaroo Valley at the time of the 2005 flood event. However, the 2005 event was relatively small, less than a 20% AEP event. The largest flood during which any of the current residents were living in Kangaroo Valley was the 1975 event which was in the order of a 10% AEP event.

During the community workshop that was held as part of the consultation process, attendees demonstrated a high level of awareness of flood behaviour within their Township, and an understanding of the flood risks resulting from this behaviour. However, given that none had experienced a major flood, it is highly likely that the community is underappreciating the risks associated with flooding in the study area.

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

12.2 Education and Awareness Program

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

12.2.1 Short Term

12.2.1.1 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.

12.2.1.2 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 will help the community to better understand the flood event and general catchment flood behaviour. This may include the collection / determination of data such as:

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

12.2.2 Medium Term

12.2.2.1 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.

12.2.2.2 Develop a Flood Information Package for New Residents

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

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

12.2.2.3 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.

12.2.3 Long Term

12.2.3.1 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. Furthermore, staff and managers of schools and childcare centres should be made aware of flood risks at their sites, and encouraged and supported in identify and maintaining appropriate flood risk strategies.

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 personnel 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.

12.3 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.

12.3.1 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.

12.3.2 Actions resulting from a Period of 5 years without a large flood event

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

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

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

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

13 Floodplain Risk Management Options

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

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

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

13.2 Base Case

In order to assess the various mitigation options, it is necessary to define a base case. This base case provides a reference against which the effectiveness of various options can be assessed.

In this case, the base case is the existing Kangaroo Valley catchment, as defined in the Flood Study Review (Cardno, 2013).

13.3 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**.

A number of these options were further assessed with the hydraulic model (as marked with an asterisk (*)). These options were chosen for further assessment based on:

- Expected effectiveness
- Viability
- Liaison with the community
- Liaison with Council
- Liaison with other stakeholders

Table 13-2 Kangaroo Valley Flood Mitigation Options

Option ID	Option	Details	Expected Benefit	Major Constraints	Assess in Hydraulic Model?
Levees These options are focused on the construction of levee banks or flood walls to create barriers to flood waters					
FM 1.1	Cullan Crescent Levee	Construction of a levee behind properties on Cullan Cres to the 1% AEP level	Removal of property and house flooding in events up to and including the 1% AEP event.	Cadastre indicates that lot boundaries extent to centre of channel, which will mean works must be on private property. As the work will be done within properties that will see the benefit, this may be acceptable. Space may be limited, which may require a concrete / block-work wall that may be less appealing to residents. Based on house location and terrain, wall would need to be 4 - 8m high, which is unlikely to be supported by residents. A lower levee to provide protection in more frequent events was not investigated as the properties do not experience flooding until the 1% AEP event.	No
FM 1.2	Tennis Court Levee	Construction of a levee behind tennis courts and adjacent properties on Moss Vale Rd to the 1% AEP level	Removal of property and house flooding in events up to and including the 1% AEP event.	Only tennis courts flooded in 10% AEP, property not impacted until 2% AEP. Providing protection in the 1% AEP would require a floodwall 3m high running 600m behind the tennis courts, the open space to the west and behind the properties to the east, which would impact the aesthetics of the area, as well as restricting access to the river. The option would also require the provision of drainage for upstream overland flow to prevent ponding on the property side of the levee.	No
FM 1.3 *	Caravan Park Levee	Construction of a levee around the caravan park to the 1% AEP level	Removal of flooding within the caravan park in events up to and including the 1% AEP. Will also have positive benefits for emergency evacuation by providing the park more time to evacuate people to the adjacent Showgrounds.	No major constraints. The levee is 2.6m high at its highest. For the majority of the levee, the height is 1 – 1.5m.	Yes
FM 1.4 *	Road Raising (0.2m overtopping limit)	Road raising along Moss Vale Rd to reduce overtopping depths to 0.2m in the 1% AEP event	Will allow for safe travel and evacuation in events up to and including the 1% AEP event.	Will require road works in 5 locations through the township which may raise heritage issues, depending on the extent of raising required.	Yes
FM 1.5 *	Road Raising (flood free in 1% AEP Event)	Road raising along Moss Vale Rd to prevent overtopping in the 1% AEP event	Will allow for safe travel and evacuation in events up to and including the 1% AEP event. Will also act as a levee to prevent flooding of properties from Kangaroo River flows on the south side of the roadway	Will require road works in 5 locations through the township which may raise heritage issues, depending on the extent of raising required. May also require works to the culverts crossing under the road.	Yes

Option ID	Option	Details	Expected Benefit	Major Constraints	Assess in Hydraulic Model?
Detention Basins These options propose to create detention basins upstream of flooding issues to detain flood waters and release them in a controlled manner					
FM 2.1 *	Town Creek Detention Basin	Construction of a detention basin on the eastern branch of Town Creek, upstream of Moss Vale Rd	Reduction in downstream property flooding	Potentially would require some works on private property.	Yes
FM 2.2	Kangaroo River Detention Basin	Construction of large basin in upstream reaches of Kangaroo River	Retention of floodwaters to reduce peak flood levels downstream	Finding a suitable location may be problematic. Likely to have a significant cost associated as storage would have to be very large.	No
Channel Works These options are focused on improving the efficiency or increasing the capacity of channels within the study area.					
FM 3.1 *	Kangaroo River Vegetation Management	Clearing of vegetation within the Kangaroo River upstream and downstream of Hampden Bridge, over a length of approximately 2km.	Reduction in peak river levels due to increased conveyance	May have environmental constraints depending on the ecological value of the vegetation proposed to be removed (refer **Section 8**)	Yes
FM 3.2 *	Creek Formalisation	Formalise the channels of Jarrets Creek and Town Creek, including diversion of Town Creek 2 into Town Creek 3	Better containment and conveyance of flows, reducing the incidence of adjacent overland flooding	May require work on private property. Will also have environmental impacts due to the works in the creek. The creek will be rehabilitated, but the existing vegetation will be lost.	Yes
FM 3.3	Hampden Bridge Widening	Widen Hampden Bridge	Reduction of upstream peak river levels through increasing the capacity of the bridge, which acts as the major control in the system	Significant heritage constraints. Potentially would require works on private property. Increases in flood velocity through the bridge and the adjacent river sections may lead to increased erosion risks.	No
FM 3.4 *	Central Channel – Large	Excavation of overflow channel through central floodplain (100m wide)	Improving the conveyance and storage of this region in order to reduce peak river flood levels and flooding in the township.	Works will be on private property. Will require a large amount of earthworks to construct (approx. 915,000 m^3 of excavation).	Yes
FM 3.5 *	Central Channel – Small	Excavation of overflow channel through central floodplain (40m wide)	Improving the conveyance and storage of this region in order to reduce peak river flood levels and flooding in the township.	Works will be on private property. Will require a large amount of earthworks to construct (approx.. 145,000 m^3 of excavation)	Yes
FM 3.6	Kangaroo River Widening	Excavation of Kangaroo River banks to increase river capacity	Reduction of peak river levels and a reduction in township flooding	Significant environmental constraints. May require works on private property.	No
Drainage Augmentation These options primarily focus on increasing capacity and efficiency of culverts throughout the study area. It is noted that for modelling purposes, it was generally assumed that the existing pipe would be duplicated, or doubled in capacity. This could be optimised during the detailed design process.					
FM 4.1 *	Culvert Augmentation	Augmentation of all culverts crossing Moss Vale Rd (double capacity) and provide flood gates on all culverts to prevent backwater from river flooding	A reduction in overtopping flows at culvert crossings, and a potential reduction in peak flood levels upstream of the culvert due to the prevention of river flooding progressing upstream.	Disruption to local traffic; potential heritage constraints depending on extent of works	Yes

*** Indicates options that were assessed with the hydraulic model**

13.3.1 Preliminary Option Assessment

To test the feasibility of each of the hydraulically assessed structural options, they were first run for the 10% AEP and 1% AEP events to ensure they worked as expected and did not result in adverse flooding behaviour. The results of this analysis are summarised below in **Table 13-3**. The table summarises the outcome of the 10% and 1% AEP runs, and whether the option should be considered for further analysis. Impact plots for the 1% AEP have been prepared for each option, and the figure numbers are shown in the table.

Table 13-3 Preliminary Options Assessment Outcome

ID	Assessment Outcome	Suitable for further modelling & damage assessment?	1% AEP Impact Figure Number
FM 1.3 Caravan Park Levee	Removed flooding in the caravan park for both 10% and 1% AEP events. Some minor increases in flood levels adjacent to the levee in the 10% AEP.	Yes	13-2
FM 1.4 Road Raising (0.2m overtopping)	No impacts in the 10% AEP. Some minor impacts in the 1% AEP adjacent to the bridge of Nugents Creek in the south east. The option was successful in delivering emergency access and egress in events up to the 1% AEP, and has been retained as an option. However, no further modelling was undertaken for a damages assessment, as the option does not affect flooding on properties, and consequently, does not reduce the flood damages.	No	13-3
FM 1.5 Road Raising (No overtopping)	Flood level increases on properties on the south side of the road increases due to ponding occurring behind the raised road. May be possible to remove this by undertaking filling of the fronts of these properties. However, this option was not considered viable given: ▪ The heritage constraints ▪ That works would be required on private property ▪ That safe access and egress can be provided in the 1% AEP through option FM 1.4 that does not have these impacts	No	13-4

ID	Assessment Outcome	Suitable for further modelling & damage assessment?	1% AEP Impact Figure Number
FM 2.1 Town Creek Detention	Reductions of 0.12m downstream of the basin in the 10% AEP event. Reductions of 0.08m were observed in the 1% AEP, with a small region of increases of 0.03m from where the basin overtops in the 1% AEP.	Yes	13-5
FM 3.1 Vegetation Management	Reductions of 0.05 – 0.18m were observed within the river for the 10% AEP event. In the 1% AEP event, reductions of 0.07m were observed throughout the floodplain.	Yes	13-6
FM 3.2 Creek Formalisation	A wide reduction in flood levels was observed on both creeks as a result of the formalisation and diversion. There were some increases within Town Creek 2 (which received the diverted water) but these increases were contained within the existing creek flowpath, and did not impact properties.	Yes	13-7
FM 3.4 Central Channel Large	Significant reduction in riverine levels in the 10% AEP, ranging from 0.25m to 1.1m in the vicinity of the township. The downstream region of the central floodplain and Barrengarry Creek showed minor increases of 0.02m, but these increases did not impact properties. In the 1% AEP event, reductions of 0.08m to 0.3m were observed within the township and across the floodplain.	Yes	13-8
FM 3.5 Central Channel Small	Overall performance was similar to FM 3.4, although the reductions were of a lower magnitude; 0.03 to 0.2m in the 10% AEP event and 0.01 to 0.02m in the 1% AEP. Given the disturbances that this option would require, these reductions were not deemed large enough to warrant the works. If the works are possible, it would be better to adopt FM 3.4 to realise greater reductions.	No	13-9

ID	Assessment Outcome	Suitable for further modelling & damage assessment?	1% AEP Impact Figure Number
FM 4.1 Culvert Augmentation	Very minor improvements on 2 of the 5 culverts in the 10% AEP event, and on only 1 culvert in the 1% AEP event. Reductions did not benefit properties, or significantly reduce road overtopping.	No	13-10

13.3.2 Environmental Considerations

According to State Environmental Planning Policy (SEPP) (Infrastructure) 2007, flood mitigation works "may be carried out by or on behalf of a public authority without consent on any land". These works include construction, routine maintenance and environmental management works which applies to most of the flood mitigation options in **Table 13-3**. Although consent is not required, most flood mitigation works will require further environmental assessment.

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

When carrying out flood mitigation works, Council will be required to take out further permits, licenses and approvals such as:

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

13.4 Property Modification Options

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

Options for which funding may be available from OEH are:

- House Raising P 1
- Voluntary Purchase P 2

Details of the OEH grants available may be found at: www.environment.nsw.gov.au/coasts/Floodgrants.htm

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

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

These options are discussed in detailed below.

13.4.1 P 1 – House Raising

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

13.4.2 P 2 – Voluntary Purchase

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

13.4.3 P 3 – Building and Development Controls

The key document for flood related controls in the Shoalhaven LGA is DCP 2014, and recommended updates to this document are discussed in **Section 9.2**.

13.4.4 P 4 – House Rebuilding

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

13.4.5 P 5 – Land Swap

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

13.4.6 P 6 – Council Redevelopment

As no properties were found to be flood affected in frequent events, this option is not considered viable for the Kangaroo Valley area.

13.4.7 P 7 – Flood Proofing

Flood proofing involves undertaking structural changes and other procedures in order to reduce or eliminate the risk to life and property, and thus the damage caused by flooding. Flood proofing of buildings can be undertaken through a

combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding.

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

Examples of proofing measures include:

- All structural elements below the flood planning level shall be constructed from flood compatible materials
- 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 above 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 Kangaroo Valley floodplain.

13.5 Emergency Response Modification Options

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

- Information transfer to the SES EM 1
- Flood warning system EM 2
- Public awareness and education EM 3
- Flood warning signs at critical locations EM 4

These options are discussed in detail below.

13.5.1 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 will be detailed in the Flood Emergency Plan, to be prepared as part of the next stage of the study.

13.5.2 EM 2 – Flood Warning System

There are four existing pluvio-stations in the ranges upstream of the Township, as shown in **Figure 13-11**. These existing gauges are unlikely to be useful for flood prediction due to both the highly variable nature of rainfall across the catchment (as a result of the upstream ranges) and the fact that the gauges are all located in the upstream reaches of the catchment.

A more suitable location for a warning gauge would be the water level gauge at Hampden Bridge. Having the gauge located in the township reduces the warning time available compared to upstream gauges, but it ensures that warning of township flooding is given regardless of where the rainfall event occurs.

The trigger level adopted should be determined in consultation with the community. Lower trigger levels will provide more warning time, but will result in the alarm being triggered more frequently. Given the relatively short evacuation distances required (as all evacuation will be local, within the township), significant warning times are not required.

As a starting point for discussion with the community, a trigger level set just prior to the Kangaroo River breaking its banks at the township would provide 1 to 1.5 hours warning before access along Moss Vale Road was lost.

13.5.3 EM 3 – 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**.

13.5.4 EM 4 – 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, such as those along Nugents Creek, Town Creek and Myrtle Creek, which experience overtopping in the 2% AEP event.

13.6 Data Collection Strategies

This would involve the preparation of a flood data collection forms and processes and the use of these 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 H**.

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 will also be required at the detailed design phase.

Table 14-1 Costs of Quantitatively Assessed Options

Option ID	Option	Capital Cost	Ongoing Costs
FM 1.3	Caravan Park Levee	$300,100	$500
FM 2.1	Town Creek Detention Basin	$708,300	$10,000
FM 3.1	Kangaroo River Vegetation Management	$153,600	$15,000
FM 3.2	Creek Formalisation	$1,149,100	$2,500
FM 3.4	Central Channel - Large	$60,495,800	$25,000

14.2 Average Annual Damage for Quantitatively Assessed Options

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

The results in **Table 14-2** show that the most effective option in reducing damages was the large central channel, closely followed by the caravan park levee. The vegetation management option also had a relatively substantial reduction in damages.

Formalisation of Town Creek only resulted in a minor reduction in damages, while the detention basin option had no real 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. This 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	$216,165	-
FM 1.3	Caravan Park Levee	$200,717	$15,448.00
FM2.1	Town Creek Detention Basin	$216,168	-$3.00
FM 3.1	Kangaroo River Vegetation Management	$202,740	$13,425.00
FM 3.2	Creek Formalisation	$215,862	$303.00
FM 3.4	Central Channel - Large	$200,438	$15,727.00

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
FM 1.3	$200,717	$15,448	$213,193	$300,100	$500	$307,000	0.69	1
FM2.1	$216,168	-$3	-$41	$708,300	$10,000	$846,307	0.00	5
FM 3.1	$202,740	$13,425	$185,275	$153,600	$15,000	$360,611	0.51	2
FM 3.2	$215,862	$303	$4,181	$1,149,100	$2,500	$1,183,602	0.00	4
FM 3.4	$200,438	$15,727	$217,044	$60,495,800	$30,000	$60,909,822	0.00	3

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

It is noted that none of the proposed options have a benefit-cost ratio greater than 1.

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.

Also, whilst the options are successful in reducing flood levels, these reductions do not result in significant numbers of properties moving from having over floor flooding, to no over floor flooding. This is demonstrated in **Table 14-4** which shows the number of properties experiencing over floor flooding in each AEP event for the various options.

Table 14-4 Number of Properties (excluding caravans) with Over floor Flooding under Different Options

Option	PMF	0.5% AEP	1% AEP	2% AEP	10% AEP
Existing	89	33	22	12	0
FM 1.3	89	33	22	12	0
FM2.1	89	33	22	12	0
FM 3.1	89	33	21	12	0
FM 3.2	89	33	22	12	0
FM 3.4	89	33	22	11	0

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 Matrix Assessment

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

Each option is given a score according to how well the option meets specific considerations. In order to keep the scoring simple a system was developed for each criterion as shown in **Table 15-1**.

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. This will be updated following the exhibition of the draft report to incorporate feedback from the community.

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.

15.2 Multi-Criteria Matrix Assessment

The assignment of each option with a score for each criterion is shown in its entirety in **Appendix I**. 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 I**.

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

1. P 3 Building and Development Control Plans
2. EM 4 Public Awareness and Education
3. EM 3 Flood Warning System

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

1. FM 1.3 Caravan Park Levee
2. FM 3.1 Kangaroo Valley Vegetation Management
3. FM 3.2 Creek Formalisation

However, an analysis of the benefits and costs arising from the structural options showed that none of the options delivered a benefit-cost ratio above one. The caravan park levee had the highest ratio of 0.7, while all the other options had ratios of 0.5 or below, showing that the costs of implementing the option were at least twice as high as the resultant reduction in damages. Consequently, aside from of the caravan park levee, no other structural options are considered viable.

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 I** 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 Kangaroo Valley Floodplain Risk Management Plan (Cardno, 2014), which has been prepared as a supplementary document to this Floodplain Risk Management Study.

17 Conclusion

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

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

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

Flood affected properties and damages under existing conditions

Flood Event	Properties with Over floor flooding	Properties with Over ground flooding	Flood Damage
50% AEP	0	0	0
20% AEP	0	0	0
10% AEP	14	21	$1,805,800
2% AEP	34	31	$4,317,800
1% AEP	54	36	$7,091,500
PMF	115	94	$26,827,100
Average Annual Damage			**$216,165**

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

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

These options included:

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

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

The assessment 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 3 Building and Development Control Plans
2. EM 4 Public Awareness and Education
3. EM 3 Flood Warning System

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

1. FM 1.3 Caravan Park Levee
2. FM 3.1 Kangaroo Valley Vegetation Management
3. FM 3.2 Creek Formalisation

However, an analysis of the benefits and costs arising from the structural options showed that none of the options delivered a benefit-cost ratio above one. The caravan park levee had the highest ratio of 0.7, while all the other options had ratios of 0.5 or below, showing that the costs of implementing the option were at least twice as high as the resultant reduction in damages. Consequently, aside from of the caravan park levee, no other structural options are considered viable.

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.

18 Qualifications

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

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

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

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

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

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