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Tweed Coastal Creeks Floodplain Risk Management Plan

Final

December 2015

TWEED SHIRE COUNCIL

Tweed Coastal Creeks Floodplain Risk Management Plan

Prepared for:	Tweed Shire Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Synopsis: **Floodplain Risk Management Plan for the Tweed Coastal Creek Area**

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Executive Summary

The Tweed Coastal Creeks Floodplain Risk Management Plan (FRMP) is the result of detailed investigation and consideration of flood risk across the study area described in the Tweed Coastal Creeks Floodplain Risk Management Study (FRMS). The Floodplain Risk Management Study and Plan are integrally linked. The Study provides for the assessment of options that form the basis for the considerations and decisions in the Plan. The process has been overseen by the Tweed Shire Council Floodplain Risk Management Committee, with input from identified stakeholders and the broader community used to inform and guide the selection of measures. The Tweed Coastal Creeks Floodplain Risk Management Study and Plan was endorsed at a Tweed Shire Council meeting on the 10th December 2015.

All of the recommended measures are non-structural, such as improved flood education, emergency planning and development planning. A number of properties have also been identified as suitable for voluntary house purchase or raising.

A summary of all measures recommended for implementation and / or further investigation is provided in the table below. Further details of relative priorities, investment and key agency responsibilities are provided in the Implementation Plan in Section 7.

FRMS No	Description	Recommendation	Section
Response Modification Measures			
1	Update the Local Flood Plan	Recommended	4.1.1
2	Plan for Different Types of Flood Risk	Recommended	4.1.2
3	Plan for Flash Flooding	Recommended	4.1.3
4	Plan for Pedestrian and Local Evacuation	Recommended	4.1.4
5	Promote General Flood Awareness	Recommended	4.2.1
6	Target Education Campaigns Based on Flood Risk	Recommended	4.2.2
7	Provide Flood Information Online to the Community	Recommended	4.2.3
8	Provide Information to Assist with Personal Flood Plans	Recommended	4.2.4
9	Target New Residents and Tourists with Flood Information	Recommended	4.2.5
10	Use Social Media	Recommended	4.2.6
11	Undertake Disaster Resilience Leadership Workshops	Recommended	4.2.7
12	Enhance Gauge Network	Recommended	4.2.8
13	Install Flash Flood Warning System	Recommended	4.2.9
14	Establish Flood Watch Network	Recommended	4.2.10
15	Classify Existing and New Stream Level Gauges	Recommended	4.2.11
16	Develop Flood Intelligence Cards	Recommended	4.2.12
17	Develop Gauge Triggers	Recommended	4.2.13

FRMS No	Description	Recommendation	Section
18	Trial Flood Decision Support System	Recommended	4.2.14
19	Predict Storm Surges	Recommended	4.2.15
Property Modification Measures			
20	Voluntary House Purchase	Recommended	5.1.1
21	Voluntary House Raising	Recommended	5.1.2
22	Inform High Risk Residents	Recommended	5.1.3
Future Development and Future Flood Risk			
23	Manage Strategic Development	Recommended	6.1.1
24	Manage Future Development Flood Risk	Recommended	6.1.2
25	Implement Climate Change Adaptation Plan	Recommended	6.1.3
26	Plan for Climate Change	Recommended	6.1.4

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1 Overview

This document outlines the Plan to implement a range of floodplain management measures which were assessed as part of the Tweed Coastal Creeks Floodplain Risk Management Study (FRMS) and should be read in conjunction with the FRMS. The Plan provides practical information such as timing, priority, expense and responsibility for all of the measures recommended for implementation or further investigation.

1.1 Floodplain Risk Management Process

The NSW Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the NSW Floodplain Development Manual (DIPNR, 2005).

Under the policy, the management of flood prone land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in their floodplain management responsibilities.

The policy provides for technical and financial support by the State Government through the following four sequential stages, as outlined in Table 1 1, below.

Stage	Description
1. Flood Study	Determines the nature and extent of the flood problem (includes data collection)
2. Floodplain Risk Management Study	Evaluates management options for the floodplain in consideration of social, ecological and economic factors
3. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management with preferred options for the floodplain
4. Plan Implementation	Implementation of flood mitigation works, response and property modification measures by Council

Overseeing the entire process is the Floodplain Risk Management Committee, composed of representatives from the community and relevant industries, Council, the State Emergency Service (SES), and the Office of Environment and Heritage (OEH). Within this committee sits the Technical Committee.

1.2 Aim of the Plan

The Plan aims to manage and minimise (where practical and possible) flood risk in the Tweed Coastal Creeks area, based on the outcomes of the broader Floodplain Risk Management Study. For the purposes of the Plan, flood risk can be broadly categorised as:

Existing Risk, which describes the flood risk in the floodplain as it stands today;

Future Risk, which is associated with future developments and climate change; and

Continuing Flood Risk (sometimes called residual risk), which is the flood risk remaining after all of the floodplain management measures have been implemented (applies to both existing and future situations).

To address these three types of flood risk, the Plan ensures that:

- The use of flood prone land is planned and managed in a manner compatible with the assessed frequency and severity of flooding;
- Flood prone lands are managed considering social, economic and ecological costs and benefits, to individuals as well as the community;
- Floodplain management matters are dealt with considering community safety, health and welfare requirements;
- Information on the nature of possible future flooding is available to the public;
- All reasonable measures are taken to alleviate the hazard and damage potential resulting from development on floodplains;
- There is no significant growth in hazard and damage potential resulting from new development on floodplains; and
- Appropriate and effective flood warning systems exist, and emergency services are available for future flooding.

1.3 Responsibilities

The responsibility for land use planning in the Tweed Coastal Creeks area, including flood prone land, lies primarily with Tweed Shire Council (Council). The primary responsibilities of Council are:

- Commissioning a Floodplain Risk Management Study and implementing the Floodplain Risk Management Plan (this document);
- Preparation and application of Environmental Planning Instruments (LEP, DCP) which incorporate the planning provisions outlined in this document;
- Provide flood related information on planning certificates at time of property sale;
- Design, maintain and construct flood mitigation works;
- Promote flood readiness in the community via flood education; and
- Assist the SES in preparation of the Flood Emergency Sub Plan (FESP).

Council is supported in this role by a number of other agencies.

The **Office of Environment and Heritage** (OEH) co-fund the study and, along with Council and Federal Government, subsidise flood mitigation works to alleviate existing problems and provide specialist technical advice as part of the technical committee.

The **Department of Planning and Infrastructure** (DoPI) are also engaged in the floodplain management process through the development of regional strategies and plans under the Environmental Planning and Assessment Act (EP&A Act).

The **State Emergency Service** (SES) provides specialist technical advice about emergency planning and development controls throughout the study process. The SES is responsible for implementing the emergency planning and response measures recommended in the Plan.

The **Bureau of Meteorology** (BoM) provides specialist advice regarding flood warning and prediction and is responsible for continuing to support the Plan through continued advice in these areas.

The **Department of Community Services** (DoCS) provides assistance to the community during flood events and is responsible for assisting the SES with emergency planning.

1.4 Management Measures

Floodplain Risk Management Plans consider three distinct types of management measures: flood modification, response modification and property modification. Selection of an appropriate and effective mixture of management measures ensures that the Plan best addresses the local flood risk and is appropriate for the region and community.

Flood modification measures are designed to modify the behaviour of floodwaters by either reducing flood depths and velocities, or by excluding floodwater from certain areas.

Response modification measures change the way we respond to flood risk, through measures such as evacuation planning and education. In general, response modification measures are the simplest and most cost effective measures to install, alongside planning measures.

Property modification measures seek to reduce flood risk through careful planning of future developments. Property modification measures can also be applied to existing developments to either reduce the flood risk by raising the house, or by removing the property from the flood prone location altogether.

Future flood risk due to climate change is managed through a combination of the above measures to adapt existing development and infrastructure, and plan and design future development and infrastructure, for the predicted effects of climate change on flood risk.

2 Background

2.1 Study Area

The study area is approximately 255km^2, bounded by the town of Kingscliff to the north and the Tweed Byron Shire boundary to the south, and includes the catchments for Cudgen, Cudgera, Mooball and Yelgun Creeks, as shown in Figure 2-1.

These catchments are bisected in a north-south direction by the Pacific Highway, with predominantly agricultural and forested areas upstream and a mixture of agricultural land, sugar cane farms, forested and urban areas downstream. The upper catchments of the creek are steep, leading to a broad coastal floodplain extending between Kingscliff and Billinudgel.

The Plan area comprises three main coastal catchments; Cudgen, Cudgera and Mooball Creeks. The following sections provide a brief description of each of the main catchments, as well as the Yelgun Creek catchment, which drains to both the Mooball Creek catchment and the Marshalls Creek catchment to the south of the study area. Cudgen, Cudgera and Mooball Creeks flow to the ocean.

The study area addressed under this Study and Plan differs from the study area of the Tweed Byron Coastal Creeks Flood Study (2010), which informs this FRMS. Due to the hydraulic connectivity between Mooball and Marshalls Creek catchments, it was necessary to include the Marshalls Creek catchment in the previous Flood Study. The Marshalls Creek catchment area falls within the Byron Shire Council boundaries and will be addressed as part of the North Byron – Coastal Creeks Floodplain Risk Management Study. Where additional modelling is required as part of this FRMS, the original model (including Marshalls Creek) was used.

The Cudgen Creek catchment is the northern most catchment in this study and is approximately 100km^2 and is bounded by the Burringbar Range to the west. Towns within the Cudgen Creek catchment include Bogangar, Cabarita Beach, Tanglewood, Salt, Casuarina (South Kingscliff) and Kingscliff. The main creeks in the Cudgen catchment include Cudgen, Reserve and Clothiers Creeks. Reserve and Clothiers Creeks combine and flow into Cudgen Lake, located west of Bogangar. The upper sections of the catchment are a mixture of forested and agricultural land. The lower areas of the catchment contain agricultural land, sugar cane farms, forested and urban areas.

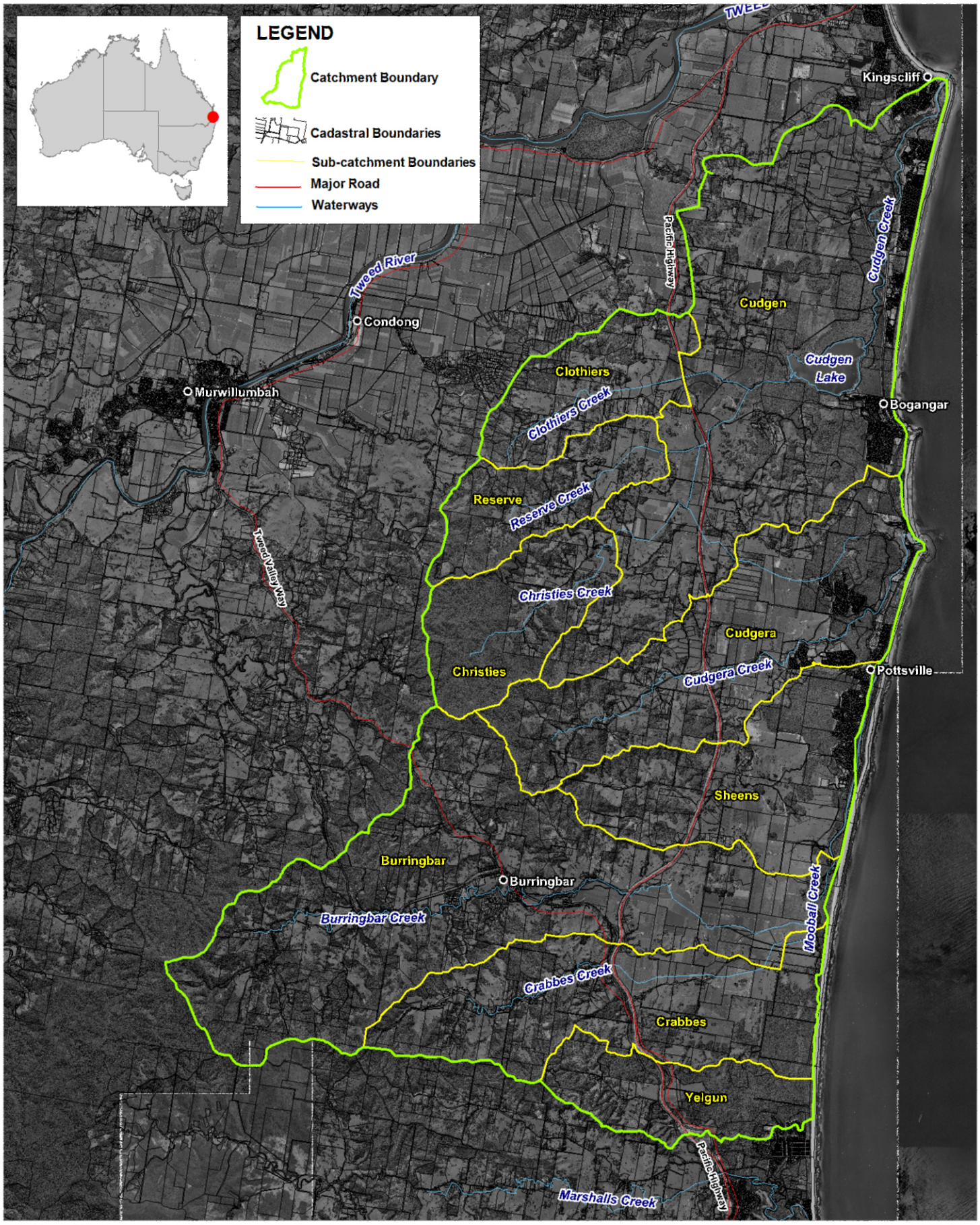
The Cudgera Creek catchment lies between the Cudgen and Mooball catchments. Cudgera Creek catchment is approximately 34km^2 and drains to the ocean at Hastings Point. Towns within the Cudgera Creek catchment include Pottsville, Hastings Point, as well as the Seabreeze and Koala Beach Estates. The catchment is linked to the Cudgen Creek catchment to the north, with Christies Creek flowing into the Cudgera Creek floodplain downstream of the Pacific Highway. To the south, the Cudgera catchment is linked to the Mooball Creek catchment via culverts underneath Pottsville Road. The main land use types in the Cudgera Creek catchment are agricultural land, sugar cane farms, forested and urban areas.

The Mooball Creek catchment lies between the Cudgera and Marshalls Creek catchments. Mooball Creek catchment is approximately 110km^2 and drains to the ocean at Pottsville. Towns within the Mooball Creek catchment include Burringbar, Mooball and Crabbes Creek upstream of the Pacific

Highway, as well as Wooyung and the Black Rocks Estate towards Pottsville in the lower floodplain. The two main creeks within the Mooball catchment are Burringbar Creek and Crabbes Creek. Burringbar Creek and Crabbes Creek join to become Mooball Creek north of Wooyung. The Mooball Creek catchment is hydraulically linked to the Cudgera Creek catchment via culverts under Pottsville Road. The Mooball Creek catchment is also linked with the Yelgun Creek catchment, with both floodplains connecting hydraulically south of Wooyung in the corridor east of the old coastal dune system. The main land use types in the Mooball catchment are agricultural land, sugar cane farms, forested and urban areas.

The Yelgun Creek catchment lies between the Mooball and Marshalls Creek catchments. The catchment is approximately 11km^2 and flows both south into Marshalls Creek and north into Mooball Creek through Billinudgel Nature Reserve. There are no major townships within the Yelgun Creek catchment. Yelgun Creek catchment is linked to the Marshalls Creek catchment at North Ocean Shores via culverts at Kallaroo Circuit. The main land use types in the Yelgun Creek catchment are agricultural land, forested and urban areas.

Development in the catchment is largely centred on the coastal strip with a number of small villages situated in the upper catchments The Far North Coast Regional Strategy (Department of Planning, 2006) was prepared to provide guidance in planning for the growth of the six North Coast Local Government Areas, including Tweed Shire, for a projected population growth of 26% over a 25 year period.



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Study Area

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2.2 Flood Risk

The coastal creeks of northern New South Wales between Brunswick Heads and Tweed Heads have a long history of flooding, with the last major flood event occurring in June 2005. The townships of Bogangar/Cabarita Beach, Hastings Point, Pottsville, Burringbar, Mooball, Wooyung and Crabbes Creek all have frequently experienced inundation from floodwaters, originating from two typical sources: heavy rainfall over the catchments and/or high tailwater levels in the ocean due to storm surge or exceptional tidal conditions.

The last major flood event which occurred across all catchments was in June 2005, which resulted in above floor level flooding of a significant number of buildings across the area. Other significant flood events occurred in May 1987 and March 1974, although these events were more localised. No other significant events have occurred in the area since 2005.

The main type of flooding addressed in the Tweed Byron Coastal Creeks Flood Study (2010), and now this Plan, is catchment or riverine flooding and this is shown in Figure 2-2. This type of flooding generally occurs following a long period of rainfall over much of the catchment. Riverine flooding causes water levels in creeks and rivers to rise and eventually spill out of bank and inundate surrounding areas. Large storms can cause catchment flooding over most of the study area which can be slow to drain from lower floodplain areas.

As this type of flooding is often a result of prolonged, catchment wide rainfall, catchment flooding can frequently be predicted by the Bureau of Meteorology (although the scale and extent of flooding is more difficult to predict).

Riverine flooding frequently occurs as a result of storm activity. As a result, ocean levels tend to be elevated and storm surges may coincide with high water levels in creeks and rivers.

Although riverine flooding dominates much of the floodplain area, some coastal regions can experience greater flood heights due to ocean flooding. Areas which can be affected by storm surges include:

- Cabarita / Bogangar;
- Hastings Point;
- Pottsville; and
- Wooyung.

Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate. Flash flooding is generally due to intense local rainfall and can quickly cause serious flooding. Flash flooding is often defined as flooding which reaches peak height within six hours from the start of rain. Due to the fast onset of flash flooding, it can be difficult to predict and there is rarely time to evacuate residents prior to hazardous flooding. In the Tweed Coastal Creeks area, the townships upstream of the Pacific Highway such as Burringbar and Crabbes Creek are known to be prone to flash flooding.

Although the Tweed Byron Coastal Creeks hydraulic model was not necessarily developed to simulate flash flooding, it is recognised that this type of fast-onset flooding is one of the dominant risks in the study area and does need to be considered within this study.

Local flooding refers to flooding around urbanised areas which is a direct result of undersized or blocked drainage infrastructure. This type of flooding is generally dominant in smaller, more frequent flood events. Local flooding can also occur during larger catchment flood events and can compound flooding problems by inundating evacuation routes.

This type of flooding was not explicitly included in the flood model developed for the Tweed Byron Flood Study due to the scale of the model. However, it is known that the effect of local flooding generally worsens existing flood risk, particularly in urban areas.

Kingscliff
Bogangar
Pottsville
Pacific Highway
Terranora
Burringbar
Tumbulgum
Condong
Tweed Valley Way
Murwillumbah

LEGEND

Study Area
Tweed River
Waterway
Cadastral Boundaries
100 Year Extent
PMF Extent

Title:
100 Year and PMF Flood Extents

Figure: 2-2
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The extent of the probable maximum flood (PMF) is significant, with high flood depths in some locations. The total population at risk of flooding is provided in Table 2-1 below.

Table 2-1 Population at Risk

Numbers at Risk	5 Year ARI	100 Year ARI	PMF
People[1]	310	1,557	8,347
Residential Properties	79	385	3130

Table 2-2 presents the number of properties, both residential and commercial for a range of design flood events within the Tweed Coastal Creeks area.

Table 2-2 Estimated Number of Inundated Properties

Flood Event (Year ARI)	Residential Properties (Inundated above Floor Level)	Residential Properties (Inundated at Ground Level)	Commercial Properties (Inundated at Ground Level)
5	1	79	0
10	9	113	0
20	27	161	4
50	133	274	7
100	152	385	9
500	498	1,077	15
PMF	2,843	3,130	75

These tables provide an indication of the number of people and properties within the flood extent, however there are a number of other factors which need to be considered relating to flood risk in the Tweed Coastal Creeks area.

In some locations, particularly in the upper catchments, flood depths and flows are likely to be of a dangerous magnitude and flood waters can rise quickly, often with short warning periods. Roads can become quickly cut and residents can become isolated. The lower floodplain areas of the Tweed Coastal Creeks area are prone to deep flood water; with peak depths of more than 2m likely in the 100 year ARI event and more than 3m in a PMF.

Isolation is a risk in the Tweed Coastal Creeks area where flooding can persist due to poor drainage. Of particular note are the ‘low islands’ illustrated around the Pottsville area, Black Rocks Estate and pockets in Bogangar. The Koala Beach Estate is almost entirely contained within a ‘high island’.

Older residents (65 years and over) are more likely to require assistance during evacuation and may be socially isolated, resulting in delayed awareness of evacuation warnings. Although the fraction of older residents in the Tweed Coastal Creeks study area (14%) is comparable to the

[1] These figures include residents of caravan parks, assuming full occupancy

national average (16%), the additional requirements of this demographic should be considered during evacuation planning.

The Tweed Coastal Creeks area has traditionally been made up of rural / agricultural land with a number of small villages along the coastal strip and further inland. More recently, there has been increased development in the area with the Tweed Local Government Area (LGA) (comprising the Tweed Valley as well as the Coastal Creeks area) now one of the five fastest growing LGAs in regional Australia. Population growth within the LGA is anticipated to increase by approximately 40% between 2015 and 2036. In the Tweed Coastal Creeks area, most of this growth to date has been in coastal areas, which has brought an influx of so-called 'sea change' residents. Many of the residents in these new developments are new to the area and are unfamiliar with the local flood behaviour.

Sugar cane is one of the major agricultural crops in the Tweed Coastal Creeks study area. Cane is generally grown on fertile floodplains, but poor drainage after floods can adversely affect crops. It is therefore important that changes to the catchment do not unacceptably increase the duration of flooding.

A 'baseline' damages assessment has been completed for the Tweed Coastal Creek area. This assessment estimated an annual average flood damages (AAD) cost of **$2.55 million**. This value includes damages incurred by residential and commercial properties and approximated infrastructure damages and damage to agriculture (sugar cane crops).

Results of this assessment are presented in Table 2-3.

Table 2-3 Flood Damage Estimates

Flood Event (year ARI)	Residential ($k)	Commercial ($k)	Infrastructure ($k)	Agricultural ($k)	Total ($k)
5	1,190	-	115	383	1,688
10	2,010	-	219	435	2,664
20	10,474	119	1,469	486	12,548
50	16,613	335	2,334	542	19,824
100	22,375	529	3,117	574	26,595
500	56,234	901	7,572	591	65,298
PMF	489,241	269,459	110,801	684	870,185
AAD					**$2.55 million**

2.3 Future Flood Risk

The Tweed Local Government Area's recent rapid growth is expected to continue based on State Planning Strategies, and the future risks to people and property of continued floodplain development need to be addressed. Furthermore, flood risk in the Tweed Coastal Creeks area is likely to increase in the future as a result of a changing climate. The effects of climate change will increase the risk for most properties which are already affected by flooding and increase the

number of properties at risk. The number of people and properties within the 100 year ARI flood extent, under both existing and future climates, is presented in Table 2-4 below.

Table 2-4 Population at Risk, Climate Change

Numbers at Risk	100 year ARI Existing Climate	100 Year ARI Future Climate	% Increase
People[2]	1,557	1,834	18
Residential properties	385	500	30

[2] These figures include residents of caravan parks assuming full occupancy

3 Flood Modification Measures

Flood modification measures are designed to modify the behaviour of floodwaters by either reducing flood depths and velocities, or by excluding floodwater from certain areas. Two flood modification measures were assessed in isolation for the study area.

The first examined the impact of dredging of Mooball Creek to reduce both flood levels and total time of flood inundation in the surrounding floodplain areas. This option did not lower the peak flood levels or overall duration of flooding. Furthermore this option was not found to be economically viable and would like cause negative environmental impacts such as salt water intrusion and loss of riparian vegetation and habitats within the estuary. As a result, this option was not carried forward.

The second option assessed the impact of lowering weirs in the Pottsville Waters residential development to see if drainage in the Dunloe Park location (site of future urban development) could be enhanced. Results from the assessment indicated that lowering the weirs had minimal impact on peak flood levels in either of the tested events. An economic assessment was not completed for the second option due to the minimal change to flood levels .The environmental impacts of the measure are likely to be minimal. Although there are unlikely to be negative impacts to flood levels and the environment, there is no evidence to justify lowering the weir level to improve flooding in the proposed development area.

As such, no flood modification measures have been included as part of the Tweed Coastal Creeks Floodplain Risk Management Plan.

4 Response Modification Measures

The following response modification options have been put forward as suggestions under the following headings to augment the evacuation planning already undertaken by the SES:

- Emergency Response Planning;
- Community Awareness and Education; and
- Flood Prediction and Warning.

4.1 Emergency Response Planning

4.1.1 Update the Local Flood Plan

The Local Flood Plan (LFP) is generally reviewed every five years, however where significant new information is made available, it is recommended that the LFP be updated more often. For instance, the SES should incorporate the findings of this Study now and should not wait five years before including new information in the LFP. More frequent reviews are particularly warranted during times of intense development or population expansion, or when changes are made to the floodplain which may significantly impact flood behaviour.

FRMS Recommendation 1: Update the Local Flood Plan
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of evacuation constraints and identification of risk reduction strategies; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES update the Local Flood Plan to include flood intelligence derived from the Tweed Byron Coastal Creeks Flood Study and the Floodplain Risk Management Study.

4.1.2 Plan for Different Types of Flood Risk

Low lying areas of the floodplain are at most risk of flooding from ocean flooding and longer duration catchment flooding, whereas the upper catchment areas are at greater risk of flash flooding. These types of flooding require different responses from both the SES and the community, which should be captured in emergency planning.

The first stage of this process is the identification of different areas of flood risk. It is recommended that five separate types of flood risk be recognised for emergency planning purposes: flash flood risk, catchment flood risk, storm surge risk, flood isolation risk and lower flood risk (those areas which are in the floodplain, but outside the 100 year ARI extent).

FRMS Recommendation 2: Plan for different types of flood risk
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of evacuation constraints and identification of risk reduction strategies; and
- Will manage and minimise existing and continuing flood risks.

Implementation

The SES has been provided with digital and hard copy mapping of the five different hydraulic risk zones. It is recommended that this mapping and accompanying information in this Study be used by the SES to inform a multi-pronged approach to flood emergency planning based on the different types of flood risk.

4.1.3 Plan for Flash Flooding

Flash flooding is recognised to be a significant risk for residents in the upper catchment areas. In addition to the inherent dangers associated with flash flooding (i.e. fast onset and dangerous waters), the risk is worsened by residents' poor awareness of the risk. It is therefore recommended that the SES use the new information from this study to update their approach to the management of flood risk in these upper catchment areas.

The best strategy for management of flash flood risk is to reduce the exposure by removing properties from the hazardous area and avoiding building new properties in known flash flooding locations. Where removal of properties is not possible, a plan should be developed which addresses flash flood risk to the remaining properties. This approach would require identifying those areas where evacuation is realistically possible and, for those areas where it is not, identifying alternative responses. These alternative responses may include shelter-in-place and partial evacuation (i.e. evacuation to a safe location, even if not a formal evacuation centre).

FRMS Recommendation 3: Plan for flash flooding
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of evacuation constraints and identification of risk reduction strategies;
- Improved community confidence when floods are predicted;
- Improved information available for emergency response;
- Improved flood awareness for residents in high evacuation risk areas; and

- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES adopt a triage approach to their flash flood planning, including identifying those areas where evacuation is realistically possible and, for those areas where it is not, identifying alternative responses. To ensure the triage approach is effective, the SES should communicate the recommended flood and evacuation response to residents living in high flood risk areas.

4.1.4 Plan for Pedestrian and Local Evacuation

Pedestrian evacuation is recommended as an alternative to vehicular evacuation for situations where it is safe and within residents' capabilities. During flood evacuations, flood warnings for the identified areas should remind residents of the option to evacuate on foot rather than by car, particularly if the area is experiencing high congestion.

FRMS Recommendation 4: Plan for pedestrian and local evacuation
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of evacuation constraints and identification of risk reduction strategies; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES identify areas where pedestrian and/or local evacuation may be suitable, update the Local Flood Plan accordingly, and provide targeted education to residents in areas which are identified as suitable for pedestrian evacuation.

4.2 Community Awareness and Education

4.2.1 Promote General Flood Awareness

There are a number of flood-related messages which need to be conveyed to the public as part of a broad scale flood awareness program. The conveyance of these messages can be through a range of formats; it will be necessary to select the best format for the message and the targeted audience.

FRMS Recommendation 5: Promote general flood awareness
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES and Council continue to promote flood awareness throughout the Tweed Coastal Creeks area using a variety of methods and platforms, tailoring these messages to different demographics as required.

4.2.2 Target Education Campaigns based on Flood Risk

There are a number of flood-related messages which need to be conveyed to the public as part of a broad scale flood awareness program. The conveyance of these messages can be through a range of formats; it will be necessary to select the best format for the message and the targeted audience.

Community awareness measures should not be considered as one-size-fits-all solutions; although some measures are suitable for the entire community, it is important that residents in high risk areas are made aware of their particular flood risk.

FRMS Recommendation 6: Target education campaigns based on flood risk
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES and Council generate specific flood awareness material for each flood risk type and ensure that each type of material is distributed to at risk residents.

4.2.3 Provide Flood Information Online to the Community

In addition to information about the effects and risks of floods, it is important that the community has an understanding of historical and design flood behaviour. This technical information may include flood depths, hazards and extents and could be presented on Council's website. Provision of this information will help the community understand the magnitude of the flood problem and the level of flood risk in their location.

An online tool will allow the community to view a range of flood model results in conjunction with information on e.g. road location, parcel boundaries etc. Interactive mapping would supplement and complement the community education program conducted by the SES. In addition to the

interactive mapping, Council may also want to consider publishing animations of modelled flood behaviour on their website.

FRMS Recommendation 7: Provide flood information online to the community
Priority: Medium
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council consider providing online, interactive flood mapping to the public.

4.2.4 Provide Information to Assist with Personal Flood Plans

In addition to targeted flood education material, some residents may have complex flood risk situations and require additional help preparing for floods. These residents should be made aware that the SES can help them prepare personal flood plans.

FRMS Recommendation 8: Provide information to assist with Personal Flood Plans
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES door knock or letterbox drop those residents who are most at risk to alert them to their flood risk and offer to help residents prepare Personal Flood Plans.

4.2.5 Target New Residents and Tourists with Flood Information

Council and the SES should ensure that some of the flood awareness material is targeted at new residents to the area and tourists, as most of the standard approaches to flood education do not reach these demographics.

FRMS Recommendation 9: Target new residents and tourists with flood information
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council and the SES should create flood awareness material specifically targeted at new residents to the area and tourists and consider novel distribution channels, including in new tenancy packs and tourist brochures.

4.2.6 Use Social Media

The MyRoadInfo website works well for longer and scheduled road closures, however is not always as responsive as the community would like. Crowdsourcing information from residents can help to provide real-time data which helps the community share information about road closures and other flood relevant information.

Although there are a number of mapping platforms aimed at crowdsourcing information, the most user-friendly approach for the Tweed Coastal Creeks community would likely be via Facebook. Residents would be able to post flood information to the page, including road closures and photos, and ask questions from both Council and other users. Facebook has been an extremely useful and well-used resource during recent flooding events throughout Australia.

FRMS Recommendation 10: Use social media
Priority: Medium
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flood risk and access to flood information; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council establish a Facebook page dedicated to flooding in the Tweed Shire (both Tweed Valley and Tweed Coastal Creeks areas).

4.2.7 Undertake Disaster Resilience Leadership Workshops

The SES has indicated that they are currently planning a Disaster Resilience Leadership Workshop, with invited representatives from the Tweed, Byron and Ballina Shire areas. The workshops are aimed at developing the skills of attendees to better support their communities through the development of flood resilience.

FRMS Recommendation 11: Undertake disaster resilience leadership workshops
Priority: High
Estimated Cost: Normal Operating Budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flooding and flood impacts;
- More informed prediction and response planning;
- Improved understanding of evacuation constraints and identify risk reduction strategies; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council provide support to the SES in planning and leading a Disaster Resilience Leadership Workshop.

4.2.8 Enhance Gauge Network

There are currently two rain gauges in the Burringbar and Upper Crabbes Creek catchments. The Upper Crabbes Creek gauge is suitable for measuring rainfall in the Crabbes Creek catchment for flood warning purposes. However, the Burringbar gauge is located in the downstream part of the catchment, and is therefore unable to provide sufficient lead time for Burringbar. To improve flood warning, it is recommended that two additional rain gauges be installed, both upstream of Burringbar.

Additional to the lead time available from rain gauges, is the need for river gauges which can be used by the community as a point of reference for actual and predicted flood levels. Considering the greatest flood risk is to Burringbar, Mooball and Crabbes Creeks, the focus of gauge network enhancements with five stream gauges is on these areas.

FRMS Recommendation 12: Enhance gauge network with two additional rain gauges and five additional stream gauges.
Priority: High
Estimated Cost: Approximately $60K for hardware plus installation and configuration costs

Benefits

The recommended measure is expected to have the following benefits:

- More informed prediction and response planning; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council establish five additional stream gauges, and two additional rain gauges in the Burringbar, Mooball and Crabbes Creek area. The gauges would be owned and operated by Council, including maintenance of stream gauges. Stream gauges should be supplemented with staff gauges in case of operational failure. Rain gauges should be incorporated into the ALERT network.

4.2.9 Install Flash Flood Warning System

A flash flood warning system could include speakers located at each of the river gauges proposed above in Recommendation 12, as well as individual household sirens for outlying properties. To minimise false alarms, it is proposed that activation of the siren network will be via manual control (SMS or push button), or via exceedance of river levels at the corresponding gauge location.

FRMS Recommendation 13: Install flash flood warning system
Priority: High
Estimated Cost: Approximately $50K for hardware plus installation and configuration costs

Benefits

The recommended measure is expected to have the following benefits:

- Improved planning for flood warning in extreme flood events; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council install a network of audible flood sirens, connected to river gauges in the regions of Burringbar, Mooball and Crabbes Creek as part of a flash flood warning system. These sirens would be owned by Council, however it is recommended that the SES are responsible for triggering the alarms. Installation of the sirens should be supported by an education campaign for residents within the region to advise residents what the sounds mean and what actions should follow sounding of the alarm.

4.2.10 Establish Flood Watch Network

Flood Watch Networks provide a formal mechanism for local residents to contribute real-time flood information and improve the SES's understanding of flooding and flood impacts across the entire study area. Information from Flood Watch Networks can help the SES with emergency response during flood events and assist with planning for future events. Flood Watch Networks have been successfully used in other areas of the Tweed Shire, including Tumbulgum and Uki.

FRMS Recommendation 14: Establish flood watch network
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flooding and flood impacts;
- Utilisation of residents' knowledge of historical and real time flood behaviour; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES actively promote the concept of Flood Watch Networks to the community, particularly in high-risk locations such as Burringbar, Mooball and Crabbes Creek. Where there is community interest in establishing a Network, the SES should provide support and information to the community to assist them initiate a Network in their local area.

4.2.11 Classify Existing and New Stream Level Gauges

The definitions of minor / moderate / major floods relate to specific, on the ground outcomes (such as likely road closures or evacuation) and help both the SES and public make sense of flood level predictions. Classifying the gauges will need to be undertaken in consultation with the BoM and the broader Flood Warning Consultative Committee.

FRMS Recommendation 15: Classify existing and new stream level gauges
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flooding and flood impacts;
- More informed prediction and response planning;
- Increased community awareness and community flood planning; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that existing and new stream level gauges be classified so that definitions of minor / moderate / major floods can be established. Information about the design flood levels at gauges within the hydraulic model extent have been provided in this Study.

4.2.12 Develop Flood Intelligence Cards

In the Tweed Valley (and in many other catchments), flood intelligence is recorded in Flood Intelligence Cards. These cards detail the relationship between flood gauge heights and flood consequences. They are used by the SES to interpret the meaning of quantitative flood predictions and to help decide appropriate flood response actions. Cards are maintained and updated by the

SES Headquarters and, as they contain sensitive information such as house addresses, are not publically available. No flood intelligence cards exist for the Coastal Creeks study area.

FRMS Recommendation 16: Develop Flood Intelligence Cards
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Better understanding and quantification of flood risk;
- Improved response planning and evacuation procedures; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that the SES develop Flood Intelligence Cards for the existing stream level gauges and any new gauges installed, using information provided in the Tweed Byron Coastal Creeks Flood Study and the Tweed Coastal Creek Floodplain Risk Management Study, as well as historical and anecdotal information about flood consequences and past floods.

4.2.13 Develop Gauge Triggers

Development of triggers will increase the value of data provided by rainfall and stream gauges and help Council and emergency management staff make decisions during flood events. Triggers can be developed using historical information and flood models to try to estimate what stream level or rainfall depth will lead to critical flood outcomes. For instance, triggers might be set for a stream gauge which recognises that a highway downstream of the gauge is likely to be cut should the gauge reach a particular level.

FRMS Recommendation 17: Develop Gauge Triggers
Priority: High
Estimated Cost: Approximately $30K for additional flood modelling

Benefits

The recommended measure is expected to have the following benefits:

- Improved understanding of flooding and flood impacts;
- More informed prediction and response planning; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council seek to develop trigger levels for the stream and rainfall gauges within the Tweed Coastal Creeks area. Development of these triggers will require some additional

flood modelling to better understand flood dynamics and the outcome of various rainfall / ocean boundary conditions.

4.2.14 Trial Flood Decision Support System

In consultation with the Richmond-Tweed SES and OEH, BMT WBM is currently developing a web-based Flood Decision Support System (DSS) for the Richmond-Tweed Region. The system will display real-time rainfall and river level data for every available gauge in the area, as well as radar rainfall. Incorporated into the system will be flood mapping for the populated areas, dynamically linked to river gauges, floor level survey databases, evacuation routes and critical infrastructure such as medical, aged care, child care and education facilities. The Flood DSS will be capable of issuing alerts based on threshold exceedances.

FRMS Recommendation 18: Trial Flood Decision Support System
Priority: High
Estimated Cost: To be determined, based on complexity and ongoing support costs

Benefits

The recommended measure is expected to have the following benefits:

- Better understanding and quantification of flood risk;
- Improved response planning and evacuation procedures; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council and the SES take part in the trial Flood Decision Support System being developed for the Richmond-Tweed Region, in conjunction with the Office of Environment and Heritage and other Councils in the region.

4.2.15 Predict Storm Surges

Storm surge predictions are currently issued on the peak prior to the storm, i.e. 12 hours prior to peak. This may not be sufficient time to prepare, warn and evacuate the public.

The Bureau of Meteorology's research centre is currently developing forecast guidance products which aim to predict ocean levels out to several days and will extend warning lead time for storm surge events.

FRMS Recommendation 19: Predict Storm Surges
Priority: High
Estimated Cost: Normal BoM operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved evacuation capability through earlier prediction; and

- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council maintain ongoing communication with the Bureau of Meteorology on this issue and incorporate future forecast guidance products as they become available.

5 Property Modification Measures

Property modification measures seek to reduce flood risk through careful planning of future developments. Property modification measures can also be applied to existing developments to either reduce the flood risk by raising the house, or by removing the property from the flood prone location altogether.

5.1 Voluntary House Purchase

The primary objective of voluntary house purchase (VHP) is to reduce risks to personal safety by purchasing houses located in areas subject to excessive hazard. Such measures can only be undertaken on a voluntary basis with the property owner. Post-purchase, the property should be rezoned for flood compatible use, such as parkland.

Using the recommended hydraulic hazard categories where each of the hydraulic hazard criteria are linked to safety outcomes in terms of building structural damage, vehicle safety and pedestrian safety, the VHP assessment has recommended purchasing all properties within the H5 and H6 hydraulic hazard category areas, and properties in the H4 hazard category which cannot be raised for structural reasons (VHP Option 2).

FRMS Recommendation 20: Voluntary house purchase
Priority: Medium
Estimated Cost: $12.8m

Benefits

The recommended measure is expected to have the following benefits:

- Improved safety through removal of people from high hazard areas; and
- Will manage and minimise future and continuing flood risks.

Implementation

It is recommended that Council extend their existing VHP scheme across the Tweed Coastal Creeks area and implement VHP Option 2. This measure should be implemented in conjunction with Recommendations 21 and 22.

5.2 Voluntary House Raising

Voluntary house raising (VHR) is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings. Such measures can only be undertaken on a voluntary basis. Potential eligible properties were identified based on the hydraulic hazard at the location of the property in a 100 year ARI event, whether the property is currently subject to above floor flooding in a 100 year ARI event, and whether the house design is suitable for raising.

The VHR assessment recommends the voluntary raising of all properties in the H3 or H4 hydraulic categories in the 100 year ARI event (VHR Option 2). Furthermore, if this option is adopted then VHP Option 2 must be carried forward to ensure those properties within H4 are included, recognising that properties in the H4 hydraulic hazard area which cannot be raised due to structural

reasons are included in VHP Option 2 for purchase. Properties in the H3 hydraulic hazard area which are unsuitable for raising have been excluded from this assessment.

FRMS Recommendation 21: Voluntary House Raising
Priority: Medium
Estimated Cost: $2.7m

Benefits

The recommended measure is expected to have the following benefits:

- Improved safety (if isolated); and
- Will manage and minimise future and continuing flood risks.

Implementation

It is recommended that Council extend their existing VHR scheme across the Tweed Coastal Creeks area and implement VHR Option 2. This measure should be implemented in conjunction with Recommendations 21 and 22.

5.3 Inform High Risk Residents

Although VHP and VHR continue to be supported in theory, in practice there is little financial support available to implement these measures. As a consequence, it is essential to ensure that all residents (both owners and tenants) who are potentially exposed to high risk flooding are informed of their specific flood risk. This measure in conjunction with recommendations 6 and 7 will help to improve the flood resilience of residents living in high risk areas.

FRMS Recommendation 22: Inform High Risk Residents
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved safety; and
- Will manage and minimise existing and continuing flood risks.

Implementation

It is recommended that Council contact all residents in properties identified under the VHP or VHR scheme as being in high risk areas and discuss the location specific flood risk. Residents who are interested can also work with the SES on a Personal Flood Plan (Recommendation 8).

6 Future Development and Future Flood Risk

6.1 Manage Strategic Development

Parts of the Tweed Coastal Creeks area are subject to development pressure and whilst it is always preferable to avoid flood risk through effective land use planning, it is also recognised that pressures for land development, the lack of suitable land outside the floodplain, and a range of other non-flood related issues mean that use of some floodplain land may still be the best option for the community.

The cumulative development scenario tested as part of this study has identified a number of specific locations which are either partially or fully within the 100 year ARI design flood extent and found if all of the sites are filled, in addition to 1% of each rural zoned lot in the flood storage area, there is unlikely to be unacceptable cumulative impacts across the study area.

FRMS Recommendation 23: Manage strategic development
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Reduced likelihood of multiple developments in the floodplain causing cumulative flood impacts; and
- Will manage and minimise future flood risks.

Implementation

It is recommended that Council adopt the cumulative development scenario for the management of cumulative hydraulic impacts associated with future development. The adopted scenario can be updated as development plans change into the future on the basis of revised hydraulic assessment and acceptable impacts. This cumulative development scenario should be linked to a development control requiring appropriate hydraulic assessment and management of both local and cumulative development impacts.

6.2 Manage Future Development Flood Risk

Land use planning and development controls are key mechanisms by which Council can manage the risks to property and people in flood affected areas. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost. These improvements will ensure that future development is located in the most suitable area of the catchment according to land use, and dictates any building controls which may be required to manage flood risk.

FRMS Recommendation 24: Manage future development flood risk
Priority: High
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Reduced likelihood that future developments will be built in high flood risk areas;
- Reduced likelihood that future developments will cause offsite flood impacts; and
- Will manage and minimise future flood risks.

Implementation

It is recommended that Council update relevant development controls and related policies to incorporate the recommendations made in this Study and the Tweed Valley Floodplain Risk Management Study.

6.3 Implement Climate Change Adaptation Plan

A climate change adaptation plan was developed for Tweed Shire Council (in conjunction with Byron Shire Council) in 2009. This plan utilised information provided by Council representatives to highlight climate change related risks and develop actions to address these risks. The adaptation plan also recommended that climate change policy be applied consistently across all of Council's planning documents and that further quantitative assessments are commissioned to support the qualitative recommendations in the report.

FRMS Recommendation 25: Implement Climate Change Adaption Plan
Priority: Medium
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved ability for Council and residents to adapt to a changing climate and increased flood risk; and
- Will manage and minimise future flood risks.

Implementation

It is recommended that Council implement the Adaptation Plan using new information from the Tweed Byron Coastal Creeks Flood Study and the Tweed Coastal Creeks Floodplain Risk Management Study.

6.4 Plan for Climate Change

The 2010 NSW Sea Level Rise Policy recommends that strategic and statutory planning documents could respond to the projected 2050 and 2100 coastal flood risk area by restricting the

intensification of development in areas subject to predicted climate change flood risk or applying planning controls to manage the additional risk. A suite of planning controls were recommended in the Tweed Valley Floodplain Risk Management Study which are relevant shire wide.

FRMS Recommendation 26: Plan for climate change
Priority: Medium
Estimated Cost: Normal operating budget

Benefits

The recommended measure is expected to have the following benefits:

- Improved management of future development with consideration to future flood risk; and
- Will manage and minimise future flood risks.

Implementation

It is recommended that Council apply the planning controls relating to climate change to the entire Shire, including the Tweed Coastal Creeks area.

7 Implementation Plan

The creation of a Floodplain Risk Management Plan is not the end point of this study: rather, the Plan acts as a dynamic resource which will be utilised by a reduced version of the committee to guide future floodplain management for the Tweed Coastal Creeks area.

The committee will have to make decisions about how to coordinate and prioritise the various recommendations. These decisions will be influenced by factors such as:

- When the measure can be implemented;
- What resources are required to implement the measure;
- What constraints may need to be addressed prior to implementing the measure (or may prevent implementing the measure);
- How to address the identified constraints; and
- How effective the measures are likely to be.

In general, measures which are readily implemented for a low cost should be prioritised, however the committee must also consider the measures which are likely to improve personal safety for the greatest number of residents.

An implementation plan has been developed, summarising the required actions, responsibilities, estimated costs and priorities for each of the recommended measures. This plan is provided in Table 7-1 below.

Note that recommendations should be checked for consistency against Council's statutory powers and obligations prior to adoption.

Table 7-1 Implementation Plan

FRMS Option	Measure	Required Actions	Responsibility	Estimated Cost	Priority
1	Update the Local Flood Plan	It is recommended that the SES updated the Local Flood Plan to include flood intelligence derived from the Tweed Byron Coastal Creeks Flood Study and this Floodplain Risk Management Study.	SES	Normal operating budget	HIGH
2	Plan for Different Types of Flood Risk	The SES has been provided with digital and hard copy mapping of the five different hydraulic risk zones. It is recommended that this mapping and the accompanying information in this Study be used by the SES to inform a multi-pronged approach to flood emergency planning based on the different types of flood risk.	SES	Normal operating budget	HIGH
3	Plan for Flash Flooding	It is recommended that the SES adopt a triage approach to their flash flood planning, including identifying those areas where evacuation is realistically possible and, for those areas where it is not, identifying alternative responses. To ensure the triage approach is effective, the SES should communicate the recommended flood and evacuation response to residents living in high flood risk areas.	SES	Normal operating budget	HIGH
4	Plan for Pedestrian and Local Evacuation	It is recommended that the SES identify areas where pedestrian and/or local evacuation may be suitable, update the Local Flood Plan accordingly, and providing targeted education to residents in areas which are identified as suitable for pedestrian evacuation.	SES	Normal operating budget	HIGH
5	Promote General Flood Awareness	It is recommended that the SES and Council continue to promote flood awareness throughout the Tweed Coastal Creeks area using a variety of methods and platforms, tailoring these messages to different demographics as required.	SES / TSC	Normal operating budget	HIGH
6	Target Education Campaigns based on Flood Risk	It is recommended that the SES and Council generate specific flood awareness material for each flood risk type and ensure that each type of material is distributed to at-risk residents.	SES / TSC	Normal operating budget	HIGH
7	Provide Flood Information	It is recommended that Council consider providing online,	TSC	Normal operating	MEDIUM

FRMS Option	Measure	Required Actions	Responsibility	Estimated Cost	Priority
	Online to the Community	interactive flood mapping to the public.		budget	
8	Provide Information to Assist with Personal Flood Plans	It is recommended that the SES door knock or letterbox drop those residents who are most at risk to alert them to their flood risk and offer to help residents prepare Personal Flood Plans.	SES	Normal operating budget	HIGH
9	Target New Residents and Tourists with Flood Information	It is recommended that Council and the SES should create flood awareness material specifically targeted at new residents to the area and tourists, and consider novel distribution channels, including in new tenancy packs and tourist brochures.	SES /TSC	Normal operating budget	HIGH
10	Use Social Media	It is recommended that Council establish a Facebook page dedicated to flooding in the Tweed Shire (both Tweed Valley and Tweed Coastal Creeks areas).	TSC	Normal operating budget	MEDIUM
11	Undertake Disaster Resilience Leadership Workshops	It is recommended that Council provide to support to the SES in planning and leading a Disaster Resilience Leadership Workshop.	TSC	Normal operating budget	HIGH
12	Enhance Gauge Network	It is recommended that Council establish five additional stream gauges, and two additional rain gauges in the Burringbar, Mooball and Crabbes Creek area. The gauges would be owned and operated by Council, including maintenance of stream gauges. Stream gauges should be supplemented with manual staff gauges in case of operational failure. Rain gauges should be incorporated into the ALERT network.	TSC	Approximately $60K for hardware plus installation and configuration costs	HIGH
13	Install Flash Flood Warning System	It is recommended that Council install a network of audible flood sirens, connected to river gauges in the regions of Burringbar, Mooball and Crabbes Creek as part of a flash flood warning system. These sirens would be owned by Council, however it is recommended that the SES are responsible for triggering the alarms. Installation of the sirens should be supported by an education campaign for residents within the region to advise residents what the sounds mean and what actions should follow sounding of the alarm.	TSC	Approximately $50K for hardware plus installation and configuration costs	HIGH
14	Establish Flood Watch	It is recommended that the SES actively promote the concept of	SES	Normal operating	HIGH

FRMS Option	Measure	Required Actions	Responsibility	Estimated Cost	Priority
	Network	Flood Watch Networks to the community, particularly in high-risk locations such as Burringbar, Mooball and Crabbes Creek. Where there is community interest in establishing a Network, the SES should provide support and information to the community to assist them initiate a Network in their local area.		budget	
15	Classify Existing and New Stream Level Gauges	It is recommended that existing and new stream level gauges be classified so that definitions of minor / moderate / major floods can be established. Information about the design flood levels at gauges within the hydraulic model extent have been provided in this Study.	BoM	Normal operating budget	HIGH
16	Develop Flood Intelligence Cards	It is recommended that the SES develop Flood Intelligence Cards for the existing stream level gauges and any new gauges in the study area using information provided in the Tweed Byron Coastal Creeks Flood Study and this Study, as well as historical and anecdotal information about flood consequences and past floods.	SES	Normal operating budget	HIGH
17	Develop Gauge Triggers	It is recommended that Council seek to develop trigger levels for the stream and rainfall gauges within the Tweed Coastal Creeks area. Development of these triggers will require some additional flood modelling to better understand flood dynamics and the outcome of various rainfall / ocean boundary conditions.	TSC	Approximately $30K for additional flood modelling	HIGH
18	Trial Flood Decision Support System	It is recommended that Council and the SES take part in the trial Flood Decision Support System being developed for the Richmond-Tweed Region, in conjunction with the Office of Environment and Heritage and other Councils in the region.	TSC / SES	To be determined, based on complexity and ongoing support costs	HIGH
19	Predict Storm Surges	It is recommended that Council maintain ongoing communication with the Bureau of Meteorology on this issue and incorporate future forecast guidance products as they become available.	TSC / BoM	Normal BoM operating budget	HIGH
20	Voluntary House Purchase	It is recommended that Council extend their existing VHP scheme across the Tweed Coastal Creeks area and implement VHP Option 2.	TSC / OEH	$12.8m	MEDIUM

FRMS Option	Measure	Required Actions	Responsibility	Estimated Cost	Priority
21	Voluntary House Raising	It is recommended that Council extend their existing VHR scheme across the Tweed Coastal Creeks area and implement VHR Option 2.	TSC / OEH	$2.7m	MEDIUM
22	Inform High Risk Residents	It is recommended that Council contact all residents in properties identified under the VHP or VHR scheme as being in high risk areas and discuss the location specific flood risk.	TSC	Normal operating budget	HIGH
23	Manage Strategic Development	It is recommended that Council adopt the cumulative development scenario for the management of cumulative hydraulic impacts associated with future development. The adopted scenario can be updated as development plans change into the future on the basis of revised hydraulic assessment and acceptable impacts. This cumulative development scenario should be linked to a development control requiring appropriate hydraulic assessment and management of both local and cumulative development impacts.	TSC	Normal operating budget	HIGH
24	Manage Future Development Flood Risk	It is recommended that Council update relevant development controls and related policies to incorporate the recommendations made in this Study and the Tweed Valley Floodplain Risk Management Study.	TSC	Normal operating budget	HIGH
25	Implement Climate Change Adaptation Plan	It is recommended that Council implement the Climate Change Adaptation Plan using new information from the Tweed Byron Coastal Creeks Flood Study and this Study.	TSC	Normal operating budget	MEDIUM
26	Plan for Climate Change	It is recommended that Council apply the planning controls relating to climate change to the entire Shire, including the Tweed Coastal Creeks area.	TSC	Normal operating budget	MEDIUM

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