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Tweed Coastal Creeks Floodplain Risk Management Study

Final

December 2015

TWEED SHIRE COUNCIL

Tweed Coastal Creeks Floodplain Risk Management Study

Prepared for:	Tweed Shire Council
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Document:	R.B17892.007.04.docx
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Client Reference:	

Synopsis: Floodplain Risk Management Study for the Tweed Coastal Creeks area.

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	21/08/2015	JET		CD	
1	27/08/2015	JET		CD	
2	14/09/2015	JET		CD	
3	26/11/2015	JET		CD	
4	09/03/2016	JET		CD	

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Tweed Shire Council	PDF	PDF	PDF	PDF	PDF						
BMT WBM File	PDF	PDF	PDF	PDF	PDF						
BMT WBM Library	PDF	PDF	PDF	PDF	PDF						

Executive Summary

This Tweed Coastal Creeks Floodplain Risk Management Study was endorsed at a Tweed Shire Council meeting on the 10th December 2015.

This Study draws together a wide range of floodplain risk management options which have been investigated as part of the Tweed Coastal Creeks Floodplain Risk Management Study. These options have been identified through extensive consultation with agencies including Tweed Shire Council (Council), the State Emergency Service (SES) and the Office of Environment and Heritage, as well as consultation with the community and industry.

Each option in this Study was investigated to determine the likely impacts and where possible, the economic cost and benefits of implementing each measure. This document summarises the existing flood risk, describes relevant benefits and constraints to various floodplain management measures, and considers the planning and development issues associated with a region facing significant development pressures.

Existing Flood Risk

The coastal creeks of northern New South Wales between Brunswick Heads and Tweed Heads have a long history of flooding, with the most recent major flood event occurring in June 2005. The townships of Bogangar/Cabarita Beach, Hastings Point, Pottsville, Burringbar, Mooball, Wooyung and Crabbes Creek have all 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.

A major flood event occurred across all catchments in June 2005, which resulted in above floor level flooding of a significant number of buildings across the study 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 local community is also recognised to be vulnerable to the impacts of flooding. There are often a large number of tourists and new residents who are unfamiliar with local flood risk, and many residents who have only experienced small flood events and are unaware of the true flood risk in the area.

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 (separately) 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 the overall duration of flooding. Furthermore, this option was not found to be economically viable and would likely 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 assess whether drainage in the Dunloe Park location (site of future urban development) could be enhanced. The assessment indicated minimal change to flood levels and therefore no economic assessment was undertaken. 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. This option was not carried forward.

Response Modification Measures

Response modification measures are essential to the minimisation of personal flood risk in the Tweed Coastal Creeks study area. Flood response is the responsibility of many organisations and individuals, including the SES, Tweed Shire Council, the Bureau of Meteorology, community groups and individuals. The range of response modification options considered in this study aimed to address this wide cross-section of responsibilities.

The SES has been provided with a range of flood intelligence from this study, including flood risk zone mapping and flood extents, which can be used to update their systems and inform more detailed flood plans for areas of greatest flood risk. This information can be used to supplement the information already held by the SES, derived from prior flood modelling, historical floods and professional experience.

Other response modification measures considered as part of the study include installation of new stream and rainfall gauges, additional flood awareness education, provision of personalised flood information, and development of local flood warning systems.

Property Modification Measures

Property modification was addressed via a hydraulic assessment to identify properties which are at particularly high risk in terms of personal safety and / or property damage. Depending on the degree of risk, these properties have been recommended for either voluntary house purchase or voluntary house raising. Although these schemes continue to be supported in theory, in practice there is little financial support to implement these measures. As a consequence it is essential to ensure that all residents who are potentially exposed to high risk flooding are informed of their specific flood risk.

Future Development and Flood Risk

The study considers measures to quantify and manage flood risk into the future. Two likely drivers for increased flood risk are climate change, and continued development and increased populations on the floodplain.

Council has adopted a climate change flood scenario in line with current scientific guidance and previous state government policy which accounts for a 10% increase in rainfall intensity and a sea level rise of 91cm for the 100 year ARI event by 2100. This climate scenario will result in a greater flood extent and increase the flood risk for those already on flood prone land.

Outcomes from this study can be used to inform updates of Council's climate change adaptation plan that has been undertaken to manage this future risk to existing people and property. Council already has a number of planning mechanisms in place for limiting climate change risk to future development, and some additional recommendations have been made as part of a review of planning considerations for the study area.

Despite the existing flood risk and the risk posed by future climate change, the study area should not be sterilised. Future development can occur with well-designed flood controls and appropriate assessment to determine and limit the impact of development. This study provides recommendations which support the considered, safe and sustainable development of the area.

Summary of Measures

A summary of the floodplain risk management measures recommended in this study is presented in the table below. These measures are summarised in an options assessment matrix which highlights quantifiable impacts, costs and benefits where appropriate, but also intangible considerations such as social and environmental factors. The matrix can be used to compare options and inform the selection of measures to be adopted for implementation.

A number of other measures were considered during the study. Measures which were not carried over to this document were found to be not feasible or practicable based on hydraulic assessments and advice from members of the Floodplain Risk Management Technical Committee.

No	Modification Type	Description	Considerations	Section	Recommendation
1	Response	Update the Local Flood Plan	Improve understanding of evacuation constraints and identify risk reduction strategies Improve community confidence when floods are predicted Improve information available for emergency response Low to moderate cost	5.1.1	Update the Local Flood Plan to include flood intelligence derived from the Tweed Byron Coastal Creeks Flood Study and this Floodplain Risk Management Study.
2	Response	Plan for Different Types of Flood Risk	Improve understanding of evacuation constraints and identify risk reduction strategies Low to moderate cost	5.1.2	The SES to adopt a multi-pronged approach to flood emergency planning based on the different types of flood risk in different areas.
3	Response	Plan for Flash Flooding	Improve understanding of evacuation constraints and identify risk reduction strategies Improve community confidence when floods are predicted Improve information available for emergency response Improve flood awareness in residents in high evacuation risk areas Low to moderate cost	5.1.3	The SES to adopt a triage approach to their flash flood planning which would require identifying those areas where evacuation is realistically possible and, for those areas where it is not, identifying alternative responses
4	Response	Plan for Pedestrian and Local Evacuation	Improve understanding of evacuation constraints and identify risk reduction strategies Low to moderate cost	5.1.4	The SES to identify areas where pedestrian and/or local evacuation may be suitable and update the Local Flood Plan accordingly, and consider providing targeted education to residents in areas which are identified as suitable for pedestrian evacuation.
5	Response	Target Education Campaigns based on Flood Risk	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.1	The SES and Council should continue to improve flood awareness throughout the Tweed Coastal Creek area using a variety of methods and platforms

No	Modification Type	Description	Considerations	Section	Recommendation
6	Response	Target Education Campaigns based on Flood Risk	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.2	The SES and Council should generate specific material for each flood risk type and ensure that each type of material is distributed to at-risk residents
7	Response	Provide Flood Information Online to the Community	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.3	Council should consider the provision of online, interactive flood mapping.
8	Response	Provide Information to Assist with Personal Flood Plans	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.4	The SES should 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.
9	Response	Target New Residents and Tourists with Flood Information	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.5	The Council and the SES should ensure that some of the flood awareness material is targeted at new residents to the area and tourists.
10	Response	Use Social Media	Improve understanding of flood risk and access to flood information Low to moderate cost	5.2.6	Council should establish a Facebook page dedicated to flooding in the Tweed Shire (both Tweed Valley and Tweed Coastal Creeks areas).
11	Response	Undertake Disaster Resilience Leadership Workshops	Improve understanding of flooding and flood impacts More informed prediction and response planning Improve understanding of evacuation constraints and identify risk reduction strategies Low to moderate cost	5.2.7	Council to provide support to SES in planning and leading a Disaster Resilience Leadership Workshop
12	Response	Enhance Gauge Network	More informed prediction and response planning; Moderate cost	5.3.1	Council should establish two additional rain gauges and incorporate them into the ALERT network and establish low-cost stream gauges in Burringbar, Mooball and Crabbes Creeks
13	Response	Install Flash Flood	Plan for flood warning in an extreme flood	5.3.2	Council should install a network of audible flood sirens

No	Modification Type	Description	Considerations	Section	Recommendation
		Warning System	event Low to medium cost, depending on selected method		
14	Response	Establish Flood Watch Network	Improve understanding of flooding and flood impacts Utilise residents' knowledge of historical and real time flood behaviour Low to moderate cost	5.3.3	The SES to establish a Flood Watch Network in the Coastal Creeks study area
15	Response	Classify Existing and New Stream Level Gauges	Improve understanding of flooding and flood impacts More informed prediction and response planning Increase community awareness and community flood planning Low to moderate cost	5.3.4	Both existing and new stream level gauges should be classified so that definitions of minor / moderate / major floods can be established.
16	Response	Develop Flood Intelligence Cards	Better understanding and quantification of flood risk Improve response planning and evacuation procedures Low cost to incorporate existing flood intelligence Moderate cost to commission additional studies	5.3.5	The SES should develop Flood intelligence cards for the existing stream level gauges and any new gauges in the study area.
17	Response	Develop Gauge Triggers	Improve understanding of flooding and flood impacts More informed prediction and response planning Low to moderate cost	5.3.6	Council and the SES should develop gauge triggers to provide alerts when critical levels or rainfall depths are reached at particular rainfall and / or stream gauges
18	Response	Trial Flood Decision	Better understanding and quantification of flood risk	5.3.7	Council and the SES should take part in the Trial Flood Decision Support System being developed for the

No	Modification Type	Description	Considerations	Section	Recommendation
		Support System	Improve response planning and evacuation procedures Low to moderate cost		Richmond-Tweed region.
19	Response	Predict Storm Surges	Improve evacuation capability through earlier prediction (Already funded via BoM)	5.3.8	Council should consider the incorporation of future forecast guidance products.
20	Property	Voluntary House Purchase	Improve safety through removal of people from high hazard areas Very high cost Benefit-cost-ratio of 0.26	6.1	Council refine and extend their existing VHP scheme across the Coastal Creeks area and implement VHP Option 2.
21	Property	Voluntary House Raising	Improve safety (if isolated) May be some worsening of visual amenity if not consistent with existing streetscape Very high cost Benefit-cost-ratio of 1.0	6.2	Council refine and extend their existing VHR scheme across the Coastal Creeks area and implement VHR Option 2.
22	Property	Inform High Risk Residents	Improve safety Low cost	6.3	Council should 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.
23	Property	Manage Strategic Flood Risk	Manage hydraulic and safety risks associated with future development Low cost	7.1	Council should adopt the cumulative development scenario for the management of cumulative hydraulic impacts associated with future development
24	Property	Manage Future Development Flood Risk	Refinement of LEP flood related local provisions Updates to Tweed DCP to adequately control immediate and future floodplain development pressures Clarify high risk areas for purposes of Codes SEPP Funding of flood mitigation works necessary for future development	7.2	Council should undertake the following as part of Planning Scheme Amendments: Consider future refinement of LEP flood related local provisions Update building controls to reflect hydraulic constraints to development and filling Introduce floor level controls on commercial and industrial development where practical Retain provisions relating to enclosures below habitable

No	Modification Type	Description	Considerations	Section	Recommendation
			Updates to Council's flood policies Building controls Refinement of Section 149 notifications Availability of flood information to the public Low cost		floors Introduce consistent car parking and driveway controls Retain and refine provisions relating to caravan parks and moveable dwellings Detail definition of acceptable on-site or communal refuge Provision of guidance for assessing climate change effects Controls for management of flood risks from stormwater and overland flow paths Specify high risk areas identified and mapped for complying development Establishment of S94 contributions plans in future development areas where required FRMP to supersede Council's flood policies Refinements to Section 149 notification and notations Periodic reviews of protocols to release flood risk information to public as available
25	Property	Implement Climate Change Adaptation Plan	Improve flood awareness in residents of future increase in flood risk Educate residents of future increase in flood risk due to climate change Low cost	7.3.1	Council should implement the Adaptation Plan using new information from the Tweed Byron Coastal Creeks Flood Study and this Study
26	Property	Plan for Climate Change	Design development for future climate Design infrastructure for future climate Low cost	7.3.2	Council should undertake the following tasks as part of climate change planning: Apply the planning controls relating to climate change to the entire Shire including the Tweed Coastal Creeks area. Include climate change in design of infrastructure and flood defences; Incorporate climate change in development planning.

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1 Introduction

This document examines existing and future flood risk for the Tweed Coastal Creeks area, and assesses and makes recommendations for a range of flood, response and property modification measures to minimise the community's future exposure to flood risk. The information from this document was used to inform the Tweed Coastal Creeks Floodplain Risk Management Plan; a written document outlining a plan for management of flood risk in the area. The Tweed Coastal Creeks Floodplain Risk Management Study has been prepared on behalf of Tweed Shire Council by consultants BMT WBM Pty Ltd.

1.1 Flood Risk

1.1.1 General Principles

The primary objective of the NSW Government's Flood Prone Land Policy is to "reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property" and to "reduce private and public losses resulting from floods".

At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.

The only way to completely remove flood risks from a development is for it to be located outside the extent of the probable maximum flood (PMF) [1]. This is a very risk-averse approach to floodplain management which is generally not supported by the Floodplain Development Manual (DIPNR, 2005). In particular, one of the principal tenants of the Flood Prone Land Policy is that "flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development".

When considering future development, both the policy and the Floodplain Development Manual promote the use of a "merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable. In this way the policy avoids the unnecessary sterilisation of flood prone land. Equally it ensures that flood prone land is not the subject of uncontrolled development inconsistent with its exposure to flooding".

In view of the above, a key issue to be determined is the level of risk that the community considers to be acceptable, noting that the elimination of all risk is generally not practical or appropriate.

As a general rule, almost any development involves a range of risks to property or people. For example, construction of a new subdivision introduces traffic risks which may be managed (e.g. through construction of traffic lights, signage, etc.) but are not completely eliminated. Rather the risks are reduced to a level which is considered acceptable to the community. Flood risks are managed in a similar fashion. Nevertheless, in some situations where the residual risks remain unacceptably high, alternative safer forms of development should be pursued.

[1] Probable Maximum Flood - An extreme flood deemed to be the largest flood that could conceivably occur at a specific location. It is generally not physically or economically possible to provide complete protection against this flood event. The PMF defines the extent of flood prone land (i.e. the floodplain).

1.1.2 Defining Flood Risk

Within the context of this study, 'flood risk' is defined as the combination of probabilities and consequences that may occur over the full spectrum of floods that are possible at a particular location.

1.2 Managing Flood Risk

There are three principal options for managing flood risks:

- Avoiding the risk – land use planning is the key floodplain risk management measure by which inappropriate flood risks can be avoided. Effective land use planning ensures that only development compatible with the flood hazard can be located in the floodplain.
- Reducing the likelihood – construction of detention basins, levees and other flood modification structural measures can reduce the probability of flooding.
- Reducing the consequences – a range of measures are available including:
  - Development controls;
  - Raising flood awareness amongst communities;
  - Improved emergency management;
  - Improved flood warning;
  - Provision of insurance; and
  - Provision of disaster relief.

In every situation, avoiding the risk through effective land use planning is the preferred option. Nevertheless, 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 Floodplain Development Manual guides Councils and consent authorities to use the 'merit approach' in making these land use planning decisions, balancing flood risk with other social, environmental and economic considerations.

The management of flood risk considers options for managing both the risk to property and the risk to people.

1.2.1 Risk to Property

The most common method of reducing the consequences to property is by applying development controls that specify the minimum height of floor levels relative to a given probability flood. A range of flood planning levels (FPLs) are usually established by Councils for this purpose, and may vary depending on the use of the building (e.g. residential, commercial, industrial, community services, emergency facilities).

Other complementary development controls are used to manage property risks including the use of flood compatible building materials and methods as well as ensuring buildings are strong enough to withstand the forces of flood waters without collapse. These types of controls are included in Council's Development Control Plan (DCP).

1.2.2 Risk to People

When considering future development in the Tweed Shire Local Government Area (LGA), risk to property can generally be managed, provided appropriate controls are applied. However, risk to life is seen as the key flood constraint within several flood prone localities. Accordingly, the consideration of flood risk to people and the most appropriate means to manage these risks is the focus of a large part of this Study.

A range of non-structural measures have been considered, including identifying evacuation and emergency management constraints, and increasing the community's awareness and preparedness for flooding.

Emergency management is a principal mechanism that requires consideration within the land use planning process as it can influence the:

- Location of new development – in areas free of flood risk or where evacuation away from the flood risk is possible;
- Form of development – so that it is designed to allow for pedestrian and/or vehicular evacuation, and buildings that are structurally resilient to the forces of floodwaters if unavoidably required to provide a refuge; and
- Connections between developments and safe refuges or support facilities – to ensure that pedestrian paths and road systems are designed to facilitate evacuation and access to safe refuges, support facilities and/or evacuation centres.

The report of the 2009 Victorian Bushfires Royal Commission articulated and emphasised the following principles of emergency risk management. As core principles they can be readily applied to the management of hazards other than bushfire (Opper, 2011):

- Protection of life is the highest priority;
- Property protection is always secondary;
- Urban design and development must take into account expected human behaviour;
- Urban design and development must take into account the expected range of severity of hazards;
- Emergency management strategies must take into account expected human behaviour;
- Emergency management strategies must take into account the expected range of severity of the hazards; and
- The safest place for people to be during the impact of hazard is away from the area being impacted.

There are no prescriptive standards for an acceptable risk to life for floodplain developments. Consent authorities require guidance on characteristics of the floodplain, matters of best practice and levels of risk considered acceptable to the community.

Experience from floods across the nation suggests that flooding is dangerous but not particularly so. The most serious loss of life in floods during the 20th and 21st centuries occurred recently

during the January 2011 floods in the Toowoomba, the Lockyer Valley, Brisbane and Ipswich areas when around 30 people lost their lives. This follows the Brisbane floods of 1974 when 12 lives were lost. The other most significant loss of life during floods occurred during the 1955 floods in Maitland when 14 people lost their lives and about 90 people lost their lives when a large part of the township of Gundagai was washed away in one night in 1852.

When deaths occur during floods, most die due to misadventure, exposure to unidentified risks, or by foolhardiness.

When compared to other voluntary and involuntary lifestyle risks that the community accepts (e.g. traffic fatalities, accidents at home, fatal cancers), the risk of death during floods is not seen as large. However, individual risk is different to what a society might consider acceptable because a number of people might be involved and their identity is unknown. These societal risks reflect communities' aversions to disasters and it has been suggested that in respect of flooding, society might accept one fatality in a 100 year ARI flood increasing to about 20 fatalities in a PMF. While statistical values (which are by nature imprecise and vary between communities) are less important, it is recognised that society does accept some risk of fatalities from flooding.

1.3 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.

Table 1-1 Floodplain Risk Management Process

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

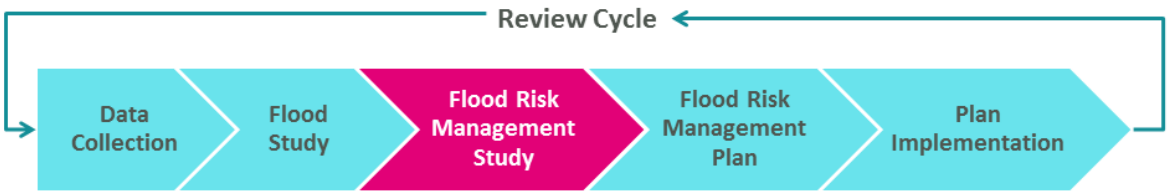

Figure 1-1 Stages of Floodplain Risk Management Process

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 who discuss technical aspects of the project to ensure there is a best-practice approach to the study.

This study represents the second of the four stages for the Tweed Coastal Creeks area. The study has been prepared for Tweed Shire Council to identify and assess potential flood mitigation options and to outline how flood prone land within the study area may be managed. The floodplain risk management study 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.

1.4 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.

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 study 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.

It is important to recognise that this study area differs from the study area of the Tweed Byron Coastal Creeks Flood Study (2010), which informs this Study. 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 in the future as part of the North Byron Coastal Creeks Floodplain Risk Management Study. Where additional hydraulic modelling was required as part of this Study, the original model (including Marshalls Creek) was used.

The Cudgen Creek catchment is the northern most catchment in this study. Cudgen Creek catchment is approximately 100km^2 in area and is bounded by the Burringbar Range to the west. Towns within the Cudgen Creek catchment include Bogangar, Cabarita Beach, Tanglewood, Salt, Casuarina 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. Townships within the Cudgera Creek catchment include Pottsville and 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. Townships 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. The 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.

1.5 Initial Consultation

Consultation provides a forum for the relevant stakeholders, including the community, to work together to shape a collective vision for the catchment and future floodplain risk management. Effective consultation can increase community acceptance of the Floodplain Risk Management Plan and provide the opportunity for better decision making.

Consultation with major stakeholders (community, industry and environmental groups) was conducted early in the study and outcomes were used to inform the management measures assessment process. Tweed Shire Council conducted stakeholder consultation during January 2012. Letters requesting input into the Study process were sent to community and business groups. Copies of the letter issued by Council and responses received can be found in Appendix A and Appendix B, respectively.

There were two dominant issues raised in the stakeholder consultation:

(1) A proposed development at lot 156 Creek Street, Hastings Point; and

(2) Siltation of waterways.

1.5.1 Creek Street, Hastings Point Development

Concern about a proposed development in Creek Street, Hastings Point was raised as a key issue from the stakeholder responses, particularly in relation to the Tweed Byron Coastal Creeks flood model and its representation of the boundaries between the Cudgen and Cudgera creek catchments. Council examined this issue as part of a Development Appraisal and confirmed no concerns regarding the validity of the flood model for a flood impact assessment for the project on Creek Street.

1.5.2 Siltation of Waterways

Siltation of waterways emerged as a major issue from stakeholder responses, with concern that reduced creek capacity has exacerbated local flooding issues. In particular, stakeholders suggested that siltation of waterways may be delaying drainage after the flood peak and damaging sugarcane crops.

Stakeholders reported that the Crabbes / Mooball Creek, Clothiers / Reserve Creeks and Cudgen Lake and Cudgen Creek systems were both affected by siltation. There is also concern that siltation in Marshalls Creek is influencing flooding in the Bilinudgel and Yelgun Creek catchments. Overgrown vegetation in waterways was also identified as potentially worsening local flooding.

1.5.3 Other Issues

In addition to these letters, Council has conducted ongoing consultation with a number of key and concerned stakeholder groups, particularly the sugar cane growers. Although generally informal in

nature, the consultation recognised the sugar cane grower's concerns regarding drainage and flood inundation times in the lower floodplain.

A number of other flooding issues were reported by stakeholders, including:

- Earthworks altering flow around Wooyung Road (opposite Old Coast Road) and the altered flow exceeding the existing culvert capacity.
- Emergency response issues, including requests for more information on evacuation centres and routes, installation of flood warning signs and flood markers, and the management of emergency response issues locally.
- Local drainage issues, including clearing of drains and land clearing.
- The impact of past development projects on flooding, including Black Rocks Estate and the pedestrian bridge over Cudgen Creek.

Figure 1-2 Consultation Process

1.5.4 Online Community Consultation

Online community consultation was conducted by Council during February and March 2012. The survey was directly linked from Council's website and advertised in the February 2012 edition of the Tweed Link. The electronic survey received 51 responses, of which 17 related to the study area.

The survey asked questions about six distinct aspects of the Floodplain Risk Management process:

(1) General Flooding Concerns – Personal flood risk, climate change, flood preparedness.

(2) Flood Modification Measures – Levees, dredging, improvements to infrastructure and maintenance procedures.

(3) Response Modification Measures – Flood education, flood warning and emergency planning.

(4) Property Modification Measures – Flood related development controls, voluntary house purchase and voluntary house raising.

(5) Flood Evacuation – Flood evacuation plans, evacuation centres and ability to evacuate.

(6) Flood Information – Most convenient location for flood information.

1.5.5 General Flooding Concerns

More than half of respondents were very concerned about drainage after the flood peak, particularly the drainage of Cudgen Creek, and the inlet/outlet between Cudgen Lake and Cudgen Creek. Siltation of creeks and blockage of drainage is seen to increase flooding in residential areas.

Some respondents were concerned about isolation if local roads become flooded or heavy traffic prevents evacuation.

There was also some concern about the effect that lakes constructed as part of the Dunloe Park sand quarry will have on broader catchment flooding and waterway health.

Particular locations identified as requiring maintenance or additional drainage infrastructure were Clothiers Creek Road, Tamarind Avenue and Tweed Coast Road.

1.5.5.1 Flood Modification Measures

Improvements to drainage infrastructure and maintenance practices, as well as dredging of the creeks, were strongly supported. Specifically mentioned was the maintenance of drainage in Tamarind Avenue and clearing of a drainage path from Cudgen Lake to the ocean.

There was some support for reinstatement of waterways to natural pathways and better infiltration zones in industrial areas.

1.5.5.2 Response Modification Measures

Respondents generally agreed that flood awareness, flood warning, and evacuation planning measures could be improved.

It was noted that information about road closures was not updated frequently enough and this information was not shared widely enough.

Responses also indicated that flood warnings should be issued through a wider variety of media (including SMS and social media).

1.5.5.3 Property Modification Measures

In general, the respondents support development controls for new buildings in flood prone areas and believe these same controls should be extended to additions or extensions to existing buildings.

There were mixed feelings about whether industrial buildings should be allowed in areas of higher flood risk than residential buildings. One of the objections states that allowing industrial building in flood prone areas will increase the risk of water pollution during floods.

1.5.5.4 Flood Evacuation

Very few respondents were aware of a flood plan relating to their area or know where their nearest evacuation centre is, yet most are confident of being able to evacuate during a flood.

In addition, there were specific evacuation concerns primarily related to isolation (e.g. provision of food and water during this time) and traffic congestion during evacuation.

1.5.5.5 Flood Information

An overwhelming majority of respondents indicated that they would look for flood information on the internet. Council's website was specifically mentioned as a place where the community would prefer to source flood related information.

In addition to online information, many respondents highlighted the importance of radio, particularly during power outages.

A wide variety of media was supported by the community to ensure that flood information reaches all at-risk individuals, irrespective of power outages / location / phone reception etc.

1.6 Public Exhibition Consultation

The draft Tweed Coastal Creeks Floodplain Risk Management Study and Plan (including supporting Discussion Papers) were put on exhibition by Tweed Shire Council from 6th October to 17 November 2015. During the exhibition period, electronic copies of all documents were available on Council's website, with hard copies provided at Council's Murwillumbah office. During the exhibition period, a number of key stakeholders also sought private meetings with Council to discuss specific aspects.

Two community sessions were hosted by Council and BMT WBM towards the end of the initial exhibition period. The first session was held at the Burringbar School of Arts on 26th October, with a second session held at the Cabarita Sports Club (Les Burger Field), Cabarita the following day. Both consultations had sessions in the early evening (5:30 – 6:30).

The community sessions were held as drop-in sessions, including presentations from Council and BMT WBM, a question and answer session, and the provision of information via posters and take-home brochures. These sessions had a dual purpose:

(1) To inform the community about the draft Study and Plan (including methodology, outcomes and recommendations), and general flood behaviour and risk in the catchment; and

(2) To consult with the community about the draft Study and Plan, especially to obtain public feedback on recommendations and discuss alternative options.

Hard-copy flood maps were available to support discussion with residents. A number of issues were raised at the community sessions and through written submissions. Responses received can be found in Appendix C. These issues are summarised below.

1.6.1 Engineering Options

Many of the responses requested further consideration of 'engineering options' (i.e. flood modification options) in the Study, including:

- Sedimentation of Mooball Creek and its impact on Pottsville;
- Sedimentation of Cudgera Creek;
- Measures to address the flooding of Cudgera Creek Road;
- Slowing water further up the Mooball Creek catchment with a dam;
- Installation of relief pipes in the area of Wooyung to convey floodwaters under the road;
- Increasing outlets or widening existing outlets from creeks; and
- Non-return valves on outlets to creeks.

1.6.2 Flood Education

A comment was raised about why residents of caravan parks were not included within the calculation of risk.

1.6.3 Flood Warning and Evacuation

One response requested that the public should be allowed to receive warnings when trigger levels are reached on stream gauges. It also suggested that signage should be placed across flash flooding points on roads as the most effective way of reducing risk. There was a comment regarding the evacuation routes not being workable and what the evacuation point should be if Crabbes Creek Public School was removed as an evacuation centre.

1.6.4 Planning and Development

Planning and development issues were raised by several consultation responses, with a range of issues discussed. These included: a comment about building houses on piers on floodplains and waterways not being practical, and making the cumulative development scenario available to community members. In addition a comment was received which noted that allowing more development in the floodplain areas would increase existing flood problems.

1.6.5 Other issues

Other issues were raised in the responses which were beyond the scope of the study. These included:

- Floodplains. These should be left alone as most are disappearing as well as fauna and flora and could be used for other activities
- Insurance. In relation to potential cost of flood damages with buildings constructed in a known floodplain.

1.7 Other Consultation Activities

In parallel with the community sessions, during the Public Exhibition period, Council undertook the additional briefing sessions and discussions as documented below:

- Briefing Session - Agricultural Stakeholders - 2 October 2015 with representatives of:
  - Cudgen Drainage Union
  - Mooball Crabbes Creek Drainage Union
  - NSW Canegrowers
  - NSW Sugar Milling Cooperative
- Briefing Session - TSC - Tweed River Committee - 14 October 2015;
- Briefing Session - TSC - Tweed Coastal Committee - 14 October 2015;
- Onsite Inspection - Burringbar Creek Mooball - 6 November 2015; and
- Onsite Meeting - Mooball Village - 6 November 2015.

1.8 Incorporation into Study

All of the issues raised during the various consultation processes have been considered by the Floodplain Management Committee, including those beyond the scope of the study. These issues have been addressed in the study in various ways, including one or a combination of the following:

- Creation of a Frequently Asked Questions (FAQs) brochure discussing some of the most topical issues related to flooding and floodplain management in the Tweed Coastal Creeks area. This brochure is attached to the study (see Appendix D) as well as available separately. The FAQs brochure provides a useful medium in which to address issues that are beyond the scope of the study.
- Inclusion and / or clarification of relevant issues in study.
- Provision of individual responses to submissions received.
- Direct discussion with an individual or organisation where the issue is localised and not relevant to other residents.
- Recognition that some issues will continue to evoke conflicting responses and that not all parties can be satisfied all of the time.

2 Methodology

The process used to define flood risk and subsequently assess measures to manage the risk, is provided in the NSW Floodplain Development Manual (2005). This process was followed during the development of the Tweed Coastal Creeks Floodplain Risk Management Study (FRMS), in conjunction with industry standard approaches. During the development of the Study, a series of Discussion Papers was prepared for consideration by the Floodplain Risk Management Committee and the Technical Committee. These papers provide extensive background information for the Study; however do not form part of the Study or Plan. A description of the methodology and sources of information and data is provided below.

2.1 Information and Data

The Tweed Coastal Creeks FRMS covers a wide geographic area with multiple townships and a diverse range of land uses. In addition, the area is subject to multiple types of flood risk and faces development pressures. Therefore, a wide range of information and data sources was required for the characterisation of flood risk in this area, including flood behaviour, demographic data, property survey and planning information.

Information about flood behaviour in the Tweed Coastal Creeks area was primarily derived from the Tweed Byron Coastal Creeks Flood Study (2010). Some additional flood modelling was required during this Study, particularly to quantify the hydraulic impacts of potential management measures and future development, as well as evacuation constraints.

Demographic data was important to highlight the flood risk to people in the Tweed Coastal Creeks area. This information, including population, numbers of vehicles and vulnerability indices (such as age), was derived primarily from the 2011 Census and geographically distributed to help identify which sections of the population are exposed to the greatest flood risk.

An extensive property survey was commissioned as part of the FRMS to accurately identify the location of every property in flood prone land (both residential and commercial) and record information about floor levels, building and contents. This data informed the damages assessment and was also used to identify potential properties for voluntary house raising or purchase.

A review was completed of the Tweed Shire Council planning framework in relation to flood risk, including the Development Control Plan (DCP) and Local Environment Plan (LEP) during the development of the Tweed Valley FRMS and this Study has drawn from this previous work. The review looked at ways the existing planning documents could incorporate best-practice flood planning controls together with specific flood risk management recommendations for this Study.

2.2 Hydraulic Impact Assessment

Hydraulic impact assessments look at the way that flood behaviour (e.g. depth, velocity, duration of inundation) might change as a result of changes in the floodplain, such as raising a flood levee, building a residential development or dredging a river. An assessment starts by using a flood model to define the design flood behaviour (e.g. a flood with a 100 year Average Recurrence Interval

(ARI)[2]) for existing conditions. The flood model is then altered to include the changes in the floodplain, and the results are compared to estimate the impact (positive or negative) on flood behaviour.

2.3 Evacuation Capability Assessment

Evacuation capability assessments consider the ability of people within the floodplain to evacuate safely during a flood event. Many aspects of evacuation planning (flood behaviour, community response and traffic) are difficult to predict and are highly uncertain, however a solid understanding of flood risk to people and the suitability of evacuation infrastructure elements will help to highlight weaknesses in the overall evacuation process.

Standard evacuation planning is suitable for regions with sufficient time available to evacuate. However, for locations where flood waters generally rise quickly (flash flooding environments), residents are unlikely to have sufficient time to safely evacuate. This study recognises that flooding mechanisms vary across the Tweed Coastal Creeks area and that it would not be appropriate to use a 'one size fits all' approach to evacuation planning. As a result, a formal evacuation capability assessment was not undertaken, but various aspects of flood behaviour, including extents, hazards and relative timing was provided in flood maps. These maps will assist the SES to plan for flood evacuations and identify options to reduce risk, particularly in areas where there may be insufficient time to safely evacuate everyone.

2.4 Flood Damages Assessment

The main objective of the flood damages assessment is to establish the 'baseline' economic costs of flooding (i.e. based on current conditions) which can then be used to help quantify the benefits of potential mitigation measures.

2.5 Benefit Cost Assessment

Benefit cost assessments are carried out on proposed management options to determine the economic merits of pursuing and / or implementing these options. The assessments compare the likely reduction in flood damages (i.e. economic benefit) against the cost of implementing the option (e.g. construction and maintenance). This comparison produces a ratio which can help inform the decision making process (cost-benefit-ratio).

2.6 Planning Assessment

In addition to the above quantitative assessments, recommendations made to update Council's planning instruments with best-practice flood planning controls based on flood behaviour. A hydraulic assessment was undertaken on future large-scale urban developments planned for the Tweed Coastal Creeks area to examine the cumulative impacts of filling multiple locations within the same floodplain. Furthermore, the potential impacts of climate change were assessed to ensure that future development is able cope with the increased flood risk that climate change predictions are suggesting.

[2] Average Recurrence Interval - The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

3 Existing Risk

3.1 Flood Behaviour

The coastal creeks of northern New South Wales between Brunswick Heads and Tweed Heads have a long history of flooding, with the most recent major flood event occurring in June 2005. The townships of Bogangar/Cabarita Beach, Hastings Point, Pottsville, Burringbar, Mooball, Wooyung and Crabbes Creek have all 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 flood event which occurred across all catchments in June 2005 resulted in above floor level flooding of a significant number of buildings across the study 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 Study, is catchment or riverine flooding. 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, this type of 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 study 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 FRMS.

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 Coastal Creeks Flood Study (2010) due to the broad scale nature of the model. However, it is known that the effects of local flooding generally worsens existing flood risk, particularly in urban areas.

3.1.1 Hydraulic Categories

Hydraulic categorisation is one of the tools used to identify flood behaviour and risk in the FRMS. Outcomes of the categorisation are primarily used to inform future land use planning. The categorisation is not used to assess individual developments, but rather to give a catchment-scale overview of which areas may be appropriate for various types of land use.

Three hydraulic categories are defined in the Floodplain Development Manual, as follows:

- **Floodways** – Areas conveying a significant proportion of flood flow where partial blocking will adversely affect flood behaviour. Future development should not be allowed to take place in these areas.
- **Flood Storage Areas** – Areas outside floodways which store significant volumes of floodwaters. Reduction in flood storage would cause downstream flood flows to increase.
- **Flood Fringe** – The remaining area of land affected by flooding, after floodway and flood storage has been defined. Development in flood fringe areas would not generally cause significant hydraulic impact.

3.1.1.1 High Flow Areas

As part of the Tweed Valley Flood Study Update (2009), a definition was adopted which was used to define areas of high flow. These high flow areas identified locations in the floodplain that conveyed the majority of floodwaters.

High flow areas were defined as having a velocity-depth product (VxD) of more than 0.3m^2/s. A number of other criteria were compared. However this definition provided the best representation of major flow paths. This definition of high flow areas was adopted in the Tweed Valley Floodplain Risk Management Study (2012) as the ‘floodway’ area (as discussed in Section 2.2.2 below) and will inform future planning decisions.

The same definition was also found to represent major flow paths in the Tweed Coastal Creeks area. It is recommended that this criterion be used to define the floodway in this study.

3.1.1.2 Tweed Shire Hydraulic Categories

Hydraulic categories were investigated for the Tweed Shire area as part of the Tweed Valley Floodplain Risk Management Study (2012). Two different approaches to these categories were considered, with the definitions in Table 3-1 found to provide the closest approximation of the categories defined by the Floodplain Development Manual.

Table 3-1 Tweed Valley Hydraulic Categories

Hydraulic Category	Definition
Floodway	100 year ARI velocity x depth > 0.3m^2/s
Flood Storage	100 year ARI velocity x depth > 0.025m^2/s
Flood Fringe	Remainder of floodplain (up to PMF)

While consistency across the LGA is a high priority, these same definitions were not found to be suitable in the Tweed Coastal Creeks area. As described above, the floodway definition was carried over from the Tweed Valley FRMS; however the flood fringe area had to be drastically reduced to avoid unacceptable impacts.

Although isolated locations within the 100 year ARI extent may be filled without causing unacceptable impacts, due to the flood behaviour in the study area, it was difficult to identify a consistent hydraulic definition which could be applied in this setting. As a result, the flood storage definition has been adopted as the 100 year ARI extent, excluding the floodway. The flood fringe is therefore land beyond the 100 year ARI extent, but within the floodplain (PMF extent). The adopted definitions for hydraulic categories in the Tweed Coastal Creeks study area are provided in Table 3-2.

Table 3-2 Tweed Coastal Creeks Hydraulic Categories

Hydraulic Category	Definition
Floodway	100 year ARI velocity x depth > 0.3m^2/s
Flood Storage	Land beyond the Floodway which, if completely filled, would cause unacceptable impacts in the 100 year ARI event
Flood Fringe	Flood prone land beyond the flood storage areas (up to the PMF extent)

These categories were mapped for the Tweed Coastal Creeks area, as shown in Figure 3-1.

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

LEGEND

- Study Area
- Tweed River
- Waterway
- Cadastral Boundaries

Hydraulic Categories

- Floodway - 100 Year ARI depth velocity > 0.3m²/s
- Flood Storage - land beyond the Floodway which, if completely filled, would cause unacceptable impacts in the 100 Year ARI event
- Flood Fringe - flood prone land beyond the Flood Storage areas (up to the PMF extent)

Title:
Tweed Coastal Creeks Hydraulic Categories

Figure: **3-1**

Rev: **A**

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Approx. Scale

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3.2 Summary

Two clear conclusions can be drawn based on the modelling and mapping undertaken as part of the hydraulic categorisation:

(1) The upper catchment areas, such as Burringbar, Mooball and Crabbes Creek convey high flood flows (are in the floodway). The Floodplain Development Manual's definition of hydraulic categories precludes future development in floodways; and

(2) The Tweed Coastal Creeks study area is sensitive to development within the 100 year ARI flood extent. Future development should proceed with caution.

3.2.1 Duration of Flooding

Sugarcane 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.

However, due to the flat topography in much of the lower catchment area, drainage from rural areas can be slow, i.e. in the order of days even for relatively frequent (small) flood events. Most of the final drainage to occur in the floodplain happens via small-scale drains in the sugar cane fields (cane drains). These cane drains are not included in the Tweed Byron Coastal Creeks hydraulic model, and as a result, the model does not provide a good representation of drainage behaviour.

The duration that the floodplain remains flooded above 30cm has been mapped for the 100 year ARI 36 hour catchment dominated flood in Figure 3-2. Due to the nature of the hydraulic model used to produce this map, the map should be considered indicative only. If further information about duration of inundation or drainage behaviour is required, additional detail would be required in the model.

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

LEGEND

Study Area
Tweed River
Waterway
Cadastral Boundaries

Duration of Flooding Over 30cm (hrs)

0 to 12
12 to 24
24 to 36
36 to 48
48 to 60
60 to 72
Greater than 72

Title:
Duration of Flood Inundation, 100 Year ARI 36 Hour Event

Figure: 3-2
Rev: B

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Approx. Scale

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3.3 Risk to People

Residents throughout the Tweed Coastal Creeks study area face a range of different flood hazards: those in the upper catchment must be prepared for fast-onset flooding which can have high flood flow rates, while residents in the lower floodplain regions may become isolated for prolonged periods. These various aspects of flood hazard have been mapped to help identify the critical hazards faced by residents in different areas.

The total population at risk of flooding is provided in Table 3-3 below. These numbers are estimates of the total people and properties within the flood extent for the 5 and 100 year ARI events and the Probable Maximum Flood[3] (PMF).

Table 3-3 Population at Risk

Numbers at Risk	5 Year ARI	100 Year ARI	PMF
People[4]	310	1,557	8,347
Residential Properties	79	385	3,130

Older residents (defined here as 65 years and over) are more likely to require assistance during evacuation and may be socially isolated, resulting in delayed awareness of evacuation warnings (State Emergency Service, 2014). Although the fraction of older residents in the Tweed Coastal Creeks study area (14%) is comparable to the 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 has been in coastal areas, which has brought an influx of so-called ‘sea change’ residents. Many of the residents in these locations are new to the area and are unfamiliar with the local flood behaviour.

Vulnerable residents and institutions (such as aged care facilities) were identified as part of this Study. This information can be used in conjunction with quantitative evacuation capability assessments to highlight areas of particular concern. These areas may require evacuation plans surplus to broader community requirements or need additional assistance during evacuation.

Deep flood waters can be extremely hazardous, even if moving slowly or still. Lower floodplain areas of the Tweed Coastal Creeks study 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.

Flood depths for these two events are shown in Figure 3-3 and Figure 3-4. It is important to note that there may be areas with increased localised flooding due to obstructions from debris etc.

[3] Probable Maximum Flood - An extreme flood deemed to be the largest flood that could conceivably occur at a specific location. It is generally not physically or economically possible to provide complete protection against this flood event. The PMF defines the extent of flood prone land (i.e. the floodplain).
[4] These figures include residents of caravan parks, assuming full occupancy.

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

Flood Depths (m)
0.00 to 0.5
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 3.00
3.00 to 4.00
Greater than 4.00

LEGEND
Study Area
Tweed River
Waterway
Cadastral Boundaries

Title:
Peak 100 Year Flood Depth

Figure: 3-3
Rev: A

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Approx. Scale

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

Flood Depths (m)
0.00 to 0.5
0.50 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 3.00
3.00 to 4.00
Greater than 4.00

LEGEND
Study Area
Tweed River
Waterway
Cadastral Boundaries

Title:
Peak PMF Flood Depth

Figure: 3-4
Rev: A

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3.3.1 Isolation

Isolation can be a major risk, particularly when the isolation persists for more than a few hours; essential services (such as electricity and water) are cut-off, or where isolated residents require medical attention.

During periods of isolation, residents can become stressed or anxious, there may be food and water shortages and medical emergencies may become more serious due to delayed treatment. Identification of islands can inform future planning decisions, either through evacuation plans which ensure residents are evacuated prior to isolation, or as a backup, services are installed on a high island area.

Isolation is a risk in the Tweed Coastal Creeks area where flooding can persist due to poor drainage. Low and high island areas were mapped and are presented for the study area in Figure 3-5. 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.

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

LEGEND

- Study Area
- Tweed River
- Waterway
- Cadastral Boundaries
- High Island (isolated in PMF; unlikely to be inundated)
- Low Island (isolated in 100 Year ARI Flood; inundated in larger flood events)
- Low Island (isolated in 20 Year ARI Flood; inundated in larger flood events)

Title:
Low and High Islands

Figure: 3-5

Rev: A

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Approx. Scale

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www.bmtwbm.com.au

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3.3.2 Vulnerable Institutions

The term ‘vulnerable institution’ encompasses any organisation which either houses vulnerable residents or is more vulnerable to flooding than standard properties. The types of vulnerable institutions which have been identified as part of this study include:

- Caravan parks;
- Aged care facilities / retirement villages; and
- Schools.

Vulnerable institutions within the study area are shown in Figure 3-6.

S1
S3
S2
CP2
N1
CP1
CP3
Bogangar
S4
S5
CP4
S6
CP5
Pacific Highway
Terranora
S7
S8
Tumbulgum
Condong
Tweed Valley Way
Murwillumbah

CP1 Hastings Point Caravan Park
CP2 North Star Holiday Resort and Caravan Park
CP3 Pottsville North Holiday Park
CP4 Pottsville South Holiday Park
CP5 Wooyung Beach
N1 Hastings Point Retirement Community
S1 Kingscliff Public School
S2 St Anthony's Catholic Primary School
S3 TAFE NSW
S4 Pippies Early Childhood Centre
S5 Pottsville Beach Public School
S6 Pottsville Community Pre-School
S7 Crabbes Creek Public School
S8 Burringbar Public School

LEGEND

- Study Area
- Tweed River
- Waterway
- Cadastral Boundaries
- Caravan Parks
- Schools
- Nursing Homes
- PMF Flood Extent

Title:
Vulnerable Institutions

Figure: 3-6
Rev: B

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0km 2 4
Approx. Scale

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Filepath : I:\B17892_I_BRH Tweed FMH\DRG-WKG\DP2\FLD_017_130412_Vulnerable_Institutions.WOR

3.3.3 Evacuation

3.3.3.1 Flood Prediction and Warning

The Bureau of Meteorology relies primarily on broader weather patterns and stream gauge information from the Tweed Valley catchment to make decisions on potential flooding in the Tweed Coastal Creeks area. There is no formal hydrology model in place for the Tweed Coastal Creeks area which is capable of predicting likely downstream impacts as a result of predicted and / or actual rainfall. Water level predictions are not made for the two stream gauges in the study area.

3.3.3.2 Evacuation Centres

There are eight evacuation centres accessible from the Tweed Coastal Creeks study area. These centres are places of refuge during flood events and should ideally be out of the PMF extent. Crabbes Creek Public School is within both the 100 year ARI and PMF flood extents, and is believed to have flooded in the past. Based on current information, this location is considered unsuitable for use as an evacuation centre.

3.3.3.3 Evacuation Routes

In general, the evacuation routes in the Tweed Coastal Creeks study area have poor flood immunity, which would severely impede the evacuation process. During a 100 year ARI flood event, evacuation routes are likely to either become inundated within 6½ hours of the storm commencing, or remain flood free during the entire duration of the flood. Due to the time required for flood prediction, SES response, dissemination of flood warnings and community preparation, 6 ½ hours is insufficient time to even commence evacuation. Residents who need to be evacuated via roads that close in the 100 year ARI flood event will not be able to do so, according to standard planning and time-frames.

During a PMF flood event, all designated evacuation routes are likely to become inundated. Many roads may flood as early as 1 or 2 hours following the commencement of the storm, with most closing before 8 hours have elapsed. As for the 100 year event, evacuation will be extremely difficult in these circumstances and may even be dangerous to commence, based on standard planning and time-frames.

It is important to note that local flooding, due to blocked or overflowing drains, may cause roads to become flooded earlier than shown in the maps below, effectively worsening the evacuation problem.

Kingscliff Public School
Kingscliff TAFE
Cudgen Public School
Cabarita Beach Surf Club
Bogangar (Cabarita) Public School
Pottsville Beach Public School
Pacific Highway
Terranora
Tumbulgum
Condong
Murwillumbah
Tweed Valley Way
Crabbes Creek Public School
Burringbar School of Arts

LEGEND

- Study Area
- Tweed River
- Waterway
- Cadastral Boundaries
- Evacuation Centre (Tweed Local Flood Plan)
- Evacuation Route (Tweed Local Flood Plan)
- PMF Flood Extent

Title:
Evacuation Infrastructure

Figure: 3-7

Rev: A

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Approx. Scale

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

LEGEND

Study Area
Tweed River
Waterway
Cadastral Boundaries

Evacuation Centre (Tweed Local Flood Plan)
Evacuation Route (Tweed Local Flood Plan)
Historical Road Closers (Provided by Historic Information)

Hydraulic Model Results: Time of First Inundation Causing Road Closure
< 2 hrs
2 - 4 hrs
4 - 6 hrs
> 6 hrs

Title: **Road Closures, 100 Year ARI Flood**

Figure: **3-8**

Rev: **B**

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Approx. Scale

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Filepath : I:\B17892_I_BRH Tweed FMH\DRG-WKG\DP2\FLD_014_120717_Q100_evac_routes_RCP.WOR

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

LEGEND

Study Area
Tweed River
Waterway
Cadastral Boundaries

Evacuation Centre (Tweed Local Flood Plan)
Evacuation Route (Tweed Local Flood Plan)
Historic Road Closures (Provided by Historic Information)

Hyrdaulic Model Results: Time of First Inundation Causing Road Closure

< 2 hrs
2 - 4 hrs
4 - 6 hrs
> 6 hrs

Title:
Road Closures, PMF

Figure: 3-9
Rev: B

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Approx. Scale

BMT WBM
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Filepath : I:\B17892_I_BRH Tweed FMH\DRG-WKG\DP2\FLD_015_120717_QPMF_evac_routes_RCP.WOR

3.4 Risk to Property

In addition to personal risk, properties can also be at risk of serious structural damage due to high velocities, depths and flood flows, as well as internal, external and indirect losses. Using the flood model and property survey, the number of residential and commercial properties experiencing above floor flooding was estimated, shown in Table 3-4.

Table 3-4 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

3.4.1 Flood Damages

A 'baseline' damages assessment has been completed for the entire FRMS area, using the existing flood model. This assessment estimated an annual average damages (AAD) of **$2.55 million**. This value includes damages incurred by residential and commercial properties and approximated infrastructure damages and damage to agriculture (sugarcane crops).

Results of this assessment for the area are presented in Table 3-4.

Table 3-5 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**

4 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 separately as part of the FRMS.

4.1 Flood Modification Option 1

During the community and stakeholder consultation, a number of responses indicated that one of the community's major concerns was prolonged flooding in sugarcane fields. Anecdotal evidence suggests that flood waters have taken longer to drain from the fields in recent years than in the past. Worsened drainage is generally attributed to increased siltation in the creeks. Following additional consultation with the Cane Growers Association of the region, the Technical Committee opted to test the impacts of dredging Mooball Creek on drainage of adjacent sugarcane fields.

Dredging of Mooball Creek was proposed as a means of reducing both flood levels and total time of flood inundation in the surrounding floodplain areas.

This assessment tested the impact of dredging the lower Mooball Creek on flood duration for 5 and 20 year ARI flood events. The tested option represents the upper limit of what could feasibly be achieved.

4.1.1 Assessment Summary

Results from the assessment indicate that dredging the creek would have limited to negligible improvements on flood magnitude, extent and duration of inundation. Furthermore, dredging of the creek was not found to be economically viable. The economic benefit to the local cane industry was low and was far exceeded by the cost of dredging. Negative environmental impacts such as salt water intrusion and loss of riparian vegetation and habitats within the estuary are likely to result from dredging and would likely require formal assessment through the preparation of an Environmental Impact Statement. This option was not recommended to be carried forward within the FRMS.

It is recognised that the resolution of the hydraulic model used for this assessment is not detailed enough to include many of the small cane drains which can influence drainage of floods in this area. Nonetheless, it is not believed that inclusion of the drains in the hydraulic model would significantly affect the outcome of the assessment.

4.2 Flood Modification Option 2

The Tweed Cumulative Coastal Development Plan designates the area of Dunloe Park as a site of future urban development. Most of the proposed development site is on high ground; however the north eastern corner of the site is susceptible to poor drainage and flooding. Currently, the proposed development site drains through wetland and a system of weirs, canals and tidal exchange culverts in the Pottsville Waters residential development to the west.

The flooding that impacts the proposed development area is caused by rainfall events within the Mooball Creek catchment. The site drains through the wetland into the Pottsville Waters canal system. The wetland is generally flat, which causes floodwaters to drain slowly.

The assessment tested the impact of lowering the weirs from their existing level of 2.5m AHD to 2.0m AHD. The overflow channels, which have an invert level of 1.7m AHD, were not modified to ensure that the connectivity of the wetland and canal remains under non-flood conditions.

4.2.1 Assessment Summary

The assessment tested the impacts of lowering the weir on peak flood level impacts for the 20 and 100 year ARI flood events using the hydraulic model. 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 this option due to the minimal change to flood levels and the difficulty in assessing the economic benefit of creating development potential. 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. This option was not recommended to be carried forward within the FRMS.

The hydraulic model was modified for this assessment to improve representation and accuracy of relevant drainage infrastructure. However, it is recognised that the resolution of the hydraulic model and the poor accuracy of topographic data in the wetland area does not provide a good representation of fine-scale flooding behaviour.

4.3 Additional Flood Modification Options Considered

A number of other flood modification options are available to mitigate flooding on a catchment scale and were considered as part of this study. However, these options are generally very expensive and can have significant environmental implications. None were identified as being suitable for further assessment to benefit the broader study area.

5 Response Modification Measures

The following response modification measures 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.

5.1 Emergency Response Planning

5.1.1 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, should the findings of this Study not be available before the completion of the review, the SES 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.

Specific issues which should be considered for the next review include:

- Include information from this Study and the Tweed Byron Coastal Creeks Flood Study
- Remove Crabbes Creek Public School as an evacuation centre
- Remove Crabbes Creek Public School as a helicopter landing site
- Assess evacuation centre capacity
- List Tweed Coastal Creeks stream gauges
- Identify flood prone roads.

Recommendation 1: Update the Local Flood Plan to include flood intelligence derived from the Tweed Byron Coastal Creeks Flood Study and this Floodplain Risk Management Study.

5.1.2 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:

(1) Flash flood risk

(2) Catchment flood risk

(3) Storm surge risk

(4) Flood isolation risk

(5) Lower flood risk (in the floodplain but outside 100 year ARI extent).

Note that properties in the catchment flood risk area may also be vulnerable to storm surge flooding.

Recommendation 2: The SES to adopt a multi-pronged approach to flood emergency planning based on the different types of flood risk in different areas.

5.1.3 Plan for Flash Flooding

Flash flooding is recognised to be a significant risk for residents in the 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.

Recommendation 3: The SES to adopt a triage approach to their flash flood planning which would require identifying those areas where evacuation is realistically possible and, for those areas where it is not, identifying alternative responses.

5.1.4 Plan for Pedestrian and Local Evacuation

The standard flood evacuation process requires more than six hours from the start of rain for the SES to prepare and issue flood warnings, residents to understand and respond to those warnings, and for residents to travel to the nearest evacuation centre. In locations where flash flooding is likely to occur, residents will not have sufficient time to safely evacuate by vehicle before they become affected by dangerous flooding.

Pedestrian evacuation should be considered where residents have access to local high ground and it is safer to shelter in these locations than enter the floodplain en route to an evacuation centre. 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.

Recommendation 4: The SES to identify areas where pedestrian and/or local evacuation may be suitable, update the LFP accordingly, and consider providing targeted education to residents in areas which are identified as suitable for pedestrian evacuation.

5.2 Community Awareness and Education

5.2.1 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.

Recommendation 5: The SES and Council should continue to promote flood awareness throughout the Tweed Coastal Creek area using a variety of methods and platforms.

5.2.2 Target Education Campaigns based on Flood Risk

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 and therefore undertake a targeted education campaign in the identified areas.

For instance, residents in areas prone to flash flooding should be made aware that floods may occur without warning, can be extremely dangerous due to high velocities, and vehicle evacuation may not be possible. The property database and map of flood risk types provided as part of this study can be used to inform the targeted material.

Recommendation 6: The SES and Council should generate specific material for each flood risk type and ensure that each type of material is distributed to at-risk residents.

5.2.3 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 could 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.

Recommendation 7: Council consider the provision of online, interactive flood mapping.

5.2.4 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.

Recommendation 8: The SES should 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.

5.2.5 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 new residents to the area and.

Recommendation 9: Council and the SES should ensure that some of the flood awareness material is targeted at new residents to the area and tourists.

5.2.6 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. 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.

Recommendation 10: Council should establish a Facebook page dedicated to flooding in the Tweed Shire (both Tweed Valley and Tweed Coastal Creeks areas).

5.2.7 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. Representatives will be from community organisations, such as Rotary and Red Cross, will develop the skills and projects to better support their communities through the development of flood resilience.

Recommendation 11: Council to provide support to SES in planning and leading a Disaster Resilience Leadership Workshop.

5.3 Flood Prediction and Warning

There are two distinct aspects of the flood warning system which could be improved upon:

(1) Real-time monitoring; and

(2) Improved interpretation of data.

5.3.1 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 low-cost stream gauges is on these areas.

Recommendation 12: Council should establish two additional rain gauges and incorporate them into the ALERT network and establish of five low-cost stream gauges in Burringbar, Mooball and Crabbes Creeks.

5.3.2 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.

Recommendation 13: Council should install a network of audible flood sirens.

5.3.3 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, and interest has been expressed by community members to establish a Flood Watch Network in the Wooyung area

Recommendation 14: The SES to establish a Flood Watch Network in the Coastal Creeks study area.

5.3.4 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.

Recommendation 15: Both existing and new stream level gauges should be classified so that definitions of minor / moderate / major floods can be established.

5.3.5 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.

Recommendation 16: The SES to develop Flood Intelligence Cards for the existing stream level gauges and any new gauges in the study area.

5.3.6 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.

Triggers can be set up in the Environment or other flood warning system which automatically sends SMS or email alarm notifications to key staff once thresholds are exceeded. This arrangement ensures that staff are aware of developing flood conditions, even if they are not actively monitoring the gauges.

It is also important to note that the triggers must not be overly conservative so that unnecessary warnings and evacuation orders are issued.

Recommendation 17: Council and the SES should develop gauge triggers to provide alerts when critical levels or rainfall depths are reached at particular rainfall and / or stream gauges.

5.3.7 Trial Flood Decision Support System

In consultation with the Richmond-Tweed SES and OEH, BMT WBM are 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. A trial of the DSS will be available for the SES and Councils to test over the 2015/2016 wet season.

Recommendation 18: Council and the SES should take part in the Trial Flood Decision Support System being developed for the Richmond-Tweed region.

5.3.8 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.

Recommendation 19: Council should consider the incorporation of future forecast guidance products.

6 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.

The two property modification measures have been put forward within the Tweed Coastal Creeks study area:

- Voluntary house purchase; and
- Voluntary house raising.

These measures are only applicable to residential properties.

6.1 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 considered two options for property eligibility for the Tweed Coastal Creeks area:

- VHP Option 1 - properties in H4, H5 and H6 hydraulic categories
- VHP Option 2 - properties in H5 and H6 hydraulic categories.

Removal of all identified properties from the floodplain would remove residents from high flood risk locations, greatly improving community safety.

The preferred option which addresses safety to residents is VHP Option 1, however it is recognised that this option may be expensive to implement. Furthermore, some of the properties in H4 may be suitable for Voluntary House Raising. Therefore, it is recommended that VHP Option 2 be carried forward (in conjunction with the recommendation in Section 6.2).

Option	Number of properties	Cost
VHP 1	45	$18m
VHP 2	32*	$12.8m

* Includes 15 properties from the H4 hazard category which are not suitable for house raising

Recommendation 20: Council should extend their existing VHP scheme across the Coastal Creeks area and implement VHP Option 2.

6.2 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. VHR is a suitable management measure for houses in low hazard areas of the floodplain (NSWG, 2005). Properties in high hydraulic hazard category areas H5 and H6 are addressed in Section 6.1 (Voluntary House Purchase).

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 was undertaken on all properties within the H3 or H4 hydraulic hazard categories in a 100 year ARI event. It should be noted that properties in H4 hydraulic hazard areas have been assessed in both the VHP and VHR options. While it is recommended that properties in H4 hydraulic hazard category area be considered for purchase, it is recognised that this may not be economically feasible in the short term. The alternative option of raising those properties in H4 hydraulic hazard category areas was included in the assessment.

The VHR assessment has considered two options for property eligibility for the Tweed Coastal Creeks area:

- VHR Option 1: Voluntary raising of all properties in the H3 hydraulic category in the 100 year ARI event (should be selected if VHP Option 1 implemented); and
- VHR Option 2: Voluntary raising of all properties in the H3 or H4 hydraulic categories in the 100 year ARI event (should be selected if VHP Option 2 implemented).

The preferred option which addresses safety to residents is VHR Option 2. Furthermore, if VHP Option 2 is adopted then VHP Option 2 must be carried forward to ensure those properties within H4 are included.

Option	Number of properties	Cost
VHR 1	26	$ 1.8m
VHR 2	39	$ 2.7m

Recommendation 21: Council should extend their existing VHR scheme and implement VHR Option 2.

6.3 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. Residents who are interested can also work with the SES on a Personal Flood Plan (Recommendation 8).

Recommendation 22: 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.

7 Future Development and Climate Change Flood Risk

7.1 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 Floodplain Development Manual guides Councils and consent authorities to use the merit-based approach in making these land use decisions, balancing flood risk with other social, environmental and economic considerations.

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.

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.

Recommendation 23: Council should adopt the cumulative development scenario for the management of cumulative hydraulic impacts associated with future development.

7.2 Manage Future Development Flood Risk

The Tweed Valley Floodplain Risk Management Study undertook a rigorous review of Council's Current planning controls and recommendations for improvements to the controls were provided. These recommendations have yet to be incorporated into the appropriate planning instruments by Council. 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.

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. The Tweed Valley Floodplain Risk Management Study reviewed the planning and development controls and provided the following key recommendations for development controls and related policies which are also relevant for the Tweed Coastal Creeks area.

Recommendation 24a: Update the Tweed LEP (2014)

- The flood provisions in LEP 2014 (clauses 7.3 and 7.4) should be reviewed at an appropriate future opportunity in consultation with the DPI. Preferably a singular flood clause should be adopted that is consistent with the DPI Model Clause with the exception that its application should be to the whole of the floodplain (i.e. up to the PMF) as defined by the Floodplain Development Manual, whether or not mapped as the flood planning area.
- Should the LEP 2014 clauses be reviewed as recommended, the accompanying Flood Planning Map should delineate the PMF extent as the "flood planning area" (for the purposes of the LEP). This would effectively mean deleting the 100 year flood extent from these maps, to simplify the application of the relevant clause and the requirements of any future amendments to the Map as further information becomes available.
- The LEP 2014 flood maps should also include a note that not all flood liable lands may have been mapped. This is consistent with Departmental directions.
- The LEP 2014 flood maps should also have climate change flood extents included for the year 2050 and 2100.

Recommendation 24b: Update the Tweed Development Control Plan 2008

- Flood mapping of the 100 year flood extent (with climate change scenarios) and "high flow areas" has already been adopted as part of Council's DCP. It is at the DCP level that this more detailed information is of relevance, and more easily amended as further information becomes known.
- Additional useful information such as flood depth maps are not necessary in the DCP, but should be separately maintained by Council as part of its general GIS information.
- The application of a risk management approach to the structure and content of the DCP controls and mapping would be desirable. Such a detailed reworking of the DCP document was beyond the scope of this study. Future reviews should also consider adoption of flood maps that categorise the whole floodplain based on risk.
- The following recommendations are made for review of the Tweed DCP, in particular Section A3, including:
  - Update controls to reflect hydraulic constraints to development fill including adoption of a cumulative development scenario, permissible rural development scenario and associated hydraulic assessment requirements;
  - The introduction of floor level controls that encourage the attainment of a minimum floor level (typically the 100 year ARI flood level) on commercial and industrial development for at least those that meet the 'habitable room' definition but with sufficient flexibility to allow for dispensation when such controls can clearly not be practically met;
  - Support for the intent of the DCP provisions relating to enclosures below habitable floors, with refinement to specify the objectives of the controls, define what constitutes enclosure and non-habitable uses, and specifying the uses of flood compatible material for all parts of a building below the design flood level;
  - Review car parking and driveway controls and ensure consistency in particular for basement car parking across the study area;
  - Support for the intent of the DCP provisions relating to caravan parks and moveable dwellings, with refinement to impose equivalent controls on long term residents as standard residential development; clarification of 'high land'; and greater specificity in regard to assessing hydraulic impact;
  - Additional detail as to what would constitute an acceptable on-site or communal refuge where proposed as a secondary emergency management measure and for special types of development such as aged care;
  - Controls for management of flood risks from stormwater and overland flow paths

Recommendation 24c: Complying Development

- The FRMP should specify that only areas identified and mapped by Council to be other than land below the 100 year flood level and not evacuation constrained (e.g. a low flood island) are deemed to be high risk for the purposes of the Codes SEPP. This information should desirably be mapped so it can be readily provided to private certifiers and the general public upon enquiry.

Recommendation 24d: Section 94 Contributions Plans

- Contribution Plans could be established within the study area, where it is necessary or appropriate to fund flood mitigation works through such plans. This would be relevant in new greenfield release areas or substantial urban renewal areas (such as the Tweed City Centre) where such works are required to ensure the acceptability of the development (e.g. for the upgrading of evacuation routes or evacuation centres to cater for increased population densities).
- The Plans cannot be used to rectify existing problems in established areas. Where such works are required for both existing and future development the cost could be apportioned between the future development (within a Section 94 Plan) and existing development (to be funded by Council through general revenue or other sources such as special grants).

Recommendation 24e: Tweed Shire Flood Risk Management Policy 2007

- Tweed Shire Flood Risk Management Policy 2007 should ultimately be replaced with FRMPs that apply to the various floodplains in the LGA. The Tweed Valley FRMP would be the first of these
- The individual FRMPs should contain Council's policies for all matters relating to flood risk management, including town planning recommendations relating to strategic planning, development controls and the communication of information where shown in planning documents.
- A number of SEPPs including deemed SEPPs (being the North Coast REP) refer to, and sometimes define, flood liable land. These policies are not entirely consistent in this regard. Council does not have control of these policies but the FRMP should be forwarded to the DPI when adopted with a request that any future policy reviews have regard to this FRMP.

Recommendation 24f: Building Controls

- The definition of high hazard areas and the development controls that apply to these areas should be reviewed by Council, particularly with consideration to inclusion of an extreme hazard definition. This review should be undertaken as part of future reviews of Development Control Plan Section A3 – Development of Flood Liable Land.
- Within high hazard area future development should be restricted to ensure no additional development is placed at risk. In the lower hazard areas, where it is suitable to allow future development, building controls may be used to address the residual flood risk and provide additional protection for structures.
- New development which is planned within the 100 year ARI design flood event extent should be tested in the hydraulic model to ensure no off site flood impacts

Recommendation 24g: Section 149 Notifications

- As Section A3 of the Tweed DCP applies to all land up to the PMF, Council must notify this on Section 149(2) certificates.
- Include a notation that not all flood liable land may be mapped.
- Include a notation that flood extents projected into the future may change due to climate change effects.
- It is recommended that a notation be included on all certificates to indicate that further information in regard to flood risks may be available upon enquiry with Council or in a Section 149(5) Certificate.

• Council's Section 149 certificates should recognise that inundation from stormwater and overland flow (except for 'local drainage') is 'flooding' under the Floodplain Development Manual and the presence or absence of such inundation risks and policies should be notified accordingly.
Recommendation 24h: Release of Flood Information to the Public • Adopt as a development control a maximum filling threshold of 1% of flood prone land area outside of floodways (VxD > 0.3 m^2/s), below which cumulative development assessment is generally not required. → maybe note that the same definition of floodways was retained for coastal creeks and also that (if it's true) the same rural fill percentage was retained • The application of the 2100 climate change design flood level for habitable floors of new rural dwellings and an associated fill pad; • Support for the existing DCP provisions relating to evacuation from rural dwellings where there is an existing dwelling house entitlement (i.e. provision of an on-site refuge as a secondary measure); and • A requirement for high level vehicular or pedestrian access to a refuge outside of the PMF for development proposals on rural zoned land that relates to a subdivision that would create an additional dwelling entitlement or a use not related to the residential or agricultural use of land (such as an educational establishment, child care centre, aged care facilities or the like).
Recommendation 24i: Rural Development • Adopt as a development control a maximum filling threshold of 1% of flood prone land area outside of floodways (VxD > 0.3 m2/s), below which cumulative development assessment is generally not required. → maybe note that the same definition of floodways was retained for coastal creeks and also that (if it's true) the same rural fill percentage was retained • The application of the 2100 climate change design flood level for habitable floors of new rural dwellings and an associated fill pad; • Support for the existing DCP provisions relating to evacuation from rural dwellings where there is an existing dwelling house entitlement (i.e. provision of an on-site refuge as a secondary measure); and • A requirement for high level vehicular or pedestrian access to a refuge outside of the PMF for development proposals on rural zoned land that relates to a subdivision that would create an additional dwelling entitlement or a use not related to the residential or agricultural use of land (such as an educational establishment, child care centre, aged care facilities or the like).

7.3 Implement Climate Change Adaptation Plan

Responsible long-term flood management planning must consider whether the flood risk is likely to change within the planning time-frame. The latest science and government policy indicates that climate change is likely to worsen flooding in the Coastal Creeks study area in the future. This additional risk due to more intense rainfall and higher sea levels must be considered when planning future land use and infrastructure, and when determining how to best protect existing properties.

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.

In addition to these flood specific 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. Further detail about these recommendations can be found in the Byron and Tweed Shire Councils Climate Change Adaptation Action Plan (GHD, 2009).

Recommendation 25: Council should implement the Adaptation Plan using new information from the Tweed Byron Coastal Creeks Flood Study and this Study.

7.4 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.

Recommendation 26: Council should apply the planning controls relating to climate change to the entire Shire including the Tweed Coastal Creeks area.

Appendix A Initial Consultation Stakeholder Consultation Letter

Council Reference:
Your Reference:

1 February 2012

MAIL MERGE
xxx
xxx

Dear Sir / Madam

Coastal Creeks Floodplain Risk Management Study

Council is calling for stakeholder input to the current Coastal Creeks Floodplain Risk Management Study, being conducted by consultants BMT WBM Pty Ltd in order to:

- Identify and assess options to mitigate flood risks affecting various localities in the study area (from South Kingscliff to Wooyung, inland to Burringbar).
- Prepare a plan that details how flood prone land within the study area will be managed, with regard to the NSW Floodplain Development Manual (2005).

Council welcomes the input of XXXX in the preparation of the Floodplain Risk Management Study and Plan, and invites you to provide a written submission. Submissions should be received by Friday, 2 March 2012. Please advise if you require further time due to meeting schedules etc.

Council would like feedback on flood related issues such as:

- Emergency response issues experienced by your community/organisation in previous events, and how this could be improved.
- Previous flood damage experienced by your community/organisation in previous events, and how this could be minimised.
- The level of flood awareness in your community/organisation, and how this could be improved.
- Flood modification options (structural options such as levees and drainage) that should be investigated.
- Current development controls (in Tweed Local Environment Plan, Development Control Plan Section A3 - Development of Flood Liable Land, Flood Risk Management Policy) and how they could be improved. These planning documents can be downloaded from Council's website www.tweed.nsw.gov.au
- Other property controls such as voluntary purchase or house raising that should be investigated.
- Environmental, social and economic implications of past or future floods.
- River bank treatments and riparian vegetation projects and their usefulness.
- The potential impacts of climate change because of increased sea levels and increased rainfall intensities, and how these impacts should be addressed.

- The implications of development on the floodplain, including future development proposals you are aware of.
- Any other flooding issues specific to your locality, community or industry.

The consultants will review your submission and address it in discussion papers, before finalising the Floodplain Risk Management Study. Confidential submissions will be accepted.

Alternately you may wish to encourage your members to fill out an online survey relating to the project. A link to this survey is located in the "What's New" section of our internet home page at www.tweed.nsw.gov.au.

The Coastal Creeks Flood Study 2010 was prepared as the first stage of the study, and may provide useful information in the preparation of your submission. The flood study is available on Council's website at:
www.tweed.nsw.gov.au/PlanningBuilding/CCFloodStudy.aspx
Section 9 of the study report addresses the potential impacts of climate change, such as sea level rise, on floodplain behaviour. Council will consider climate change policies as part of the Risk Management Study.

The draft study is expected to be publicly exhibited after June 2012, when further consultation will be available.

Your assistance with the Coastal Creeks Floodplain Risk Management Study will be greatly appreciated.

Yours faithfully

Danny Rose
PLANNING AND INFRASTRUCTURE ENGINEER

Appendix B Initial Consultation Stakeholder Responses

Are you concerned about the following?

	Very Concerned	Somewhat concerned	Not Concerned	Didn't Respond
Flooding on your property?	8	4	9	0
Your ability to evacuate during a flood?	5	7	9	0
Flooding of your building?	3	4	14	0
Drainage after the flood peak	11	4	6	0
Whether you are well prepared for a flood?	3	8	10	0
The effect of sea level rise / climate change?	6	9	6	0

Please specify other concerns you may have about flooding in your area

Inundation of crops causing financial loss.

Poor drainage, impact of development, siltation of all coastal creeks, lack of access to major drainage systems for maintenance purposes.

When our creek rises, all residents of my street cannot get out.

Inadequate drainage of Cudgen Creek.

not enough publicity within our town of flooding end of shire

Access in and out of the town and the reliability of information on the myroadsinfo website. Also if power is out, how to get accurate information about roads

We are prepared and live out of the flood zone, but are unable to leave our property in a flood. My main concern is the risk of people trying to leave and getting caught in the flood waters and the risk of storm surge.

We live on the Cudgen lake drainage canal at Rosewood Avenue. During the recent heavy rain the water level of the canal came within 300mm of breaking the bank and was backing up filling the gutter on the roadway.

Being cut off by bad roads and flood waters.

All our flood water (all our normal water flow) has to flow in and out of Cudgen Lake. Over the years the flow of the water has deteriorated that much that there is very little flow. The Cudgen Lake inlet and outlet into Cudgen Creek are badly blocked and need to be looked at. The Lake needs to be made tidal again, as it was years ago. I am a member of the Cudgen Drainage Union and the problem of drainage has become a big problem in the Round Mountain, Clothiers Creek areas. The Cudgen Lake is supposed to be a Nature Reserve, a clogged inlet and outlet doesn't do much for the wildlife and certainly does nothing to alleviate the flooding of our land and others in the Round Mountain area.

There is never any maintenance done on the Clothiers Creek Road that is always cut off and the waterway around Friday Island and beyond is never maintained - the dense growth only adds to the danger.

The placement of two 50 acre lakes that will be built for the Dunloe Park sand mine, will this affect the amount of flooding and the time flood waters take to recede further up Mooball creek (Wooyong, Mooball, Burringbah areas west of the sand mine area). The effects on the environment of the movement of acid sulphate soils from where the sand mine will be built and in particular the build up of sand in the mouth of Mooball Creek at Pottsville.

Property/building flooding - unlikely due to elevation Evacuation - very unlikely to be necessary Sea level rise - only if greater than 0.5m.

The drains are blocked in Tamarind Avenue - my street. Council is supposed to fixing this and it is being pushed back again and again. It was nearly too late 2 weeks ago!

The Tweed Coast Road ALWAYS floods at Cudgen near the gas tank. Why not put some pipes on current road and fill to cover there by raising the road level, very cheap.

Landslip, erosion, collapse of retaining walls and roadway.

Do you think Council should consider Flood Modification Measures such as:

	Strongly Agree	Agree	N/A	Disagree	Strongly Disagree	Didn't Respond
Levees to increase flood protection?	1	5	3	6	3	3
Dredging of waterways?	10	4	1	2	1	3
Improvements to drainage and infrastructure?	13	4	0	1	0	3
Improvements to maintenance practices?	12	5	0	1	0	0

Please specify other flood modification measures you believe Council should consider

Reinstatement of natural waterways to historical capacities, to rectify effects of man-made alterations to environment.

Consultation with long term residents regarding changes to flow patterns.

Insist that Australia converts to 100% renewable energy and sets an example so we can minimise the harm from long term climate change.

Investigate drainage from Cudgen Lake to ocean, possible restriction in out flow due to debris and over grown waterway.

More maintenance of existing roads, drains and improvements to overall drainage.

I feel if the above ticked boxes were attended to that should cover dramatically what is needed.

Ban the mining of sand at Dunloe Park and anywhere on the coastal flood plains.

As a general principle I disagree with levee, dredging etc to protect new structures. Planning should ensure that all facilities and structures are located or built to be above 1:1000 year flood levels or designed to survive.

Drains in high risk areas e.g. Tamarind Ave should be cleared and maintained regularly.

Better infiltration zones (less concreted areas) in commercial / industrial development.

Do you believe the following Response Modification Measures are worth considering?

	Strongly Agree	Agree	N/A	Disagree	Strongly Disagree	Didn't Respond
Flood education campaigns to raise community awareness?	5	11	0	2	0	3
Flood warning and emergency planning (eg could flood warnings be improved?)?	7	8	2	1	0	3

Please specify other Response Modification Measures you believe are worth considering

Better communication about which roads are under threat and likely to flood, especially from within Council in relation to their staff safety. And ensuring that off-site offices are considered in information communication, taking into account that computers and phones often go down in emergency situations.

Location specific test warnings such as are being implemented in Victoria after the Black Saturday bushfires, school campaigns.

Improved access to property flood level info.

More information available on where roads are closed.

People who live in their local area should already what to do and what to expect in a flood. If they are stupid enough to drive or walk into flood water, that's their problem.

The allowing of building properties so close to the water - i.e. around Friday Island and not elevated enough.

During the recent flooding of the Tweed area there was very little information on the flooding in rural areas of the Tweed on the local radio. However north of the border every 30 minutes on the morning radio show there was a complete report of road closures and areas where water is over the road.

The issuing of flood and emergency warnings must encompass all methods of communication - reliance on radio and TV is totally inadequate, SMS, email, and other social media should also be used as widely as possible. Example: I only heard of the recent water restrictions AFTER they had been lifted!

What is your opinion of the following Property Modification Measures?

	Strongly Agree	Agree	N/A	Disagree	Strongly Disagree	Didn't Respond
Council should impose development controls on new buildings on flood prone land	13	4	0	1	0	3
Industrial and commercial buildings should be allowed to be built in areas of higher flood risk than residential buildings	0	6	1	9	2	3
Sheds, garages etc should be allowed to be built in areas of higher flood risk than residential buildings	0	9	1	6	2	3
Additions / extensions to existing houses should be subject to new flood related development controls	6	9	0	3	0	3
Properties in high flood risk areas should be purchased by Council in agreement with the owner	2	6	3	6	1	3
Financial assistance should be provided to raise flood prone buildings that can be raised	1	5	3	8	1	3

Please specify other Property Modification Measures you believe are worth considering

All new development controls to consider 1m sea level rise by the end of this century.

Council monies should be directed at roads, drainage and levees.

If a person bought a property in a flood prone area, that should be their problem to fix it. When you purchase a property you should search and find out information about flooding before you sign the contract.

The placement of industrial and commercial buildings on flood prone land will only back flood waters up and slow the waters progress out to sea.

All new structures should be built above design flood levels. Only waiver should be if the owner/builder waives ALL public liability, including responsibility/liability for evacuation and rescue, in perpetuity for building below design flood levels.

Allowing industrial development in flood prone areas is likely to increase pollution impacts due to products / chemicals stored in these areas.

	Yes	No	Didn't Respond
Are you aware of a flood evacuation plan for your area?	1	17	3
Do you know the location of a flood evacuation centre near you?	2	16	3
Are you confident of being able to evacuate during a flood event?	11	7	3

Please specify any concerns you have about evacuation during a flood event and evacuation planning.

There needs to be more awareness of flood in our town.

My own house is probably safe, but food has to be bought in and that would be a problem.

This is not an issue as I am intensely aware of where it floods in our area (resident >30 years) and tend not to try to evacuate if I'm at home as wwe are high and dry although the road is cut off.

I could be easily cut of and not able to get any supplies or assistance in a relatively unpopulated part of the shire. All the focus will go to towns and not rural areas.

I have seen nil information on the first two questions in the 28 years I have lived here.

Able to evacuate subject to roads being open and sufficient warning in super-extreme flood events.

Traffic congestion. The route may be open, but will everyone be trying to use it at once.

Where would you consider the most convenient location for flood information?

Internet	Local library	At Council	Other (please specify)
17	2	4	RADIO! The internet is only as good as the power supply. Council would be helpful but once again you are dependent on power. Radio is reliable and can be powered by batteries and should be considered as the number one medium for information. ABC local radio is a fantastic source of information during flood events and should be promoted as such, as the SES can be too easily be overwhelmed by calls about road closures etc when their phone lines need to be open for emergency response. Council web site. Radio may be some peoples only option; or some sort of SMS service. Local radio and TV stations should broadcast information. Radio and Post Offices. An information package should be sent to all land and home owners who live in or who are in areas that may be flooded or are affected by flood waters (floods cutting off evacuation routes in case of prolonged flooding. It is the responsibility of home and property owners to inform their tenants of possible flooding that could affect them. Internet would be my first visited source when seeking general and specific event information. Notifications of emergency events must be by all available broadcast means including radio, TV, SMS, email, phone recordings, social media web sites (not just Facebook and Twitter) and any others that develop in the future. Strong emphasis must be placed on "push" communication that does not rely on the resident to initiate access.

Do you have any other comments relating to the Floodplain Risk Management Study?

The Study should consider the integrated coastal floodplain, especially in the south of the Shire, including the northern end of the Brunswick catchment.

The ability for farmers to farm in the tweed valley is dependent upon an adequate drainage system. Unfortunately over the years the lack of major maintenance such as dredging of waterways has had significant implications on the entire drainage system which in turn impacts the entire farming industries of the Tweed. This together with development and the construction of levees has had a significant financial impact on the farming community in general.

Very anxious about kings forest development adding to Bogangar flood heights

A "New Residents Pack" would be good idea, formulated by council for real estate agents to hand out to new tenants and property or business owners. This could include all the vital emergency response numbers as well as the usual bushfire and flood advice.

More country roads need to be made flood proof so people can get out in emergencies.

Council have been approving developments in flood prone areas for years and building this low country up, therefore the water doesn't spread over the low lying areas, it gets deeper and affects more people. This is only common sense which the powers that be seem to lack. They are only looking at today and not how this will affect people in the long term. The rivers of the Tweed Shire and Cudgen Lake should all be dredged.

Consult with the people who have lived in the Tweed area and have the knowledge of the effects from previous flooding levels.

Would be nice if our council actually did something re flood situation in Tamarind Avenue.

It's an important process. Thanks to Council for taking it on.

Appendix C Public Exhibition Responses

POTTSVILLE COMMUNITY ASSOCIATION INC

PO BOX 56

POTTSVILLE BEACH 2489

9th November, 2015

DATE 12 NOV 2015

Mr Troy Green,
General Manager
Tweed Shire Council,
PO Box 816,
Murwillumbah NSW 2484

Dear Mr Green,

Thankyou for the opportunity to provide feedback to the Coastal Creeks Floodplain Risk Management Study and Plan currently on exhibition.

Our members raised two major concerns with this document.

1. From attending one of the Council run information sessions on this document, it is understood that the effects of the build-up of sand and sediment in the first 500m of the Mooball Creek closest to the mouth, was examined for its potential impact on the cane fields upstream of Pottsville and that it was found that flood durations would be reduced from 24 hours to 19 hours.

   Can you please use the sophisticated flood modelling tool available to Council to confirm that the effect of the increased sedimentation at this location, will not increase the potential for flooding of the existing CBD and Pottsville Waters business and residences.

2. The sedimentation of Cudgera Creek was also cause for concern. Can you include measures to address the flooding of Cudgera Creek Road which is known to flood in medium flood events and temporarily cut access to the Pacific highway, which is the main gateway for access to the airport and hospitals.

Regards

Chris Cherry

President

Pottsville Community Association

Tweed Coastal Creeks FRMS
General Manager
Tweed Shire Council

C & D Van Zyderveld
24 Creek Street
Hastings Point. NSW
14/11/2015

TWEED SHIRE COUNCIL
RECEIVED
DATE 17 NOV 2015

Councils should not even consider allowing future development in or near coastal creeks and floodplain areas, they should know by past developments in the area.

By allowing more development in these floodplain areas it will only increase the existing problem, not a future solution, high water table areas, affect of king tides and rising sea levels.

Allowing these areas floodplains and waterways to be filled will change the water course causing flooding in another area, shifting the problem, putting other properties at risk.

Building houses on piers in floodplains and waterways above the recommended flood height and water flowing under these houses during heavy rain periods and flooding doesn't seem practical, and is beyond belief from a responsible council to even consider this kind of development, when there are so many other areas suitable for development.

Insurance will be another problem, potential cost of flood damages to property with buildings constructed in a known floodplain or major waterways.

If possible increase the outlets or widen the existing outlets from the creeks and estuarys to allow water to flow rapidly to the sea during flooding.

With some of the smaller drain outlets, non return valves could be considered depending on the situation.

Better drainage in some areas should help relieve water to subside during flooding

The floodplains close to coastal creeks in some areas are best left alone in there natural state, as most of the floodplains are disappearing as well as the fauna and flora. The community could use floodplain areas for all kinds of activities under the guidance of the council.

Kind Regards

C & D Van Zyderveld.

Draft Tweed Coastal Creeks Area Floodplain Risk Management Study & Plan

Feedback Form (continued)

Contact Details

Draft Tweed Coastal Creeks Area Floodplain Risk Management Study & Plan

Feedback Form

The draft Tweed Coastal Creeks Floodplain Risk Management Study and Plan is currently on exhibition.

Download from Council's website *www.tweed.nsw.gov.au*

Please provide your feedback:

By Post

Tweed Coastal Creeks FRMS
General Manager
Tweed Shire Council
PO Box 816
Murwillumbah NSW 2484

By Email

stwohill@tweed.nsw.gov.au

By Hand

To representatives at the Community Sessions

CREEKS FLOODPLAIN RISK MANAGEMENT STUDY
TWEED SHIRE COUNCIL

SUBMISSION POINTS

As a resident of Mooball for the past ten years I have been in a position to observe flooding patterns on many occasions and therefore submit theses points for consideration both in this area and elsewhere.

The water from the Burringbar range travelling along Mooball creek gradually gathers on the floodplain (largely cane fields) in the Wooyung / Yelgun area. With extreme weather events this can eventually back fill into parts of Mooball and Burringbar to varying degrees.

The clearance of water from Burringbar / Mooball in these high rainfall is influenced mainly by the continued rate of fall and the tides. Example is water from the creek at Mooball, in very heavy continued rainfall could be spread 50 metres from the creek but with the fall slowing and outgoing tide could be back inside the creek banks in about two to three hours depending on depth.

However the water does not move so well further down in the floodplain where the land has no drop off and the volume is so high.

One proposal I put forward is the possibility of slowing the water flow higher up in the creek so as to give the water levels further down stream a chance to clear better and thus reduce the impact of such a large volume of water clearing so slowly and impacting at times quite negatively on the cane fields.

A second proposal is to consider the installation of relief pipes in the area of Wooyung so that water over a certain height in heavy rainfall could be channelled under the road at some point where the creek travels along side the Wooyung / Pottsville road and send excess water straight out to the ocean and not rely on the water exiting through the creek mouth.

Whilst I do not have diagrams for these ideas, the concept has been discussed in detail with Steve Twohill, who I thank very much for his willingness to listen and other relevant informative material he provided, to give me a very clear understanding of what the flood study is looking to achieve.

One final point I would make is in relation to warnings . It appears from a meeting I attended and other conversation that there is a need for an efficient warning system for impending flood risk. I am of the understanding that water level warning markers are the main consideration with funding a problem. What I propose is a possible stop gap measure in the meantime.

Is there a visual done by some person in authority when it is known flood waters are rising. If not could there be and if so could it be effective to collect the mobile phone numbers of residents in risk areas to be used for a central SMS send out of a warning message. This I am sure would reach the majority of those affected, especially if they knew this message would come and therefore would be looking out for it.

I also have some photographs taken during two different flood events, one being in 2012. I was actually at my house during this event and observed the water movement throughout the day of extreme rainfall.

I am available to discuss these ideas in further detail should it be required. Otherwise all the best with the study and implementation.

I can be contacted if needed on mobile 0413045150 or email gazzamatazz@outlook.com

Regards
Gary Street

From: Steve Twohill
To: Steve Twohill
Subject: FW: Sedimentation in Mooball Creek Pottsville
Date: Tuesday, 17 November 2015 7:13:41 AM

Steve Twohill BEng | Flooding and Stormwater Engineer
Engineering | Roads and Stormwater

p (02) 6670 2759 | f (02) 6670 2429 | e stwohill@tweed.nsw.gov.au | w www.tweed.nsw.gov.au
Civic and Cultural Centre Tumbulgum Road Murwillumbah NSW 2484 | PO Box 816 Murwillumbah NSW 2484
Customer Service: (02) 6670 2400 or 1300 292 872 ABN: 90 178 732 496
Our values: transparency | customer focus | fairness | reliability | progressiveness | value for money | collaboration
Please consider the environment before printing this email. One tonne of paper is equivalent to 13 trees and 30 kL of water

-----Original Message-----
From: Tony Cosgrove [mailto:pca.mailbox@gmail.com]
Sent: Tuesday, 6 October 2015 10:10 AM
To: Corporate Email
Subject: Sedimentation in Mooball Creek Pottsville

Troy Green
General Manager, Tweed Shire Council

Dear Mr Green

At the September general meeting of the Pottsville Community Association a member raised concern about the impact that a build up of sediment in the Mooball Creek, Pottsville, might have on the village during significant flooding events in the future.

Members of the Association are aware that the Council has gathered extensive data about flooding in the Shire and have developed excellent computer software to assist in simulation exercises.

The Association would like to know whether the Council has yet conducted a study using that or similar software to determine the possible impact on the village of Pottsville of a flood with the current level of sedimentation in the creek and again with further build up of sedimentation. If such simulation exercises have been done the Association would appreciate being informed of the results of the exercise.

Alternatively, if such exercises have not been carried out, is it possible for Council to assist our Association with advice about how we might access such data.

Yours sincerely
Tony Cosgrove

Secretary
Pottsville Community Association

pca.mailbox@gmail.com

From: Steve Twohill
To: Steve Twohill
Subject: FW: Submission to Coastal Creeks Floodplain Risk & Management Study & Plan
Date: Tuesday, 17 November 2015 1:34:23 PM
Attachments: image001.png
image002.png

Tweed Coastal Creeks Floodplain Risk Management Study & Plan
Submission on draft document to be reviewed and addressed in the response to submissions and any updates to the Final Draft reporting for the TCCFRMS&P.

Steve Twohill **BEng** | Flooding and Stormwater Engineer
Engineering | Roads and Stormwater

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Please consider the environment before printing this email. One tonne of paper is equivalent to 13 trees and 30 kL of water

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From: Wooyung Park [mailto:info@wooyungbeach.com.au]
Sent: Tuesday, 17 November 2015 1:23 PM
To: Corporate Email
Subject: Submission to Coastal Creeks Floodplain Risk & Management Study & Plan

Dear Mr Green,

Thankyou for the opportunity to provide feedback on the Coastal Creeks Floodplain Risk & Management Study & Plan.

We would like to provide the following feedback.

- We would like to support the formation of a Flood Watch network and would volunteer to be part of it as we believe the current plan demonstrates that much of the flooding at Wooyung is not understood due to inability to access this area during flood times.

- The management plan says there are no significant townships west of the highway in the study area. This does not sufficiently take Yelgun and Crabbes Creek into consideration, both of which are significantly effected by flooding and need to have more consideration in these documents. It would also appear negligent not to mention the presence of the permanent festival site at Wooyung / Yelgun, contained within the Study area. This site can contain up to 35,000 people camping on site for up to 5 days, multiple times per year and needs to have consideration in this document. The reference to a future plan which will be done for North Byron which will also encompass this area is not sufficient as the the current plan includes this land and its feeder creeks in the study area so it needs to form part of the current consideration, as does the significant drainage and filling works which have been done on that site in the recent years.

- Flash flooding in floodway areas on Yelgun Creek and Crabbes Creek need to be included on page 13 and in the summary on page 17. This is well documented in the detailed flooding studies done for the permanent event site by Molino Stewart Pty Ltd and the Flood specialist employed by the Department of Planning for the sites approval.

- Map on page 17 does not include Billinudgel Creek running parallel to the ocean south of Wooyung Rd and exiting through the Kallaroo Bund in Figure 3.1 and 3.2.

- Nothing on Figure 3 is mapped as having an inundation greater than 72 hours. This does not fit with experience in the Wooyung floodplain and an examination of road closures for Wooyung Rd would not support this finding where Wooyung road is often inundated for minor flood occurrences for long periods. Photos available.

- Please justify why residents of caravan parks are not included in the calculation of risk to people provided in Table 3.3. These people are some of the most vulnerable in our community and it would seem to be appropriate to include them here?

- Caravan Parks are listed as vulnerable institutions but then not included in Figure 3.6. The event site should also be included in Figure 3.6 as it periodically contains up to 35,000 people not from this area, mostly unaware of flood risks and potentially under the influence of substances and many may be juveniles.

- The proposed evacuation roots in Figure 3.7 are not workable with exits proposed from Wooyung along Wooyung Rd to Crabbes Creek. The section of Wooyung Rd which usually floods first is west of the fruit stall and residents west of this point should evacuate towards Crabbes Creek (although if Crabbes Creek Public School is being removed as an evacuation point then where they should go to is unclear) Residents east of the fruit stall on Wooyung Rd should be directed east and along Tweed Coast Road to Pottsville Community Hall as this section of Tweed Coast road remains flood free in even the largest events to date. Floodwaters regularly close Wooyung road east of Jones' rd and those residents located between Jones' Rd and the Fruit stall are often isolated for periods of 24 hours or more in small -medium flood events. Photos available.

- The road inundation points marked on Figure 3.8 are inaccurate and do not represent a true flood experience on Wooyung road. The inundation point marked with a pink diamond south east of 180 Wooyung Rd does not exist and needs to be removed. Inundation occurs on Wooyung Rd at the cane pad just south east of the fruit stall and at the low point due west of the fruit stall as is marked on the figure but also on Wooyung road east of Jones Rd, which is not marked on this Figure and should be included. Also why is no inundation point listed on the Pottsville - Mooball road at Burringbar creek crossing and at the unnamed creek just west of the Mooball sewerage plant? Photos available. Please correct these inaccuracies before finalising the management plan for this area.

- We strongly support the action to improve the gauge network for this area. We currently use the gauges located at Yelgun creek, Crabbes Creek and Marshalls creek to indicate flood behaviour and gauge evacuation measures required in our area but we are strongly dependent on creek heights in Mooball Creek at Pottsville as that tells us how quickly the water will be able to get away and if it is likely to back up here. We are also strongly effected by the rainfall and stream heights on Burringbar creek at Mooball and would ask that two new stream gauges are included, one at Burringbar creek at Mooball and one at Mooball Creek at Pottsville after Warwick Park road. Please also include a rainfall gauge at upper Burringbar.

- Please make the cumulative development scenario modelled by Council referred to in Recommendation 22 available to community members to allow residents to determine if there are likely to be "unacceptable cumulative impacts" on their properties. Individual property owners have a right to this information and how the future planning of Council may impact their land.

- Floodplain Risk and Management Plan Figure 2.1 does not mark either Yelgun creek or Billinudgel Creek

- Please consider that the most effective way of reducing risk in Floodways and flash flooding points is to identify where these occur and place signage such as DO NOT CROSS WHEN FLOODED etc, these are simple but effective and immediately reminds people of the significant dangers present rather than relying on people having taken in the information from an information kit which may have never been opened and also captures those travelling through the area.

- Please consider allowing public to register to receive warnings when trigger levels are reached on stream gauges referred to in Recommendation 17 to give more flood warning times for those interested in using the gauge system.

Thankyou for taking our concerns into your consideration and please especially correct the evacuation inaccuracies proposed in Figure 3.7.

Regards
Chris Cherry

515 Wooyung Rd, Wooyung, NSW 2483
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Wooyung Beach Holiday Park
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Appendix D Frequently Asked Questions (FAQ)

Frequently Asked Questions

Tweed Coastal Creeks Floodplain Risk Management Study & Plan

The Draft Tweed Coastal Creeks Floodplain Risk Management Study and Plan was placed on exhibition in October / November 2015 for public comment. The Study reviewed flood risk in the Tweed Coastal Creeks area, including risks to people and other potential impacts of flooding, and assessed a wide range of options to reduce and manage these risks. The Plan outlined the recommendations of the Study and a prioritised plan to implement these.

The following information has been collated in response to some of the frequently asked questions that arose during the study and consultation process.

Contact
Steve Twohill
Flooding and Stormwater Engineer
02 6670 2759
stwohill@tweed.nsw.gov.au

Frequently Asked Questions

Tweed Coastal Creeks Floodplain Risk Management Study & Plan

What is the Probable Maximum Flood (PMF) and why is it used?

The PMF is the worst case scenario for flooding and is used for emergency response planning and specialised land use planning such as the siting of critical infrastructure (e.g. hospitals). Most other planning decisions are based on the 100 year Average Recurrence Interval (ARI) flood and an allowance for uncertainty and the potential effects of climate change.

The PMF is a theoretical flood resulting from the largest rainfall that could possibly occur within the catchment, and therefore is extremely rare and unlikely. It is also used to determine which areas are potentially flood prone (in the floodplain) and which areas are flood free (only land outside the PMF extent is truly 'flood free').

How has flood mapping affected property values?

Reviews of the effect of flood risk disclosure show that most international and domestic studies found no change in residential property values, and that property values are more likely to be affected by actual flooding than flood mapping. Flood mapping has been available for the Tweed Coastal Creeks area since 2010 and is not new to this study.

Council is not in a position to estimate whether this flood mapping has had any effect on property values in the Tweed Coastal Creeks area as they are subject to a range of market factors. Irrespective of this, Council has a duty of care to advise property owners, occupiers and developers on the extent and level of flooding as outlined in the floodplain management process set out by the State Government.

How has flood mapping affected insurance?

Council is aware that insurance premiums have risen in recent years and is actively engaging with the Insurance Council of Australia (ICA) through the NSW Floodplain Management Association to raise issues highlighted by members of the Tweed Coastal Creeks community. Through this engagement, Council understands that flood insurance is a relatively new product for the insurance industry and premium increases have not been limited to the Tweed Coastal Creeks area. The inclusion of flood insurance in home and contents policies accounts for some, but not all, of the recent increases in premiums. Other factors include reinsurance costs (which is impacted by global events), profit margins, and government taxes.

Flood mapping has been available for the Tweed Coastal Creeks area since 2010 and is not new to this study. However, some residents have highlighted recent instances where insurance companies may be incorrectly interpreting flood mapping. Council has been proactive in this area by dealing directly with the ICA, individual insurance companies, and individual community members who have queries relating to their flood liability and require information to pass on to insurers. Projects such as the compilation of a national flood study database and standardisation of flooding definitions and mapping will help inform insurers as they continue to develop their understanding of, and pricing of flood

insurance. In the absence of flood mapping, insurers will tend to quote higher premiums to cover unknown risk.

Council's discussions with the insurance industry have emphasised the need for flood insurance premiums to reflect the true risk of floods occurring at a property. Properties that are located above the 100 year ARI flood level but below the PMF event are at the low end of the risk profile and premiums should be priced accordingly. Pricing is however a matter for each insurance company to determine based on a variety of factors.

Why doesn't the study include stormwater?

Flooding can happen by a number of processes: high tides and elevated ocean levels can inundate coastal areas, prolonged rain over the catchment can cause the creeks to overtop their banks, intense localised rain can cause small creeks to rise very quickly (referred to as flash flooding) and inundation can also occur when the capacity of stormwater infrastructure is exceeded. Some or all of these types of flooding can occur during the same weather event, however they require different (though compatible) approaches to manage flood risk.

The focus of the Tweed Coastal Creeks Floodplain Risk Management Study was creek (or catchment), ocean and flash flooding. However, it is recognised that stormwater flooding is also a risk in the Tweed Coastal Creeks area and will be addressed in subsequent studies. Flood studies to date have been conducted at a regional scale, and have only included major trunk drainage infrastructure, not individual stormwater drains in each street.

How were the floodplain management options selected?

A Floodplain Risk Management Committee was formed at the beginning of the study, made up of representatives from Council, the State Emergency Service, the Office of Environment and Heritage (State Government), elected community representatives and the floodplain management consultants (BMT WBM). The Committee undertook a preliminary review of all flood management options and identified management measures which would be investigated in more detail during the study.

A key objective of the study was to identify opportunities to minimise flood risk to the community, property and infrastructure now and into the future. In an area as large and diverse as Tweed Coastal Creeks, there are many floodplain management options to consider, such as dredging creeks, land use and development planning for areas at risk, community awareness and information and options for emergency response planning. However, not all measures are feasible, on economic, environmental and / or social grounds.

The Committee decided some preliminary options were not feasible and / or did not justify further investigation. These options included the dredging of Mooball Creek and lowering the weirs at Pottsville Waters.

Frequently Asked Questions

Tweed Coastal Creeks Floodplain Risk Management Study & Plan

Why hasn't dredging of waterways to remove sedimentation been recommended?

The study assessed the potential for dredging of a large section of Mooball Creek to reduce both flood levels and the total time of flood inundation in the surrounding floodplain areas. The tested option was not found to lower peak flood levels or overall duration of flooding. In addition, numerous other constraints were identified which limited the feasibility of creek dredging.

While this option was location specific, many of the constraints identified through the assessment are relevant to waterway dredging in general, including:

- During large flood events, waterways in lower catchment areas generally convey a small fraction of the total flood volume. Increasing the capacity of the waterway channel provides only a small amount of additional volume and is unlikely to reduce peak flood levels in floodplain areas.
- Dredging is expensive through both initial capital costs and ongoing maintenance works. If the spoil material contains hazardous materials (such as acid sulphate soils), disposal can be very expensive.
- Dredging is a temporary measure only and requires ongoing maintenance to maintain depths and volumes.
- Dredging has onerous approval requirements which can be expensive and time-consuming, particularly in the inter-tidal zone.
- Dredging can lead to bank instability, which may have knock-on effects such as bank erosion and a greater sediment load in the creek.
- Dredging can cause salt-water intrusion higher up in the waterway, which can have negative effects for natural and agricultural systems.

Due to these issues, it is unlikely that dredging can provide an effective and sustainable solution to flooding in the Tweed Coastal Creeks area.

How does the SES plan for flood events?

The State Emergency Service (SES) records their evacuation strategies and flood risk information in the Local Flood Plan, which is a sub-plan of the Tweed Shire Disaster Plan (DISPLAN). The Local Flood Plan describes the process that the SES will follow in the event of a flood, including the logistics of warning and evacuating communities throughout the Tweed Coastal Creeks area. Local knowledge, information about past flood events and recommendations from studies, such as the Tweed Coastal Creeks Floodplain Risk Management Study, are all used to develop the Local Flood Plan.

In conjunction with the Local Flood Plan, the SES conducts a range of education and awareness campaigns throughout the year, with a stronger push leading up to the storm

season. The SES has helped many businesses and individuals develop personal flood plans and better prepare themselves for future evacuations.

Who issues flood warnings and evacuation orders?

If heavy rainfall and flooding is predicted, the Bureau of Meteorology (BoM) issues a Flood Watch, which is upgraded to a Flood Warning if creek levels are expected to go above predefined threshold levels. Flood warnings are published online as well as being provided directly to other government authorities (including the SES and Council) and broadcasters (including ABC North Coast). Flood warnings issued by the BoM don't translate predicted flood levels to risk on the ground, and as such are not used in isolation to trigger an evacuation.

The Richmond Tweed (regional) SES closely monitor local weather and will start to prepare a response if they believe flooding may occur. When a flood warning is issued by the BoM, the Tweed Shire (local) SES translates predictions of flood height into consequences, such as flooding of certain areas or roads which might become cut. The SES then provides bulletins to the media and public about the predicted flooding. If the predicted flooding may result in the need to evacuate, the Richmond Tweed SES issues an evacuation warning, which is upgraded to an evacuation order if evacuation is considered necessary.

How has climate change been considered?

Council aims to balance the economic cost of planning for climate change now, with protection of people and property in the future, via two mechanisms of planning controls for future development and a Climate Change Adaptation Action Plan already developed by Tweed Shire Council in conjunction with Byron Shire Council. Outcomes from the Tweed Valley Floodplain Risk Management Study will be used to review and update these measures.

Council has adopted a climate change projection which allows for a 10% increase in 100 year ARI rainfall intensity and 91cm increase in 100 year ARI sea level by 2100. While the State Government has since abandoned the Sea Level Rise Policy and no longer recommends statewide sea level rise benchmarks, it still requires Councils to determine local future hazards, and include consideration of potential sea level rise and climate change impacts in its flood studies and risk management studies, based on the best available data. Accordingly, Council has maintained its adopted climate change benchmarks until further authoritative advice is released, such as the 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC). Council does not possess the required expertise to use and analyse the outputs of complex climactic models to set its own benchmarks in the meantime. Climate change projections do not relate to the PMF, and insurance is based on existing risk, not projected future risks such as climate change affected flood levels.

Frequently Asked Questions

Tweed Coastal Creeks Floodplain Risk Management Study & Plan

Will new development worsen flooding?

To ensure new development does not worsen flooding, Council requires a hydraulic assessment of any development that may impact flooding by a suitably qualified engineer. This typically involves the use of the flood model to demonstrate that the proposed development itself is not subject to unacceptable flood risk, and that it does not worsen the flood risk in surrounding areas, prior to being granted development approval.

Much of the Tweed Coastal Creeks area is in the floodplain but is only likely to be flooded on rare occasions. For these areas, Council aims to encourage suitable development while ensuring that the new development isn't at serious risk of flooding and won't worsen flooding elsewhere in the catchment as a result of its construction.

Council have a detailed land use plan and associated development controls which outline where development can occur, as well as regulating certain features of the development (such as the type or size of development). During the study, a review of Council's planning mechanisms was undertaken using latest information about flooding. Development will not be permitted in areas of the catchment which have an extremely high flood risk, whereas areas which are known to be flood free do not have flood related planning controls.

How was the community consulted?

Council sought input from the community, community representatives and stakeholders throughout the study to help identify flooding problems in the catchment, potential floodplain management options and to determine whether recommended options will be acceptable to the community.

To support the decision making process, Council also sought input from a wide range of community and business groups at the start of the study. Feedback from these groups helped select and shape the management options tested during the study. The Floodplain Risk Management Committee, which includes a number of community representatives, was involved throughout the life of the study, reviewing various stages and providing valuable input to the decision making process. Towards the end of the study, the broader community was invited to view the draft Study and Plan and comment on these documents during the exhibition period (6th October to 17 November 2015). Drop-in community sessions were also held at the Burringbar School of Arts on 26th October and the Cabarita Sports Club (Les Burger Field) on the 27th October. The exhibition period and community sessions were publicised via Council's website and Tweed Link newsletter.

Council made note of all discussion points and questions made during the session. Feedback from the community was reported back to the Floodplain Risk Management Committee, who updated the Study and Plan to reflect the comments. Significant issues

raised during community consultation were considered and, if decided to be necessary, studied in greater detail before finalising the Study and Plan.

What happens next?

The main outcome of the study is the Floodplain Risk Management Plan – a roadmap for Council and other agencies (such as the SES) to implement the recommendations of the study. The Plan prioritises recommendations from the Study, provides a preliminary cost estimate and details the steps required to implement the recommendations.

Some of the recommendations, such as updating the Local Flood Plan, can be undertaken straight away, while other recommendations, will require more detailed investigation. For recommendations which require a major investment, Council will apply for funding through the NSW State Government's Floodplain Management Program.

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