Planning Proposal

Dungog Local Environmental Plan 2014 | Amendment to flood planning levels

Prepared for Dungog Shire Council | 20 March 2018

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Final

Report J180030RP1 | Prepared for Dungog Shire Council | 20 March 2018

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Introduction

I1. Background

I1.1 Planning proposal origin

This planning proposal has been prepared by EMM Consulting Pty Limited on behalf of Dungog Shire Council (Council) to amend the *Dungog Local Environmental Plan 2014* (DLEP 2014) to have a flood planning level (FPL) at the 1:500 Average Recurrent Interval (ARI) plus 0.5 m freeboard within the Dungog Tailwater area (the site).

This process was prompted by extreme flooding April 2015 which resulted in three fatalities, washed four houses away and flooded approximately 80 dwellings, many to ceiling level. In the aftermath of this event, Council adopted an interim FPL based on a post-behaviour analysis of the event and began the process of a more comprehensive analysis of flood risk in the Dungog area. This process resulted in the *Dungog Floodplain Risk Management Study and Plan* (Dungog FRMS&P) (Appendix A), adopted by Council in November 2017 (Appendix B).

At its meeting on 20 June 2017, Council resolved to adopt the FPL of 1:500 ARI, plus 0.5 m freeboard (1:500 FPL), as defined by the Dungog FRMS&P. It also resolved to prepare a planning proposal to amend DLEP 2014 to implement the flood planning level (Appendix C).

This planning proposal seeks to amend DLEP 2014, as per the requirements of Council's resolution, and as supported by the Dungog FRMS&P.

I1.2 Other relevant matters

The Dungog FRMS&P makes two further relevant recommendations, in addition to the FPL noted above.

First, it mapped an updated 1:100 ARI plus 0.5 m freeboard FPL (1:100 FPL) in the Dungog town centre area (Appendix A, Figure 4-9 and 4-11). This FPL area has been mapped as per the requirements of the Manual and, as part of the Dungog FRMS&P, has been adopted by Council. As such, it is considered to be a relevant consideration of DLEP 2014 Clause 6.3 (2)(c), and any development within the area would be required to address the requirements of DLEP 2014 Clause 6.3.

Therefore, updating the Flood Planning Map to include the updated 1:100 FPL would likely result in a more transparent and consistent application of Clause 6.3 in the area. Further, it is considered that the intent in adopting the Dungog FRMS&P was to expand the Flood Planning Map as per the updated 1:100 FPL. However, as the 20 June 2017 resolution is considered to be specific to the 1:500 FPL, the updated 1:100 FPL has not been specifically considered by this planning proposal.

Second, as noted in the Executive Summary and sections 5.1.3, 5.4 and 7.3.2 of Dungog FRMS&P, Council acquired the following properties in September 2016, where houses were extensively inundated and damaged in the April 2015 flood event:

- 294 Dowling Street;
- 296 Dowling Street;
- 298 Dowling Street;

- 300 Dowling Street; and
- 287 Dowling Street.

The properties are currently zoned as B2 Local Centre. Dungog FRMS&P recommends that DLEP 2014 be updated to ensure that the properties be rezoned to ensure that future development considers the high flood risk in the location (Table 6-10). Council is in the process of determining the most appropriate zone for the properties, given the demonstrated flood risk to the land. When this process is complete, a planning proposal will be put to Council with the goal of rezoning the land to a more appropriate zone.

Until that process is complete, this planning proposal will meet the immediate need to ensure that flood risk is considered as part of any future development on the properties.

I2. Structure of the planning proposal

This planning proposal has been prepared in accordance with Division 3.4 of the *Environmental Planning and Assessment Act 1979* and the relevant guidelines prepared by the NSW Department of Planning and Environment, including *A guide to preparing planning proposals.* It includes the following:

- description of the site and its strategic context;
- a summary of the local planning controls;
- statement of the objectives and intended outcomes of the proposal;
- explanation of the provision of the proposal;
- justification of the proposal;
- mapping to accompany the proposal;
- description of the community consultation that has taken placed and expected to occur regarding the proposal; and
- an approximate project timeline.

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Appendices

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1 Part 1 – Objectives or intended outcomes

The objective of this planning proposal is to amend *Dungog Local Environmental Plan 2014* (DLEP 2014) to implement a 1:500 Average Recurrent Interval (ARI), plus 0.5 m freeboard flood planning level (FPL) for a portion of the Dungog Local Government Area (LGA). The FPL would apply to the Dungog Tailwater area, south of Myall Creek in the Dungog town centre (Figure 1.1). The level of the FPL in this area would be 51.6 m AHD. This is the recommended flood planning level of the *Dungog Flood Risk Management Study and Plan* (2017) (Dungog FRMS&P).

The current FPL and proposed FPL are shown in Figure 1.2, below.

The intended outcome of this planning proposal is to promote development that is more responsive to the unique flood risk in this area, mitigating potential risk to life and property, and reflecting that the more common FPL of 1:100 ARI, plus 0.5 m freeboard is not appropriate in the Dungog Tailwater area.

It is considered that this planning proposal will have substantial public benefits including:

- lower risk to life and property in the Dungog area;
- lower demand for high cost flood mitigation infrastructure, increasing availability for infrastructure funding elsewhere; and
- lower demand for emergency services during flood events, making those resources available elsewhere.

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

Cadastre

Dungog Tailwater area

Dungog Tailwater area

Dungog planning proposal

Figure 1.1

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\\emmsvr1\EMMJobs\2018\J180030 - Dungog Planning Proposal for Flood Plan\GIS\02_Maps\G002_ProposedFloodPlanningLevelExpansion_20180312_02.mxd 12/03/2018

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

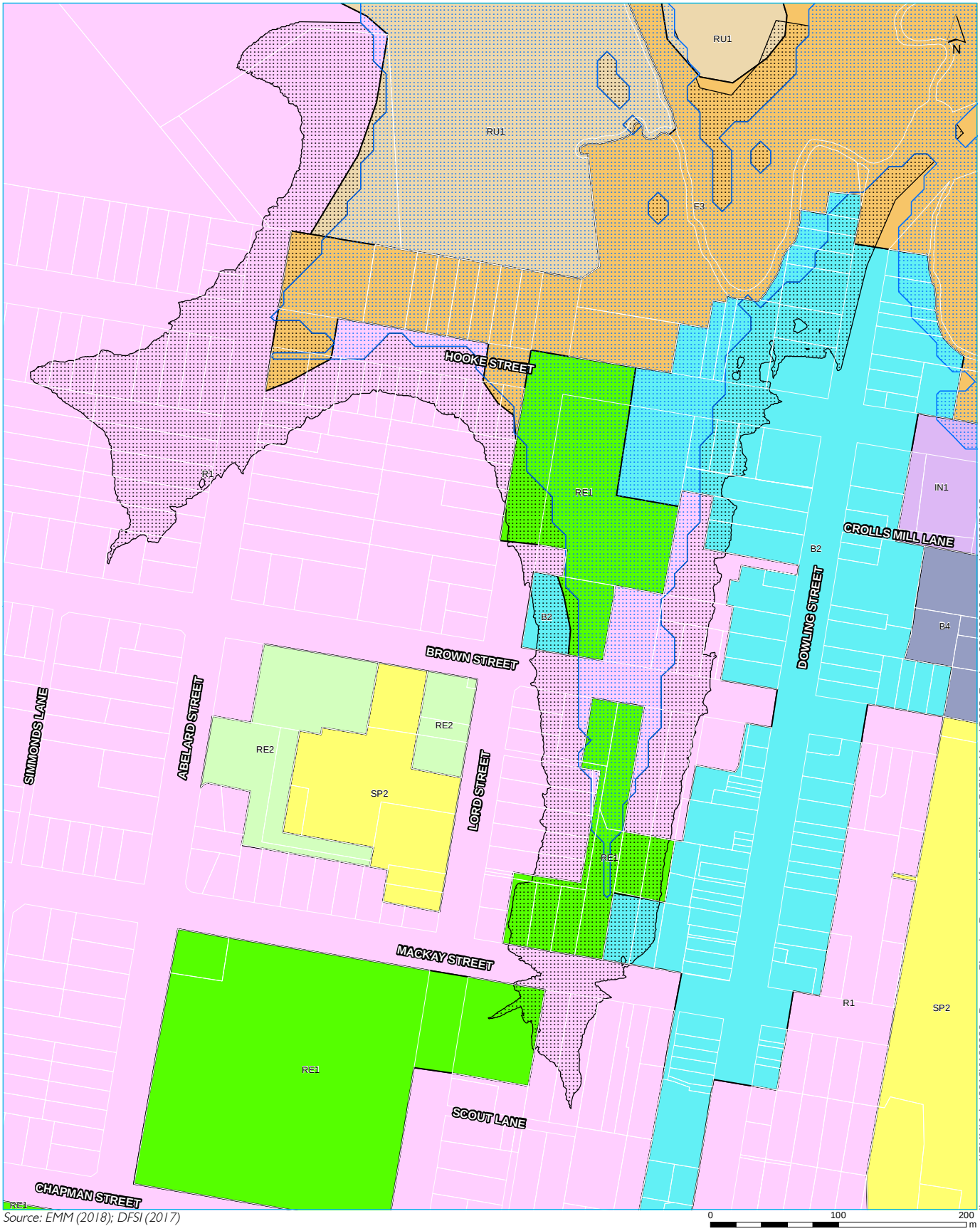
- Cadastre
- Current flood planning level
- Proposed flood planning map extension (51.6 mAHD)

Proposed flood planning map extension (with aerial)

Dungog planning proposal

Figure 1.2

EMM



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Source: EMM (2018); DFSI (2017)

KEY

- Current flood planning level
- Proposed flood planning map extension (51.6 mAHD)

Zone

- B2 Local Centre
- B4 Mixed Use
- E3 Environmental Management
- IN1 General Industrial
- R1 General Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU1 Primary Production
- SP2 Infrastructure

Proposed flood planning map extension (with land use planning)

Dungog planning proposal

Figure 1.3

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2 Part 2 - Explanation of provisions

The proposed outcome will be achieved by:

- Amending DLEP 2014 Clause 6.3 Flood Planning Area to:
  - Include a note after subclause (5) that acknowledges that the Flood Planning Map is inclusive of the Dungog Tailwater area at a level of a 1:500 ARI flood event plus 0.5 metre freeboard.
- Amend the DLEP 2014 Flood Planning Map to include the Dungog Tailwater area, as shown in Figure 1.1.

3 Part 3 - Justification

3.1 Section A – Need for the planning proposal

3.1.1 Q1 – Is the planning proposal a result of any strategic study or report?

This planning proposal is the result of the outcomes of the Dungog FRMS&P, adopted by Council in November 2017.

The primary purpose of the Dungog FRMS&P is to reduce risk to life and property by identifying, assessing and comparing various risk management options, whilst considering opportunities for environmental enhancement as part of mitigation works. The Dungog FRMS&P assessed flood risk in the Dungog LGA, possible flood risk management measures, and their associated costs.

The Dungog FRMS&P recommended a number of risk management measures, including a limited expansion of the FPL to include the Dungog Tailwater area, south of Myall Creek in the Dungog town centre. Due to a number of site-specific risks and historic flooding, the Dungog FRMS&P recommended an FPL at a level of 1:500 ARI, plus 0.5 m freeboard. Using the proposed level would mean that the FPL in this area would be 51.6 m AHD.

This planning proposal seeks to enact that recommendation of the Dungog FRMS&P.

It is noted that the Dungog FRMS&P was prepared in consultation with and endorsed by Dungog Flood Committee. This committee includes representatives from the Office of Environment and Heritage (OEH) and NSW State Emergency Service (SES). OEH is the relevant authority for floodplain risk management, whilst SES provides emergency and rescue services. As such, the Dungog FRMS&P has been prepared in consultation with relevant agencies.

3.1.2 Q2 – Is the planning proposal the best means of achieving the objectives or intended outcomes, or is there a better way.

This planning proposal is the best means of achieving the objectives and intended outcomes noted in Part 1.

Flood planning in NSW is largely split between three areas:

- legislation provides requirements for floodplain management, such as *Water Management Act 2000*;
- policy and advice is provided in documents, such as *Floodplain Development Manual: the management of flood liable land* (2005) and development control plans (DCP); and
- environmental planning instruments (EPIs) contain flood planning controls, such as local environmental plans (LEPs) and State environmental planning policies (SEPPs).

i Defining flood planning control provision areas

The principal method of defining where flood planning controls apply is via EPIs. This is reflected in Clause 6.3 of DLEP 2014, which currently identifies the flood planning level at the 1:100 ARI, plus 0.5 m

freeboard. The best way to designate the Dungog Tailwater area as an enforceable FPL, would be to update DLEP 2014 via this planning proposal.

A second method of achieving the objective of this planning proposal would be to create or modify an existing SEPP. However, given the local nature of the flood risk, this method is not appropriate.

ii Detailed flood planning assessment criteria

It is noted that Clause 6.3 of DLEP 2014 is focused on performance based criteria (ie that Council is satisfied that development will be appropriate to the flood risk characteristics) rather than prescriptive controls (eg specifying that development is built to a certain AHD). The effect of this is that all development that is to take place on land included on the Flood Planning Map undergoes a merit based assessment to determine that it is appropriate for the particular flood risk of the land.

As noted above, DCPs provide policy context for flood planning controls. Council's DCP, *Dungog Development Control Plan No 1* (DDCP) includes relevant controls for flood related matters. It sets out the objectives of controls, performance criteria and prescriptive controls that apply to lands on floodplains across the Local Government Area (LGA).

In its current form, DDCP would apply to the Dungog Tailwater area as an 'outer floodplain' area. This includes lands between the 1:100 FPL, plus 0.5 and the probable maximum flood (PMF). The indirect effect of this planning proposal would be that lands within the newly mapped area would have Section 149(2) planning certificates identify the land as being on the Flood Planning Map, with subdivision, commercial and industrial development having regard for flood affectation and evacuation. Future community facilities and critical utilities would also have to take flood levels into account.

However, as noted in Section 5.2 of the Dungog FRMS&P, Council is undertaking a review of the DDCP floodplain controls under the guidance of the recommendations of Dungog FRMS&P and in consultation with the OEH. Ultimately, the draft DDCP will include more specific controls for the Dungog Tailwater area that will represent the level of risk in the area. It is Council's intent to have the draft DDCP put on public exhibition alongside this planning proposal, post Gateway.

3.2 Section B – Relationship to the strategic planning framework

3.2.1 Q3 – Is the planning proposal consistent with the objectives and actions of the applicable regional, sub regional or district plan or strategy (including any exhibited draft plans or strategies?

i Hunter Regional Plan 2036

This planning proposal is consistent with the applicable regional plan, being *Hunter Regional Plan 2036* (the regional plan). The regional plan guides the NSW Government's land use planning priorities and decisions towards 2036, serving as a framework for more detailed land use plans, such as DLEP 2014. It was produced following extensive consultation with councils, stakeholders and the wider community, with a discussion paper and draft regional plan guiding consultation.

The table below contains relevant extracts of directions and actions from the regional plan and how this planning proposal is consistent with those objectives and actions.

Table 3.1 Hunter Regional Plan 2036 consistency

Direction	Relevance and actions	Consistency
Direction 16: Increase resilience to hazards and climate change.	The direction acknowledges that hazards and climate change present long term risks relevant for planning future growth around the Hunter and Manning rivers and their tributaries. Land use planning that supports changes to the physical environment and infrastructure can help to avoid or mange risks and building community resilience to hazards. The direction's actions below are relevant:	This planning proposal is designed to reflect current risks relating to Williams River, a major tributary of Hunter River. It will support long term changes to appropriately avoid and manage future risk to the built environment and local communities.
	16.1 Manage the risk of climate change and improve the region's resilience to flooding, sea level rise, bushfire , mine subsidence and land contamination	This planning proposal will result in an FPL that is appropriate to the level of risk in the Dungog area, as explain by the Dungog FRMS&P. This will lead to increased resilience to flooding in the area.
	16.2 Review and consistently update floodplain risk and coast zone management plans, particularly where urban growth is being investigated.	This planning proposal is prompted by the Dungog FRMS&P, a review of the floodplain risk in the Dungog area, an urbanised area.
Direction 22: Promote housing diversity	The direction acknowledges that a variety of housing types will be required across the Hunter region. This includes specialised housing for students, older people, short term visitors, visitors access health services and low income households. Local solutions are noted to be required to meet the needs of each community. The action below provides guidance for considerations for housing diversity:	This planning proposal will expand the FPL to an urbanised area with a residential population that includes older people and low income households. In the long term, it will promote more appropriate and resilient housing, either within the FPL area or in less flood affected areas.
	22.5 Include guidance in local land use strategies for expanding rural villages and rural-residential development so that such developments will: ... • Not result in greater natural hazard risk	This planning proposal acknowledges that flood risk, a type of natural hazard risk, is a relevant consideration for the planning of housing. By acknowledging the risk in the area, resources for housing development can be better allocated to lower risk areas, leading to better outcomes for future users and the wider community.

Notes: 1.Adapted from Hunter Regional Plan 2036

ii Strategic merit testing

a. Is the proposal consistent with the relevant regional plan outside of the Greater Sydney Region, the relevant district plan within the Greater Sydney Region, or corridor/precinct plans applying to the site, including any draft regional, district or corridor/precinct plans released for public comment?

As detailed in Table 3.1, this planning proposal is consistent with the relevant regional plan, *Hunter Regional Plan 2036*. There are no draft regional plans that have been released for public comment.

b. Is the proposal consistent with a relevant local council strategy that has been endorsed by the Department?

There is no local Council strategy endorsed by the Department that is applicable to this planning proposal.

However, as detailed in Section 3.1.1, this planning proposal is consistent with the Dungog FRMS&P, the relevant flood plain management strategy that has been adopted by Council. Whilst the Dungog FRMS&P has not been endorsed by the Department, it has been drafted in consultation with, and endorsed by, the Dungog Flood Committee, which includes representatives from OEH.

As such, it is consistent with a flood study that has been recommended for Council adoption by relevant agencies.

c. Is the proposal responding to a change in circumstances, such as the investment in new infrastructure or changing demographic trends that have not been recognised by existing planning controls?

This planning proposal responds to a change in the known circumstances regarding the flood risk in the Dungog Tailwater area, as detailed by the Dungog FRMS&P. The Dungog FRMS&P provides additional detail regarding flood risk in this area that allows Council to make more informed decisions regarding the requirements for development in the area.

In that way, this planning proposal does respond to a change in circumstance.

iii Site specific merit testing

a. Does the planning proposal have regard for the natural environment (including known significant environmental values, resources or hazards)?

This planning proposal has regard for the natural environment, specifically significant flood hazards, as detailed by the Dungog FRMS&P.

Over the long term, this planning proposal will result in development that is more appropriate for the level of flood risk. This could result in the following benefits:

- increase in flood storage, resulting in lower severity of flood impacts;
- reduction in obstructions, resulting in lower overall flood velocities; and
- reduction in debris in local and downstream areas.

These outcomes are likely to result in reduced natural environment impacts (eg impacts from flooding on both the natural and built environment and the community). This includes a reduction in debris being deposited in the floodplain and in/near water bodies.

b. Does the planning proposal have regard to the existing uses, approved uses and likely future uses of land in the vicinity of the proposal?

This planning proposal does not limit existing or approved uses within the Dungog Tailwater area.

Future land uses in the area will be required to address the requirements of Clause 6.3 of DLEP 2014. As such, Council would need to be satisfied that future development in the area to be included in the Flood Planning Map would meet the requirements of the Clause 6.3(5), that development:

a) Is compatible with the flood hazard of the land, and

b) Will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affection of other development or properities, and

c) Incorporates appropriate measures to manage risk to life from flood, and

d) Will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction or riparian vegetation or a reduction in the stability of river banks or watercourses, and

e) Is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

The ability and requirement to address Clause 6.3 of DLEP 2014 is considered the primary benefit of this planning proposal, as it will allow Council to more appropriately assess the flood risk of future development in the area.

c. Does the planning proposal have regard to the services and infrastructure that are or will be available to meet the demands arising from the proposal and any proposed financial arrangements for infrastructure provision?

As noted above, future development in the Dungog Tailwater area will be required to meet the requirements of Clause 6.3 of DLEP 2014. This will result in land uses and built form that is more appropriate for the flood risk within the Dungog Tailwater area.

As land within the proposed flood planning level is redeveloped, it is expected that the demand for emergency services within the area will be reduced during flood events.

If the changes proposed are not made, infrastructure investments may be required to reduce flood risk (eg expanded drainage, pumping stations, bridge replacement, etc). These measures have been assessed in the Dungog FRMS&P and largely prioritised as Very Low to Low due to significant costs in the $3.5 to $8 Million range, cost to benefit ratios of under 1 and the likely budget of Council to fund such works. In contrast, amending DLEP 2014 was prioritised as Very High. As such, this planning proposal is viewed as an effective alternative to significant expenditure on flood related infrastructure.

3.2.2 Q4 – Is the planning proposal consistent with a council's local strategy or other local strategic plan?

i Dungog Shire Council Community Strategic Plan 2012-2030

The relevant local strategic plan is *Dungog Shire Council Community Strategic Plan 2012-2030* (CSP). It incorporates seven focus areas that have been established following engagement with the community:

- Natural environment;
- Local economy;

- Community and culture;
- Rural and urban development;
- Recreation and open space;
- Public infrastructure and transport; and
- Council governance and finance.

The CSP focus areas are defined by values, priorities, goals, strategies and success criteria.

This planning proposal has been assessed against the relevant CSP focus areas in Table 3.2:

Table 3.2 Dungog Shire Council Community Strategic Plan 2012-2030 consistency

Focus area	Consistency
Natural environment	The focus area emphasises the goal of preserving and enhancing the Dungog natural environment and biodiversity, stressing the importance of local waterways. This planning proposal will ultimately result in uses and built form that will be more appropriate for the flood risk of the Dungog Tailwater area. This may result in lower debris and contamination entering the waterway and thereby enhancing their health.
Local economy	The focus area emphasises the need to support and promote local businesses, including agriculture, services and tourism. While this planning proposal will help reduce flood impacts over the long term. The consequences of flooding and flood damage can negatively impact tourism and hamper economic growth by diverting resources. As such, it is expected that this planning proposal will indirectly promote the local economy.
Community and culture	The focus area acknowledges that the health and safety of the community is important to the cultural health of the community. As detailed in the Dungog FRMS&P, the Dungog Tailwater area presents a risk to residents. The planning proposal will help mitigate this health and safety risk, thereby contributing to Dungog's cultural health.
Public infrastructure and transport	The focus area emphasises that Dungog requires investment in local services, facilities and infrastructure to meet the needs of the current and future communities. While this planning proposal will not directly contribute to public infrastructure, it provides an alternative to expensive mitigation measures that would otherwise be required to address the flood risk presented in the Dungog Tailwater area. As such, it will indirectly allow for investment in infrastructure that more directly meets the needs of the community.
Council governance and finance	The focus area outlines how Council will promote community awareness, support the community, provide for services and facilities and operate in an accessible and transparent manner. This planning proposal is the result of the development of the Dungog FRMS&P, which has been developed in extensive consultation with the community and with the support of the community. Further community consultation will be undertaken through this planning proposal process, further ensuring that it is consistent with the focus area.

Notes: 1.Adapted from Dungog Shire Council Community Strategic Plan 2012-2030

As outlined above, this planning proposal is consistent with the relevant focus area of the CSP.

ii Dungog Floodplain Risk Management Study and Plan

As detailed above, Dungog FRMS&P is the adopted flood study for the Dungog Tailwater area. It recommends that DLEP 2014 be amended to include the Dungog Tailwater area in its Flood Planning Map. As this planning proposal seeks to make that amendment, it is consistent with Dungog FRMS&P.

3.2.3 Q5 – Is the planning proposal consistent with applicable State Environmental Planning Policies?

This planning proposal is consistent with the applicable State Environmental Planning Policies (SEPPs) as detailed in the table below:

Table 3.3 State Environmental Planning Policy Consistency

SEPP	Relevance	Consistency
State Environmental Planning Policy No 62 – Sustainable Aquaculture	This SEPP seeks to encourage sustainable aquaculture. Section 1A, Section 2 of this SEPP notes extensive pond-based aquaculture is to be designed/constructed so that it will not be inundated by the discharges of a 1:100 ARI flood event. This type of development is permitted in the following types of zones that are within the Dungog Tailwater area: • RU1 Primary Production; • SP2 Infrastructure; • RE2 Private Recreation; and • E3 Environmental Management.	The SEPP is structured so that it presents minimum performance criteria and does not limit consent authorities from considering additional matters. Given this structure, the expanded flood planning level could be considered as part of a future assessment. This consideration would be consistent with this SEPP. Therefore, this planning proposal is not inconsistent with this SEPP.
State Environmental Planning Policy (Educational Establishments and Child Care Facilities) 2017	This SEPP seeks to facilitiate the delivery of educational establishments and early education and care facilities across the State. Several types of development are prohibited on flood control lots, including certain types of exempt and complying development. Flood control lots are defined as a lot located within or partly within an LEP as a flood planning area (eg normally exempt mobile/temporary childcare and complying university/TAFE child care). Further, schools and university/TAFE facilities on flood control lots would only be permitted as complying development if it can be demonstrated that development is not proposed on land that is: • a flood storage area; • a floodway area; • a flow path; • a high hazard area; or • a high risk area.	Expansion of the FPL, as defined by DLEP 2014, would reduce the area within Dungog where certain types of education and early education and care facilities are permitted as exempt or complying development, or increase the reporting requirements for those types of development. Given the exceptional circumstances of the risk presented by the Dungog Tailwater area, further detailed in Section 3.2.4, it is considered that this extra level of assessment is appropriate. Further, it is noted that the SEPP permits exempt and complying types of development. As such, assessment for the above types of development would still be available via other planning pathways.
State Environment Planning Policy (Exempt and Complying	This SEPP allows for a variety of development types to be permitted via the planning pathways of exempt and complying development.	Expansion of the FPL, as defined by DLEP 2014, would reduce the area within Dungog where exempt and complying development is possible, or increase the

Table 3.3 State Environmental Planning Policy Consistency

SEPP	Relevance	Consistency
Development Codes) 2008	Complying development for several types of development (Housing Code, Rural Housing Code and Commercial and Industrial Code) is not permitted on flood control lots (ie lots within a flood planning level), unless the developed portion of land is not: • a flood storage area; • a floodway area; • a flow path; • a high hazard area; or • a high risk area. Further types of development are not permitted as exempt or complying development (eg certain fences, and certain alterations) on flood control lots.	reporting requirements for those types of development. Given that the SEPP refers to flood planning levels as defined by LEPs, rather than specific ARIs, this is considered consistent and appropriate. Further, it is noted that this planning proposal would not directly prohibit the development types, only require development applications. This is considered appropriate, given the nature of the flood risk.
State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004	This SEPP allows for certain types of residential development for seniors or people with a disability (eg residential care facilities, self-contained dwellings and hostels). The aims of the SEPP are to increase the supply and diversity of residences for seniors and people with a disability, with the SEPP typically allowing for types and density of development that may not otherwise be permitted by an LEP. Section 6 of the SEPP states that the SEPP does not apply to land described in Schedule 1 (Environmentally sensitive land), as described in the SEPP. This includes land that is classified as a floodway, a high flooding hazard, or a natural hazard in an EPI. As explained in the Dungog FRMS&P, the area included in the Dungog Tailwater area is considered to be a high hazard area given the depths that could occur in the area during 1:100, 1:500 and PMF events. These areas and scenarios are mapped in Appendix A of the Dungog Flood Study (Royal Haskoning DHV, 2017) (Appendix D of this document). As such, it is considered that the Dungog Tailwater area is already excluded from the SEPP.	It is considered that, as the land included in the Dungog Tailwater area is mapped as a high hazard in the Dungog Flood Study, it is a high flood hazard, as per the SEPP. Therefore, the SEPP is currently not applicable to these lands. This planning proposal will further define the level of risk on the land by including land on the Flood Planning Map as well as Section 149 planning certificates. As such, this planning proposal will help ensure appropriate application of the SEPP and therefore is consistent with the SEPP.

3.2.4 Q6 – Is the planning proposal consistent with the applicable Ministerial Directions (s117 directions)?

i Overview of consistency with s117 directions

This planning proposal is consistent with the applicable s117 directions, as detailed in the table below:

Table 3.4 Section 117 Direction Consistency

S117 Direction	Relevance	Consistency
1.1 Business and industrial zones	The direction applies to planning proposals that will affect land within an existing business or industrial zone. The objective of the direction is to encourage employment growth in suitable locations, protect employment land and support identified centres. Planning proposals are to: (a) Give effect to the objectives of the direction (b) Retain the areas and locations of existing business and industrial zones (c) Not reduce the total potential floor space area for employment uses and related public services in business zones (d) Not reduce the total potential floor space area for industrial sues in industrial zones, and (e) Ensure that proposed new employment areas are in accordance with a strategy that is approved by the Secretary of the Department of Planning and Environment	This planning proposal is potentially inconsistent with subclause 4(c) of the direction. This is due to the possibility of future development not being able to meet appropriate development standards as defined by DLEP 2014 Clause 6.3 and DDCP. While this planning proposal does not directly reduce the floorspace that may be achieved in the B2 Local Centre, future development could possibly be constrained in order to meet the requirements of DLEP 2014 Clause 6.3. However, any potential inconsistency is anticipated to being minor, and thus subject to subclause (5)(d), which allows inconsistencies of minor significance. This is due to 'minor development' provisions in DDCP that allow for expansions. There is also a limited number of affected properties, with seven B2 Local Centre zoned properties being added to the Flood Planning Map. If an inconsistency does exist, subclause 5(b) allows for an inconsistency that is justified by a strategy that gives consideration to the objective of the direction. This planning proposal is supported by the Dungog FRMS&P, which gives consideration to the objective at subclause 1(a) encourage growth in suitable locations. This objective is the basis for the Dungog FRMS&P, as it seeks to identify the flood risk in the Dungog town centre area, and therefore identify suitable locations for growth. As such, any potential inconsistency is considered minor, indirect, and appropriately supported by the Dungog FRMS&P.
1.2 Rural zones	The direction does not permit rural zones to be rezoned to residential, business, industrial, village or tourist zone.	This planning proposal is consistent with the direction. While this planning proposal will affect a portion of land zoned as RU1 Primary Production, it will not rezone the land.
1.5 Rural Lands	The direction requires consistency with the Rural Planning Principles listed State Environmental Planning Policy (Rural Lands) 2008, if affecting land within a existing rural zone. Those principles are: (a) the promotion and protection of	This planning proposal is consistent with the direction. This planning proposal will result in approximately 0.1 hectares of RU1 Primary Production zoned land to be included on the Flood Planning Map. It will not directly prohibit development on the land, but will

Table 3.4 Section 117 Direction Consistency

S117 Direction	Relevance	Consistency
	opportunities for current and potential productive and sustainable economic activities in rural areas, (b) recognition of the importance of rural lands and agriculture and the changing nature of agriculture and of trends, demands and issues in agriculture in the area, region or State, (c) recognition of the significance of rural land uses to the State and rural communities, including the social and economic benefits of rural land use and development, (d) in planning for rural lands, to balance the social, economic and environmental interests of the community, (e) the identification and protection of natural resources, having regard to maintaining biodiversity, the protection of native vegetation, the importance of water resources and avoiding constrained land, (f) the provision of opportunities for rural lifestyle, settlement and housing that contribute to the social and economic welfare of rural communities, (g) the consideration of impacts on services and infrastructure and appropriate location when providing for rural housing, (h) ensuring consistency with any applicable regional strategy of the Department of Planning or any applicable local strategy endorsed by the Director-General.	require development to be assessed against Clause 6.3. This change complies with the principles of balancing the social, economic and environmental interests of the community, as described in the Dungog FRMS&P, as well as avoiding constrained land. Therefore, this planning proposal does not conflict with the relevant principles of the SEPP and is consistent with the direction.
2.1 Environment Protection Zones	The direction requires planning proposals to facilitate the protection and conservation of environmentally sensitive areas and not reduce the environment protection standards of land within environment protection zones.	This planning proposal is consistent with the direction. This planning proposal will result in approximately 1.5 hectares of E3 Environmental Management zone to be included on the Flood Planning Map. This planning proposal will not result in a reduction of environment protection standards, and as such, is consistent with the direction.
3.1 Residential Zones	The direction requires planning proposals affecting land within an existing residential zone to (4)... include provisions that encourage the provision of housing that will: (a) broad the choice of building types and locations available in the housing market, and (b) make more efficient use of existing infrastructure and services, and (c) reduce the consumption of land for	This planning proposal is potentially inconsistent with subclause 5(b) of this direction as it will require that future development on land within the expanded FPL be assessed as per the requirements of DLEP 2014 Clause 6.3. While this planning proposal does not directly reduce the residential density that may be achieved in the R1 residential zone, future development could possibly be constrained in order to meet the

Table 3.4 Section 117 Direction Consistency

S117 Direction	Relevance	Consistency
	housing and associated urban development on the urban fringe, and (d) be of good design. Further, subclause 5(b) requires that planning proposal are not to contain provision which will reduce the permissible residential density of land.	requirements of DLEP 2014 Clause 6.3. However, any potential inconsistency is anticipated to being minor, and thus subject to subclause (6)(d), which allows inconsistencies of minor significance. This is due to 'minor development' provisions in DDCP that allow for expansions to dwellings, which would be the most common method of allow for additional residential density. Further, while a more extensive redevelopment would be likely to be subject to additional controls under DDCP, this planning proposal does not, in itself, restrict development. It is not considered likely the planning proposal would require a reduced residential density, only a residential density that is designed to appropriately consider flood risk. If an inconsistency does exist, subclause 6(b) allows for an inconsistency that is justified by a strategy that gives consideration to the objective of the direction. The objective at subclause 1(c) seeks to minimise the impact of residential development on the environment and resource lands. This planning proposal is supported by the Dungog FRMS&P, which has the primary purpose of reducing risk to life and property as a result of flooding. As such, this planning proposal will lead to reduced flood impacts on the natural and built environment, it is considered that the Dungog FRMS&P and this planning proposal have given due consideration to this objective. Also, while not an 'objective' of the direction, this planning proposal and the supporting study have given consideration to and are supported by subclause 4(d), which seeks to promote housing that will be of good design. Good design is interpreted to not only mean aesthetic design, but also design that reflects the natural risks and constraints of the land. As such, any potential inconsistency is considered minor, indirect, and appropriately supported by the Dungog FRMS&P.
3.4 Integrating Land Use and Transport	The direction requires planning proposals that alter a provision to urban land to be consistent	This planning proposal is consistent with the direction.

Table 3.4 Section 117 Direction Consistency

S117 Direction	Relevance	Consistency
	with the aims, objective and principles of: (a) *Improving Transport Choice – Guidelines for planning and development* (DUAP 2001), and (b) *The Right Place for Business and Services – Planning Policy* (DUAP 2001).	*Improving Transport Choice – Guidelines for planning and development* largely focuses on the importance of promoting the growth of centres with sound planning and urban design. However, it does note the importance of assessing the appropriateness of locations for specific development proposals. While this policy focuses primarily on urban design, this planning proposal's identification of flood risk is a valid input to assessing the appropriateness of a location for development. *The Right Place for Business and Services – Planning Policy* is generally silent on the topic of environmental risk, but does contain an aim that community investment in infrastructure is protected. This planning proposal will aid in the protection of infrastructure by, over time, reducing the impacts of flooding in the area, reducing the need for investment in flood mitigation infrastructure and thereby increasing the potential for investment in other types of infrastructure. As this planning proposal does not impede accessibility of the Dungog Tailwater area specifically, and the Dungog LGA generally, and is consistent with aspects of the above policies, it is considered to be consistent with the direction.
4.3 Flood Prone Land	The direction requires planning proposals that alters a zone or provision that affects flood prone land to be consistent with the NSW Flood Prone Land Policy, the principles of the *Floodplain Development Manual 2005* (Manual) and *Guideline on Development Controls on Low Flood Risk Areas* (Guideline). Further, planning proposals must not impose flood related development controls above the residential flood planning level for residential development, unless a relevant planning authority provide adequate justification to the satisfaction of the Director-General. Finally, flood planning levels must not be inconsistent with the Floodplain Development Manual 2005 unless a relevant planning authority provides adequate justification to the satisfaction of the Director General.	This planning proposal is consistent with the principles of Manual. As per Section 1.1.1 of the Manual, the primary objective of the manual is to reduce the impact of flooding, flood liability, and losses resulting from floods. This is to be undertaken by adopting a merit approach for all development decisions, taking into account social, economic and ecological factors, as well as flooding considerations. Further, Section 1.1.2 of the Manual requires a merit based approach to selection of appropriate FPLs. Whilst a 'typical residential development' would normally warrant a 1:100 ARI, plus 0.5 freeboard, is recommended, Chapter 2 and Appendix K clearly allows for higher FPLs that balance the social, economic and cultural costs and benefits associated with more restrictive development controls. The Manual outlines this process, which includes Flood Studies that consider flood behaviour (Section 2.4), Risk Management

Table 3.4 Section 117 Direction Consistency

S117 Direction	Relevance	Consistency
		Plans, which would consider appropriate development controls (Section 2.5) and revising of development controls (Section 2.8), as appropriate. Dungog FRMS&P has provided the studies and plans to consider the development controls, with this planning proposal seeking to revise relevant development controls, as recommended. As such, it is considered that this planning proposal is consistent with the Manual. It is noted that the proposed amendment to the Flood Planning Map is inconsistent with the Guideline's principle of a standard 1:100 ARI, plus 0.5 m freeboard FPL. However, the Guideline allows for higher levels in exceptional circumstances. The exceptional circumstances relevant for this planning proposal are discussed and justified as per the requirements of the direction after this table. Pending confirmation from the Director-General (or appropriate officer), it is considered that the justification is adequate for the purposes of the Direction and that this planning proposal is consistent with the direction.
4.4 Planning for Bushfire Protection	The direction requires planning proposals that affect or are in proximity to land mapped as bushfire prone land to consult with NSW Rural Fire Service and have regard to bush fire risk.	This direction is not considered to be applicable. While this planning proposal will extend the Flood Planning Level map to incorporate land that is mapped as bush fire prone, it will not affect the land for the purposes of bush fire risk. As such, it is not considered that the direction applies.
5.10 Implementation of Regional Strategies	The direction requires planning proposals to be consistent with the applicable regional plan.	This planning proposal is consistent with the direction. As discussed in Section 3.2.1, this planning proposal is consistent with the applicable regional plan.
6.1 Approval and Referral Requirements	The direction requires planning proposals to minimise the inclusion of provisions that require the concurrence, consultation or referral of development applications to a Minister or public authority and not to contain provision requiring concurrent, consultation or referral without their approval.	This planning proposal is consistent with the direction. This planning proposal does not include provisions that would require Minister or public authority referrals.

Notes: Adapted from current Section 117 Directions as at 20 March 2017.

ii Justification of inconsistency with Floodplain Development Manual 2005 and the Guideline on Development Controls on Low Flood Risk Areas (explanation of exceptional circumstances)

Section 117 Direction 4.4 Flood Prone Land requires planning proposals to be consistent with the principles of the Manual and the Guideline. As explained in Table 3.4, this planning proposal is consistent with the Manual, but is inconsistent with the Guideline's standard FPL of 1:100 ARI, plus 0.5 m freeboard. The Guideline (as per Department of Planning Circular PS 07-03) states that:

> ... the Manual highlights that FPLs for typical residential development would generally be based around the 100 year flood plus an appropriate freeboard (typically 0.5 m).
>
> This Guideline confirms that, unless there are exceptional circumstances, councils should adopt the 100 year flood as the FPL for residential development. In proposing a case for exceptional circumstances, a Council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood.
>
> Unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land with a low probability for flooding, that is, land above the residential FPL (low flood risk areas).
>
> Justification for variations to the above should be provided in writing to, and agreed by, the Department of Natural Resources and the Department of Planning prior to exhibition of a draft local environmental plan or draft development control plan that proposes to introduce flood related development controls on residential development.

The Dungog FRMS&P has been prepared in consultation and endorsed by the Dungog Flood Committee, which included members from Council, OEH, SES and the community. These are the relevant stakeholders that are best placed to assess the risks posed by the Dungog Tailwater area, and thus, the exceptional circumstances that justify an elevated flood planning level.

The Dungog FRMS&P discusses the exceptional circumstances that justify the proposed extension of the Flood Planning Map at Section 5.3 Flood Planning Level Considerations. In summary, the Dungog FRMS&P makes the following points:

- **Local flood behaviour:** Floodplain constrictions at Bennett Bridge and the Myall Creek Rail Bridge result in the Dungog Tailwater area having a PMF nearly 3.5 m higher than the 1:100 ARI. This is more severe than the local catchment flood areas, where the PMF levels are only 0.1 to 0.8 m higher than the 1:100 ARI.

- **Particular historic flood:** The April 2015 event had real flood level of 52 m AHD, where a standard 1:100 ARI, plus 0.5 m freeboard FPL would be 50.7 m AHD.

- **Associated flood hazards:** As noted above, the Dungog Tailwater area is disproportionately exposed to high flood waters in lower-occurrence events, such as the April 2015 event. Given the particular needs of the local population (notably a significant elderly and mobility impaired population), there are additional risks to assuming that 'survivable depths' for the general population are applicable in the area.

The Dungog FRMS&P considered a number of FPLs in order to determine the most appropriate FPL for the area. For the reasons noted above, the 1:100 ARI is not considered appropriate. A 1:1000 ARI, the level of the April 2015 flood event, was also considered, but not recommended. This level is very rare. Over an 80 year timeframe, there is a 7.7% chance of experiencing a 1:1000 ARI event. However, the probability of

experiencing a second similar event is only 0.3%. Whilst it is not explicitly stated in the Dungog FRMS&P, the required AHD level that would accommodate the flood level is not seen as an appropriate balance of risk and cost.

This planning proposal instead seeks a FPL in the Dungog Tailwater area at the 1:500 ARI, plus 0.5 m freeboard level (ie 51.61 m AHD), as detailed in Dungog FRMS&P, Section 5.3. The justification is summarised as:

- **Increased survivability:** Depths as more extreme events (ie a 1:1000 ARI event) would be 0.4 m, significantly increasing survivability, compared to 1:100 ARI controls.

- **Significant increase in flood levels*:*** In local catchment flood areas, the 1:500 ARI event levels are only 0.01 to 0.2 m higher than the 1:100 ARI event levels. As such, a control modelled on an 1:100 ARI event will normally significantly mitigate impacts from more extreme events, especially if a 0.5 m freeboard was included. However the Dungog Tailwater area is 0.9 m higher, meaning that a 1:100 ARI, plus 0.5 m FPL would fail to mitigate impacts.

- **Increased likelihood:** As noted above, an event similar to the April 2015 has a 7.7% chance of happening in 80 year period, and a 0.3% chance of happening again in the next 80 years. However, a 1:500 ARI event (eg 0.2% per year), has approximately a 15% chance of happening at least once over an 80 year period.

The Manual requires a balance between likelihood, costs and benefits. The 1:500 ARI, plus 0.5 m freeboard is considered to be an appropriate balance between these considerations. It is an effective compromise between the standard 1:100 ARI, plus 0.5 m freeboard (ie 50.7 m AHD), which does not effectively mitigate against rarer events, and the very rare PMF level (53.65 m AHD). This level will promote development in the area that would be more appropriate for the flood risk in the area, whilst being more survivable for more vulnerable populations in more extreme circumstances.

As such, there is sufficient data available to demonstrate that the area represents an exceptional circumstance due to local flood behaviour, a particular historic flood and associated flood hazards.

It is also noted that the Dungog FRMS&P has undergone extensive community consultation, which is outlined in Section 5.1.1. This has included multiple community information sessions, letters to the community, advertisements in the local newspaper and media coverage. Further, the matter has been the subject of three Council meetings in the last year (June 2018 to place the Dungog FRMS&P on public exhibition/authorise this planning proposal and October/November 2018 to adopt the Dungog FRMS&P). Throughout this process, the community has been informed, consulted and involved. The continued support of the Dungog community is considered further evidence of the exceptional circumstances supporting this planning proposal.

In response to the requirement to consult with the Department of Natural Resources, it is noted that the department was abolished in April 2007, and that its functions were transferred to other agencies. However, consultation has been ongoing with the Department of Planning and Environment, including the Office of Environment and Heritage. The Office of Environment and Heritage is responsible for floodplain management under current Government administrative arrangements.

It is proposed that a Gateway Determination require approval from the Office of Environment and Heritage prior to exhibition, with the approval provided to the Director-General to confirm satisfaction with the justification. When that approval has been granted, this planning proposal will be consistent with the Guideline, and therefore it will also be consistent with the direction.

3.3 Section C – Environmental, social and economic impact?

3.3.1 Q7 – Is there any likelihood that critical habitat or threatened species, populations or ecological communities, or their habitats, will be adversely affected as a result of the proposal?

This planning proposal does not directly affect development standards or increase the development potential of land. It is unlikely that critical habitat or threatened species, populations or ecological communities or their habitats, will be adversely affected as a result of the proposal.

3.3.2 Q8 – Are there any other likely environmental effects as a result of the planning proposal and how are they proposed to be managed?

The primary environmental effect will be the long term redevelopment of land that is to be included in on the Flood Planning Map. This redevelopment will be required to address DLEP 2014 Clause 6.3, and as such, will be more responsive to the flood risk in the area.

3.3.3 Q9 – Has the planning proposal adequately addressed any social and economic effects?

A desktop analysis of the current and proposed flood planning map has identified sixty lots that will be included on the Flood Planning Map as a result of this planning proposal. These lots are described below:

- 47 lots: generally established dwellings on land zones as R1 General residential;
- 3 lots: likely established dwellings on land zoned as B2 Local Centre;
- 2 lots: established businesses on land zoned as B2 Local Centre; and
- 8 lots: community facilities or similar (eg parks, libraries, churches, etc).

i Potential impact on new development

As noted above, the long term effect of this planning proposal will be that new developments in the extended FPL area will be required to take flood risk into account when being assessed. This includes applications made under the provisions of DLEP 2014 or under SEPPs, as discussed in Section 3.2.3.

As such, the social and economic effects of this planning proposal are a potential restriction in the development potential of newly included lands, with some limitations to the expansion of social infrastructure, as discussed in Section 3.2.3. As described in Section 3.1.2, this planning proposal will not directly change development standards in the Dungog Tailwater area. Instead, it will require Council to be satisfied that development is appropriate to the flood risk. This process is guided by the DDCP.

This may result in increased costs on the part of developers (eg supporting studies by hydraulic engineers, potential engineering solutions and raised floor levels to mitigate flood risk). However, DDCP does not issue a blanket approach to all development. Instead, development is classified by potential for risk. For example, minor development, such as a commercial extension of under 35 m^2 could be built at the same floor level as the existing structure without attracting additional flood related requirements. Developments introducing a higher level of risk, such as a 60 m^2 granny flat, something that could place lives at risk or significantly affect overland flow, could require additional safeguards to ensure it was appropriate.

In this way, this planning proposal is considered to have a net positive social impact, as it will, over the long term, result in a reduced community vulnerability. It is also expected to have a net positive economic impact for the overall community as costs associate with flood impact mitigation will be internalised by developers, with costs associated with flood mitigation infrastructure or emergency services directed to other community uses.

However, it is acknowledged that this planning proposal may result in lower residential density and provision of social infrastructure that could otherwise be achieved. Given the significant flood hazard identified in the Dungog Tailwater area (Appendix D), this is considered a neutral or positive social and economic outcome, as it will prevent high risk and inappropriate development in the area.

ii Potential impact on existing development

This planning proposal will not have a direct effect on existing development. If a development within the Dungog Tailwater area would otherwise not be permitted due to Clause 6.3 of DLEP 2014, that development will not be required to be altered as a result of this planning proposal.

However, as noted above, this planning proposal may result in additional requirements for alterations or additions to existing development. Whilst minor development would likely have minor additional requirements, it is foreseeable that major developments (eg major increases to occupancy, ground level additions with the potential to result in significant flood affectation, or works below ground level) would require modification to the principal structure.

It is important to note that these modifications would not be required on their own, but could be sought as a condition of consent as justified by an assessment by a hydraulic engineer or similar. As noted above, these requirements would not be placed on development that is not being assessed as part of a new development application.

While the situation outlined above is not expected, it represents a possible economic impact of this planning proposal, which would likely result otherwise planned alteration or addition being abandoned due to significant cost. In this situation, a new development would likely be more feasible from an economic and environmental risk perspective.

The social and economic impacts of this scenario are similar to that for new development, in that while in may result in lower potential for development than otherwise would be possible, this is considered a neutral or positive social and economic outcome, as it will prevent high risk and inappropriate development in the area.

3.4 Section D – State and Commonwealth interests

3.4.1 Is there adequate public infrastructure for the planning proposal?

This planning proposal is in response to Dungog FRMS&P, a flood study that considered the flood risk in the Dungog Tailwater area and several possible mitigation measures. As discussed in Section 3.2.1iic, the assessment included a review of options of infrastructure that could mitigate the flood risk in the area. The Dungog FRMS&P generally prioritised these mitigations as low to very low, given their high cost and low cost to benefit ratio.

This planning proposal would instead seek to require future development in the area to appropriately consider flood risk during the development application process.

Therefore, this planning proposal responds to the current public infrastructure supply and may require less flood mitigation infrastructure than would otherwise be required by current controls. Further, it is possible that this planning proposal would lead to less damage to public and private infrastructure after a flood event.

3.4.2 What are the views of state and Commonwealth public authorities consulted in accordance with the Gateway determination?

Public authority consultation will be undertaken as required by the Gateway determination.

However, as detailed more fully in Section 3.1.1 and Part 5, the Dungog FRMS&P has developed with extensive consultation with state public authorities, including OEH and SES. Further, as noted in Section 3.2.4ii, concurrence from OEH is a recommended Gateway determination condition in order to comply with relevant guidelines.

4 Part 4 - Mapping

The figures below provide context for the Dungog Tailwater area and the proposed amendment to the DLEP 2014 Flood Planning Map:

- Aerial image of the affected and surrounding area (Figure 4.1);
- Current extent of the Flood Planning Level in the Dungog town centre area (Figure 4.2);
- Area of proposed expansion of the Flood Planning Level (Figure 4.3); and
- Proposed Flood Planning Level (Figure 4.4).

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

Cadastre

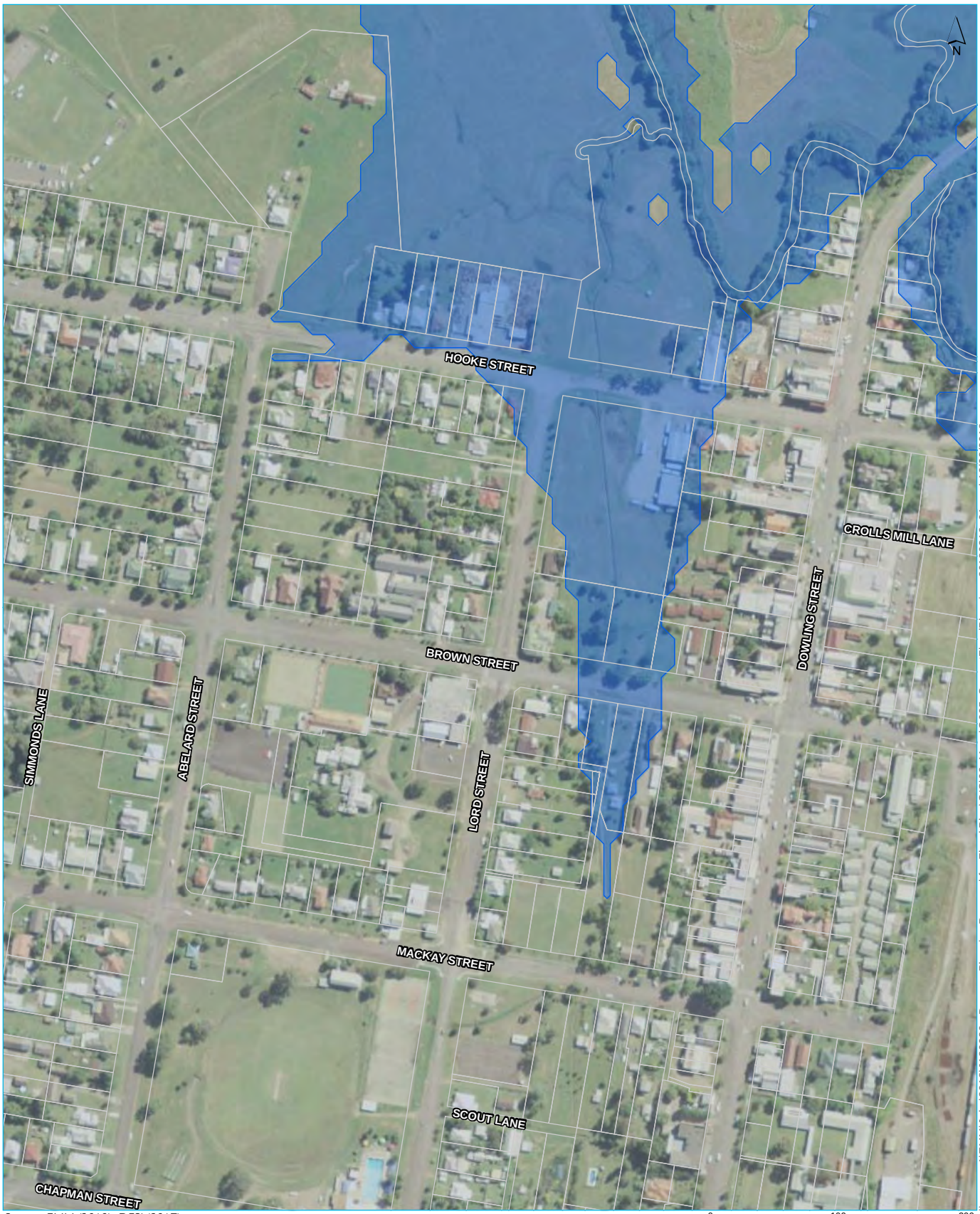
Dungog town centre

Dungog planning proposal

Figure 4.1

EMM

\\emmsvr1\EMMJobs\2018\J180030 - Dungog Planning Proposal for Flood Plan\GIS\02_Maps\G004_TownCentre_20180312_01.mxd 12/03/2018



\\emmsvr1\EMMJobs\2018\J180030 - Dungog Planning Proposal for Flood Plan\GIS\02_Maps\G005_CurrentFloodPlanning_20180312_01.mxd 12/03/2018

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

Cadastre

Current flood planning level

Current flood planning map

Dungog planning proposal

Figure 4.2

EMM

\\emmsvr1\EMMJobs\2018\J180030 - Dungog Planning Proposal for Flood Plan\GIS\02_Maps\G002_ProposedFloodPlanningLevelExpansion_20180312_02.mxd 12/03/2018

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

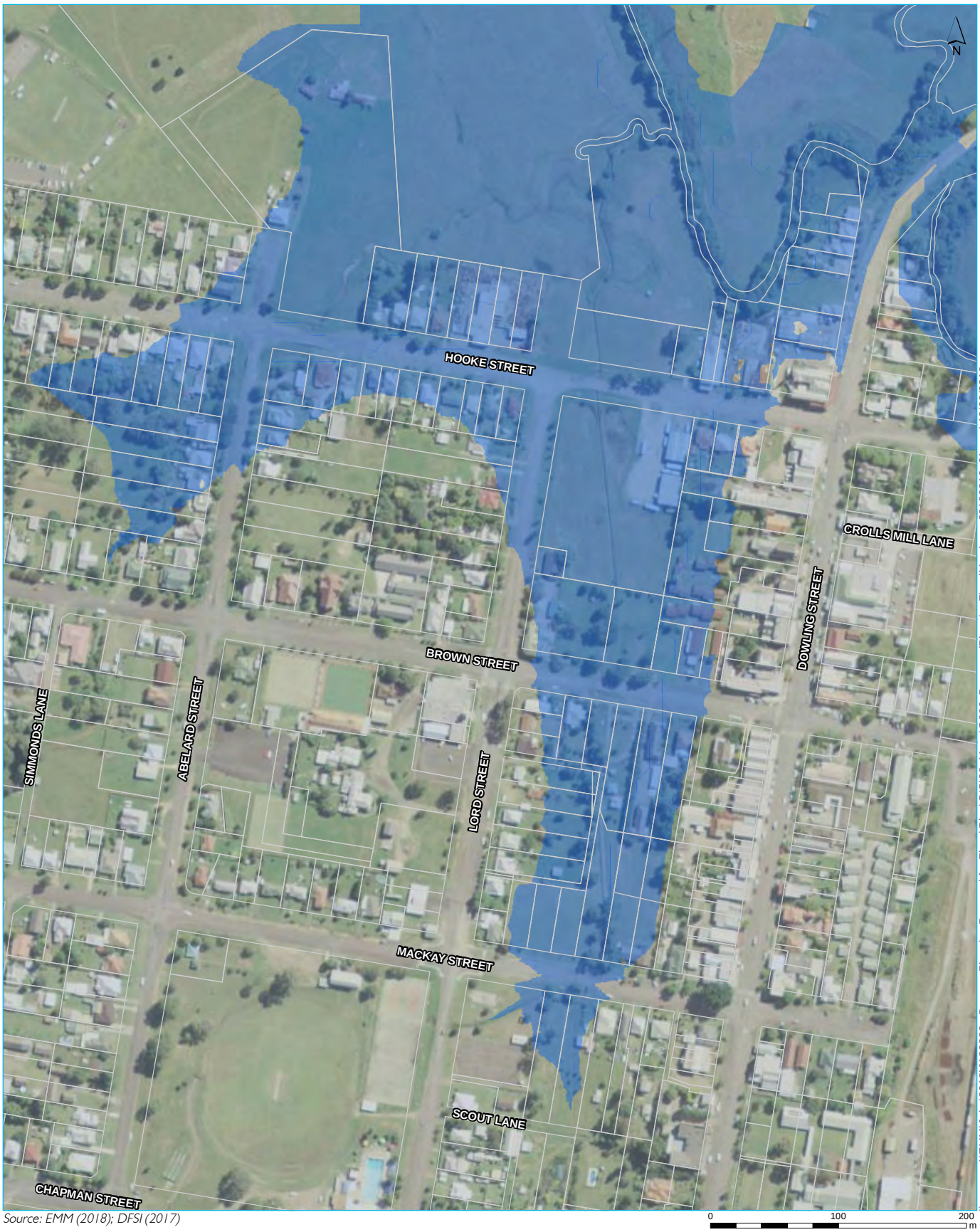
- Cadastre
- Current flood planning level
- Proposed flood planning map extension (51.6 mAHD)

Proposed flood planning map extension (with aerial)

Dungog planning proposal

Figure 4.3

EMM



\\emmsvr1\EMMJobs\2018\J180030 - Dungog Planning Proposal for Flood Plan\GIS\02_Maps\G006_ProposedPlanningFloodMapArea_20180312_01.mxd 12/03/2018

Source: EMM (2018); DFSI (2017)

0 100 200 m

GDA 1994 MGA Zone 56

KEY

Cadastre

Proposed flood planning level

Proposed flood planning map area

Dungog planning proposal

Figure 4.4

EMM

5 Part 5 - Community consultation

5.1 Consultation to date

5.1.1 Dungog FRMS&P

As explained in Section 3.1.1, this planning proposal is the result of a strategic study, the Dungog FRMS&P, which was drafted with input from the community and public authorities, as detailed below.

i Public consultation

A range of consultation and communication methods have been utilised in the preparation of the Dungog FRMS&P. These communication methods included:

- A media release in the Dungog Chronicle at the start of the project (11 July 2016);
- Development of a project study website providing information on the study and plan, providing a centralised area for documentation and information;
- Development of a project study Facebook page providing information and opportunity for feedback and engagement;
- An information brochure and questionnaire delivered to all residents and businesses in Dungog informing them of the study and requesting information on previous flood events (questionnaire was forwarded to 1,000 householders and publicised online);
- Discussions with individual home owners during site visits (approximately 35 properties visited);
- Community information session on 7 December 2016 at the Doug Walters Pavilion advertised via a letter box drop to residential properties in the Dungog township (brochures delivered to 500 households in November 2016); and
- Media news coverage of the information sessions and exhibition period.

The draft Dungog FRMS&P was reported to Council's June meeting. Council resolved to place the Dungog FRMS&P on public exhibition. The public exhibition occurred between 21 June 2017 and 21 July 2017. Communication methods included:

- Available details for the exhibition that took place (eg online, advertised in newspaper, mailouts, etc); and
- Community information session on 5 July 2017 at the Doug Walters Pavilion advertised via a letter box drop to residential properties in the Dungog township (brochures delivered to 500 households in June 2016).

In response to the exhibition of the draft Dungog FRMS&P, a single submission was received. The results of the public exhibition were reported to Council at its 18 October 2017 meeting, with no changes recommended. The Dungog FRMS&P was subsequently adopted at Council's November 2017 meeting as exhibited.

As such, the rationale, substance and consequences of this planning proposal have been well advertised to the community.

ii Public authority consultation

The Dungog FRMS&P was developed with guidance from the Dungog Flood Committee, made up of representatives from Council, OEH, SES and the local community.

Once completed, the draft Dungog FRMS&P was reported to the Dungog Flood Committee for review and approval to report to Council. Further, the outcomes of the public consultation were reported to the Dungog Flood Committee, which recommended that no changes be made and that the draft Dungog FRMS&P be reported to Council for adoption.

As such, the Dungog FRMS&P, the report that has recommended that DLEP 2014 be amended as described in this planning proposal, has been developed with extensive consultation with the relevant public authorities.

5.2 Proposed post-Gateway consultation

Section 3.34 (d) of the EP&A Act requires consultation with State or Commonwealth public authorities that will or may be adversely affected by the proposed instrument. While no public authority is expected to be adversely affected, the Guidelines require written consent from the Department of Natural Resources prior to public exhibition, as discussed in Section 3.2.4ii.

While that department has been abolished, OEH is the relevant authority for floodplain management. It is recommended that the Gateway Determination require that the OEH provide written approval for this planning proposal prior to public consultation.

Section 3.34 (c) and Schedule 1 of the EP&A Act state that if public consultation for a planning proposal is required, that the mandatory public exhibition period is 28 days. It is recommended that this planning proposal be placed on public exhibition for this period of time. The following activities will be undertaken as part of the community consultation process:

- a report seeking the authorisation of community consultation for the post-Gateway planning proposal will be put to Council, with the business paper available on Council's website;
- an advertisement with the details of the community consultation will be placed in the local newspaper, the Dungog Chronicle;
- Council's website will be updated with the community consultation details and supporting documentation;
- a letter will be sent to the properties informing the occupant of the planning proposal and community consultation;
- a 'frequently asked questions' document will be created to explain the practical effects of the planning proposal, to be made available on Council's website and included in the letter noted above; and
- a hotline will be made available for members of the community for questions regarding the planning proposal.

Given the extensive consultation undertaken thus far, and the results of that consultation, a public hearing is not recommended.

As noted in Sections 3.1.2 and 3.3.3, Council is preparing an amendment to the DDCP to reflect appropriate floodplain controls across the LGA, including the Dungog Tailwater area. It is expected that the community consultation process would occur in parallel with the planning proposal community consultation. This will allow the community to understand the practical effects of the proposed changes in a comprehensive and transparent manner.

6 Part 6 - Project timeline

Given the relatively simple nature of this planning proposal and the extensive community and public agency consultation that has been undertaken during the development of the Dungog FRMS&P, it is expected that an abbreviated Gateway and post-Gateway timetable is achievable. This timeline is outlined below:

- 21 March 2018: Planning proposal submitted to the Department
- 06 April 2018: Gateway determination received
- 23 April 2018: Public consultation begins
- 20 May 2018: Public consultation ends
- 20 June 2018: Council reviews outcome of community consultation
- 29 June 2018: Council requests Department make the amended LEP

Appendix A

Dungog Flood Risk Management Study and Plan

Dungog Floodplain Risk Management Study and Plan

Client: Dungog Shire Council

Reference: PA1316 Dungog FRMS&P

Revision: 01/Final

Date: 11 October 2017

Royal HaskoningDHV

Enhancing Society Together

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Document title:	Dungog Floodplain Risk Management Study and Plan
Document short title:	
Reference:	PA1316 Dungog FRMS&P
Revision:	01/Final
Date:	11 October 2017
Project name:	Dungog FRMS&P
Project number:	PA1316
Author(s):	Rohan Hudson and Ben Patterson
Drafted by:	Rohan Hudson
Checked by:	Ben Patterson
Date / initials:	
Approved by:	Ben Patterson
Date / initials:	

Classification
Final

Disclaimer

EXECUTIVE SUMMARY

Introduction

Dungog is located in the Upper Hunter Region of New South Wales, approximately 60 km north of Newcastle and 70 km inland from the coastline at Seal Rocks. The township of Dungog is situated at the confluence of the Williams River and Myall Creek. Three smaller catchments including the township, Common Creek and Melbee Estate catchments also provide a source of flood risk to Dungog.

Dungog Shire Council (Council) is responsible for flood risk management and local land use planning within their Local Government Area (LGA). Council has commissioned Royal HaskoningDHV (RHDHV) to produce the Dungog Floodplain Risk Management Study and Plan (FRMS&P) on behalf of Council and the NSW Office of Environment and Heritage (OEH).

The present FRMS&P included developing a Flood Study that defined flood risk in Dungog from all sources (i.e. Williams River, Myall Creek and local township catchments. The Flood Study was completed in February 2017.

History of Flooding in Dungog

The extreme flooding that devastated Dungog on the 21st of April 2015 was caused by an East Coast Low that caused significant flooding and damage to a number of areas in the Hunter Region and Sydney and is often referred to as the April 2015 “super storm”. The storm produced catastrophic flooding in Dungog resulting in three fatalities, washing four houses away and flooded some 80 dwellings, many to ceiling level. The flood event is likely to have an approximate annual exceedance probability (AEP) of 0.1% or an approximate frequency of a 1 in 1000 year average recurrence interval (ARI).

Other significant floods include: The “Pasha Bulker storm of 8th June 2007 which flooded a number of low lying properties (on Hooke Street and Dowling Street) was approximately a 1 in 20 year ARI magnitude event. Three older significant events (with a 5yr - 10yr ARI magnitude) occurred in February 1990, October 1985 and April 1946. The recent January 2016 event was smaller than a 5yr ARI event.

Community Consultation

Community consultation was undertaken to inform the community about the development of the Floodplain Risk Management Study, its likely outcomes as well as improving the community’s awareness and readiness for flooding. The consultation process provided an opportunity to collect information on the community’s flood experience, their concerns on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues. The key elements of the consultation program involved:

- Consultation with the Floodplain Management Committee through meetings, presentations and workshops;
- Development of a project study website (www.dungogfloodstudy.org) and Facebook page;
- Distribution of questionnaires and information brochures;
- Community information sessions; and
- Public exhibition of the Draft Floodplain Risk Management Study and Plan.

Flooding Behaviour

Flood behaviour in Dungog was quantified during the Dungog Flood Study (Royal HaskoningDHV, 2017) which investigated flooding from all flood mechanisms including: the Williams River, Myall Creek and the Local Township catchments. Flood extents from each individual flood mechanism were combined to produce a single envelope of design flood extents which represented the magnitude of flooding for a given frequency (i.e. annual exceedance probability (AEP) or average recurrence interval (ARI)) as discussed in **Section 4.1**.

The Dungog tailwater which is part of the Myall Creek flood mechanism is the main source of flood risk in Dungog accounting for 80-90% of above floor property inundation and flood damages. The Dungog tailwater is formed due to the floodplain constriction at Bennett Bridge, which is further influenced by the floodplain constriction at the Myall Creek Railway Bridge.

Only a few properties in Dungog are located on the Williams River floodplain. However, coincident flooding of the Williams River and Myall Creek can result in exacerbated flood levels in the Myall Creek catchment when small floods on Myall Creek occur at the same time as large floods on the Williams River.

The township of Dungog includes a small 1.6 km^2 catchment which drains into Myall Creek north of Hooke Street. Due to the small size of the catchment, this flood mechanism typically only produces “nuisance” type flash flooding which may be exacerbated by blocked or undersized drainage infrastructure. Low-lying areas to the south of Mackay Street may be influenced by backwater flowing from Myall Creek or the Williams River, which is the main source of flood risk and flood damage in Dungog.

Property Inundation Assessment

A summary of the location and frequency of above floor property inundation in Dungog is presented in **Section 4.2.2**. The assessment shows that:

- In an extreme flood (i.e. the PMF), 122 properties in Dungog are inundated above floor level. Of these properties, 89 are in the Myall Creek tailwater area, 12 are on the Williams River floodplain, 9 are adjacent to Common Creek and 12 are affected by overland flooding from the Dungog Township local catchment.
- In the rare, 0.2% AEP (500yr ARI) event, 46 properties in Dungog are inundated above floor level. Of these properties, 41 are in the Myall Creek tailwater area, 4 are on the Williams River floodplain and one property is flooded above floor level in the Dungog township local catchment.
- In the 1% AEP (100yr ARI) event, 22 properties in Dungog are inundated above floor level. Of these properties, 20 (91% of properties) are in the Myall Creek tailwater area, one is on the Williams River floodplain and one property is flooded above floor level in the Dungog township local catchment.
- In the 5% AEP (20yr ARI) event, 9 properties in Dungog are inundated above floor level. Of these properties, 8 (91% of properties) are in the Myall Creek tailwater area and one is on the Williams River floodplain and no properties are flooded above floor level in the Dungog township local catchment.

Flood Damages Assessment

The Average Annual Damage (AAD) is the main comparative factor that is derived from the flood damages assessment with which to evaluate the effectiveness of proposed mitigation options. The AAD represents the estimated tangible damages sustained every year on average over a

given 'long' period of time and is determined using the full range of flood events previously considered in the FRMS. A summary of flood damages (AAD Contribution) and property inundation is presented in **Section 4.2.3** and shows:

- That the two "minor" 20% and 5% AEP (i.e. 5yr and 20yr ARI) events, which only flood up to 16 properties (and only 9 above floor level), floods contribute over 50% of the damages in the AAD value.
- While the PMF floods 122 properties above floor level, many to a significant depth, due to the low probability of such an event it only contributes 10% of damages to the AAD value.
- Using an AAD value and a 7% discount rate over 50 years the net present value of the existing condition flood damages in Dungog is **$3.4 Million**.
- With the exception of the PMF event, typically 90% of flood damages occur in the Dungog tailwater area which is due to the Myall Creek backwater flood mechanism.
- In the April 2015 superstorm, direct, tangible flood damages of $9.0 Million were calculated for properties in Dungog. This is approximately half the near $18 Million flood damages predicted to occur in the PMF.

Planning and Development Controls

Council's existing and proposed DCP provides general provisions relating to all the floodplains and specific provisions relating to individual floodplains which are subject to a Floodplain Management Plan. Some minor revisions to the proposed DCP are recommended based on the adopted FRMS&P for Dungog and the associated flood risk mapping derived in this study. In particular the DCP should be updated to be consistent with recent NSW DoP guidance as discussed in **Section 5.2**. .

Council will also need to update the LEP to ensure that future development where Council purchased the five properties (destroyed during the April 2015 superstorm) adjacent to Bennett Bridge, considers the high flood risk at these locations.

While the Department of Planning (DoP) Circular PS 07—03 means that the setting of a higher than standard (100yr +0.5m freeboard) FPL may be difficult, it is recommended that Council seek the adoption of a FPL based on the 500yr ARI level of 51.1 m AHD. A free-board of up to 0.5m (i.e. FPL of 51.6 m AHD) should be considered to further increase the survivability for mobility impaired (i.e. wheelchair bound or elderly) residents. It is recommended that Council adopts this higher FPL until the effectiveness of the proposed flood warning system (as presented in **Section 7**)) is fully assessed. If a future Council review finds that the flood warning system is able to effectively reduce the risk to life in severe events, the reduction of the FPL towards the more typical 1% AEP with 0.5m freeboard could be considered.

Floodplain Management Options Considered

Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories including: **flood**, **property** and **response** modification measures. The following mitigation options (O1 – O11) were considered applicable/suitable for reducing flood risk in Dungog, and were therefore the subject of a detailed assessment (including flood damages and cost/benefit analysis) as part of this FRMS in **Section 6.4**.

Flood modification measures

O1) Major Myall Creek (Road and Rail) Bridge Modifications – Section 6.4.1

O2) Minor Myall Creek (Road and Rail) Bridge Modifications – Section 6.4.2

O3) Myall Creek Levee with Pumps – Section 6.4.3

O4) Myall Creek Levee with Diversion Culverts – Section 6.4.4

O5) Vegetation Removal with Scour Protection – Section 6.4.5

O6) Dungog Showground Detention Basin Augmentation – Section 6.4.6

O7) Dungog North-West Detention Basin – Section 6.4.7

Property modification measures

O8) Voluntary House Raising (VHR) – Section 6.4.8

O9) Voluntary House Purchase (VP) – Section 6.4.9

O10) Flood Resistant Surfacing for Bennett Park Tennis Courts – Section 6.4.10

Response modification measures

O11) Flood Warning System - The development of a flood warning system for Dungog is presented in detail in Section 7.

Recommended Floodplain Risk Management Options

An analysis of mitigation options O1-O5 shows that they result in a significant reduction in flood damages (between $1.3 and $2.4 Million). However, due to the high cost of implementing such measures, all benefit/cost (B/C) ratios are significantly below unity (one) and hence would not be considered for implementation on an a solely economic basis and have been given a low or very low priority in the floodplain risk management plan (FRMP).

For the O2 (Minor Bridge Upgrade) mitigation option, using the AAD approach, the calculated B/C ratio for this option is only 0.35 (due to the high cost of the scheme ($4.4 Million)). However, this mitigation measure is able to provide a 1.16 m reduction in peak flood levels for an extreme event such as the April 2015 superstorm. If future studies reveal that climate change has significantly altered the severity and intensity of storms in the Dungog region, such a scheme may be considered to reduce the impact of severe events.

Mitigation option O8 (VHR for 7 properties, demolition of 6 properties) produces the highest B/C ratio (2.2) but the lowest overall reduction in damages of just over $1.0 Million (a 30% reduction in flood damages). Given that the B/C ratio is considerably higher than one, this option would be recommended for implementation or further investigation and has been given a medium-high priority in the FRMP.

Mitigation option O9 (VP of 3 properties, VHR for 4 properties, demolition of 6 properties) produces a B/C ratio of 1.0 and hence this option could be recommended for implementation or further investigation on economic grounds. It should be noted that consideration for VP is not solely based on economic grounds and that VP schemes may be approved based on consideration of risk to life. Because VHR may increase the likelihood of residents sheltering in place during large events, there is the potential for increased risk to life during a severe event if residents can no longer be safely evacuated. **In order to reduce risk to life, option O9 should be considered in preference to option O8**. This option is considered a high priority in the FRMP.

Because none of the “flood modification measures” (O1-O7) are recommended for implementation, Dungog will still experience flood related risk to life and property issues during severe flood events. **In order to mitigate against this risk to life, a flood warning system (as presented in Section 7) is recommended**. This option is consider a very high priority in the FRMP.

Mitigation option O10 (Flood Resistant Surfacing for Bennett Park Tennis Courts) should only be considered if/when the existing court surface is next damaged.

Draft Dungog Floodplain Risk Management Plan

The following table forms an action list of the draft Dungog Floodplain Risk Management Plan (the Plan). The objective of the Plan is to recommend a range of property, response and flood modification measures to mitigate the existing and future flood affectation in the study area.

The Plan (as detailed in **Section 8**) should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

Mitigation Measures Recommended for Implementation

Measure*	Description	Estimated Capital Costs and (Ongoing Costs)	Responsibility and Funding	Priority / Time frame
O11	Flood Warning System	$50,000 to $100,000 ($5,000 / yr)	Council and OEH	**Very High** 1-2 years[1]
P1	Adopt non-standard FPL for Dungog tailwater	Council staff time of ~$5,000	Council	**Very High** <1 years
EM1	Emergency Management Planning (develop a Local Flood Plan)	SES and Council staff time of ~$10,000	SES	**High** <1 years
P2	Update LEP for purchased properties near Bennett Bridge	Council staff time of ~$5,000	Council	**High** <1 years
O9	VP for 3 properties, VHR for 4 properties demolition of 6 Alison Court properties.	VP = $900,000 VHR = $200,000 Demolition = $120,000	VP – Council and OEH VHR - Property owner and OEH Demolition – Council[2]	**High** 1-5 years[2]
O10	Bennett Park Tennis Court Surface Protection	Synpave - $100,000 Bonded grass - $180,000.	Tennis Club and/or Council and/or Insurance Agency	**Medium** After flood damage
EM2	Community Flood Education	Council / SES staff time ~$10,000	Council / SES	**Medium** 2-5 years
O2	Minor Bridge Upgrade	$4.4 Million	Council and/or NSW RMS and OEH	**Low** 5-50 years[3]

Notes: * details of the mitigation measures are provided in **Table 6-10**, and **Section 6.4**

VP = Voluntary Purchase, VHR = Voluntary House Raising

1) a NSW Floodplain Management Application for the Flood Warning System was submitted in April 2017.

2) The demolition of 6 Alison Court properties was approved by Council in April 2017. VP and VHR options are subject to the availability of Council and OEH funding and negotiations with property owners. Funding for the demolition of the 6 properties through Federal Government Disaster Recovery Funds has been approved in principle but has not been forthcoming at this time.

3) This option should be considered if bridge upgrades are being considered due to maintenance or capacity requirements or if increases in storm intensity produce more regular flooding in Dungog.

Floodplain Risk Management Plan Actions

In September 2016, Dungog Shire Council (with 2:1 funding from NSW OEH) purchased the five properties on Dowling Street adjacent to Bennett Bridge that were washed away during the April 2015 super storm. The removal of these high risk lands from private ownership ensures that the overall level of flood risk in Dungog has been reduced. Council will need to update the LEP to ensure that future development in this location considers the high flood risk at these locations.

The demolition of 6 Council owned Alison Court properties was supported by Dungog Council in April 2017, as it was deemed that the independent senior living units should not be allowed in the newly designated FPA (flood planning area). The demolition of these units is likely to occur in 2018. The demolition of these 6 properties will reduce the risk to life and also future flood damages and was included in both the VHR and VP options assessed in mitigation options O8 and O9.

In April 2017, Dungog Council submitted a floodplain management grant application to obtain 2/3 funding from the NSW Government Office of Environment and Heritage (OEH) for the design, installation and operation of a flood warning system for Dungog. If the grant application is successful, then the flood warning system should be operational by 2019.

The voluntary purchase (VP) of 3 properties is recommended in the plan and is subject to Council's resolution to acquire the property and the property owners concurrence to participate. This measure can be the subject of an OEH grant application (due for lodgement in March each year) at Councils discretion and if successful Council would be required to fund 1/3 of the costs of purchase while OEH would fund 2/3 costs. Similarly, the Voluntary House Raising (VHR) of 4 properties is recommended in the plan and is subject to Council's resolution and the property owners concurrence to participate. Whilst Council may lodge a grant application for VHR at its discretion, if successful property owners would likely be required to pay 1/3 of the costs while OEH would fund 2/3 of the costs.

Emergency management in Dungog is also being improved with SES currently in the process of updating their Flood Plan using information produced during this FRMS&P study. The updated Flood Plan was released in July 2017 and will assist the SES improve the efficiency and effectiveness of evacuating properties at risk in Dungog.

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Appendix A – Mitigation Option Cost Calculations

Abbreviations and Glossary of Terms

Abbreviations	
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff (1987)
DEM	Digital Elevation Model (a technique to define ground surface elevation data on a grid)
DoP	NSW Department of Planning
FLC	Form Loss Co-efficient (i.e. structure hydraulic loss parameter)
IEAust	Institution of Engineers Australia
IFD	Intensity Frequency Distribution
FRMS&P	Floodplain Risk Management Study and Plan
LiDAR/ALS	Light Detection and Ranging (method used to collect ground surface elevation data using an aircraft)
MHL	Manly Hydraulic Laboratory
OEH	NSW Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RHDHV	Royal HaskoningDHV
1D	One-dimensional (i.e. a flood model based on cross-section, pipe or structure information only)
2D	Two-dimensional (i.e. a flood model which is based on a full description of the ground terrain and is not restricted to cross-section data only)

Glossary of Terms	
Annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m3/s (or larger) occurring in any one year. (see also average recurrence interval)
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
Average recurrence interval (ARI)	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 20yr 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. (see also annual exceedance probability)
Catchment	The catchment at a particular point is the area of land that drains to that point.

Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100yr ARI or 1% AEP flood).
Development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving. For example meters per second (m/S)
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood Behaviour	The pattern / characteristics / nature of a flood.
Flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage
Flood hazard	The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.
Flood level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as “stage”.
Flood liable land	See flood prone land
Flood plain	Land adjacent to a river or creek that is periodically inundated due to floods. The floodplain includes all land that is susceptible to inundation by the probable maximum flood (PMF) event.
Flood plain management	The co-ordinated management of activities that occur on the floodplain
Flood plain risk management plan	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Management Manual. The plan usually contains both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives
Flood planning levels (FPL)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of landuse and for different flood plans. The concept of FPLs supersedes the “standard flood event”. As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
Flood source	The source of the floodwaters. In this study, Burrill Lake is the primary source of floodwaters.
Flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.
Floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
Freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determining the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Geomorphology	The study of the origin, characteristics and development of land forms
Gauging (tidal and flood)	Measurement of flows and water levels during tides or flood events.

Historical flood	A flood that has actually occurred
Hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems
Hydrodynamic	Pertaining to the movement of water
Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrographic survey	Survey of the bed levels of a waterway.
Hydrologic	Pertaining to rainfall-runoff processes in catchments
Hydrology	The term given to the study of the rainfall-runoff process in catchments.
Isohyet	Equal rainfall contour
Morphological	Pertaining to geomorphology
Peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
Pluviometer	A rainfall gauge capable of continuously measuring rainfall intensity
Probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Riparian	The interface between land and waterway. Literally means "along the river margins"
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Stage	See flood level
Stage hydrograph	A graph of water level over time
Sub-critical	Refers to flow in a channel that is relatively slow and deep
Topography	The shape of the surface features of land
TUFLOW	A hydraulic model that is used to simulate flood events.
Velocity	The speed at which the floodwaters are moving. A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi- 2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.
Water level	See flood level

PART A – FLOODPLAIN RISK MANAGEMENT STUDY

1 Introduction

Dungog Shire Council (Council) is responsible for flood risk management and local land use planning within the Local Government Area (LGA). Council has commissioned Royal HaskoningDHV (RHDHV) to produce the Dungog Floodplain Risk Management Study and Plan (FRMS&P) on behalf of Council and The NSW Office of Environment and Heritage (OEH). The project has been conducted under the state assisted Floodplain Management Program and received state financial support.

1.1 Study Objectives

The primary purpose of the FRMS&P is to reduce risk to life and property by identifying, assessing and comparing various risk management options whilst considering opportunities for environmental enhancement as part of the mitigation works (NSW State Government, 2005). This study assessed a suite of flood risk management measures and their associated tangible and intangible costs and determined a range of options for inclusion in the Floodplain Risk Management Plan and potential future implementation.

1.1.1 Dungog Flood Study Objectives

The FRMS&P included provision of a Flood Study that defined flood risk in Dungog from all sources (i.e. Williams River, Myall Creek and local township catchments). The flood study required the development of flood models that could define the existing flood risk in Dungog and evaluate potential mitigation options assessed as part of the Floodplain Risk Management Study. A draft Dungog Flood Study was delivered to Council in February 2017.

1.1.2 Floodplain Risk Management Study Objectives

The aim of a Floodplain Risk Management Study is to assess a range of flood mitigation strategies to alleviate flood risk in an LGA, in accordance with the NSW Government's Flood Prone Land Policy. The objectives of this study include:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk (taking into account the potential impacts of climate change).
- Reduce private and public losses due to flooding.
- Protect and where possible enhance the floodplain environment.
- Be consistent with the objectives of relevant State guidelines and policies, in particular, the Government's Flood Prone Land and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning Assessment Act, 1979.

1.1.3 Floodplain Risk Management Draft Plan Objectives

The Floodplain Risk Management Draft Plan presents a range of flood mitigation recommendations to address the existing flood liability of an LGA. The objectives of the plan are outlined below:

- Ensure that the draft floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community.

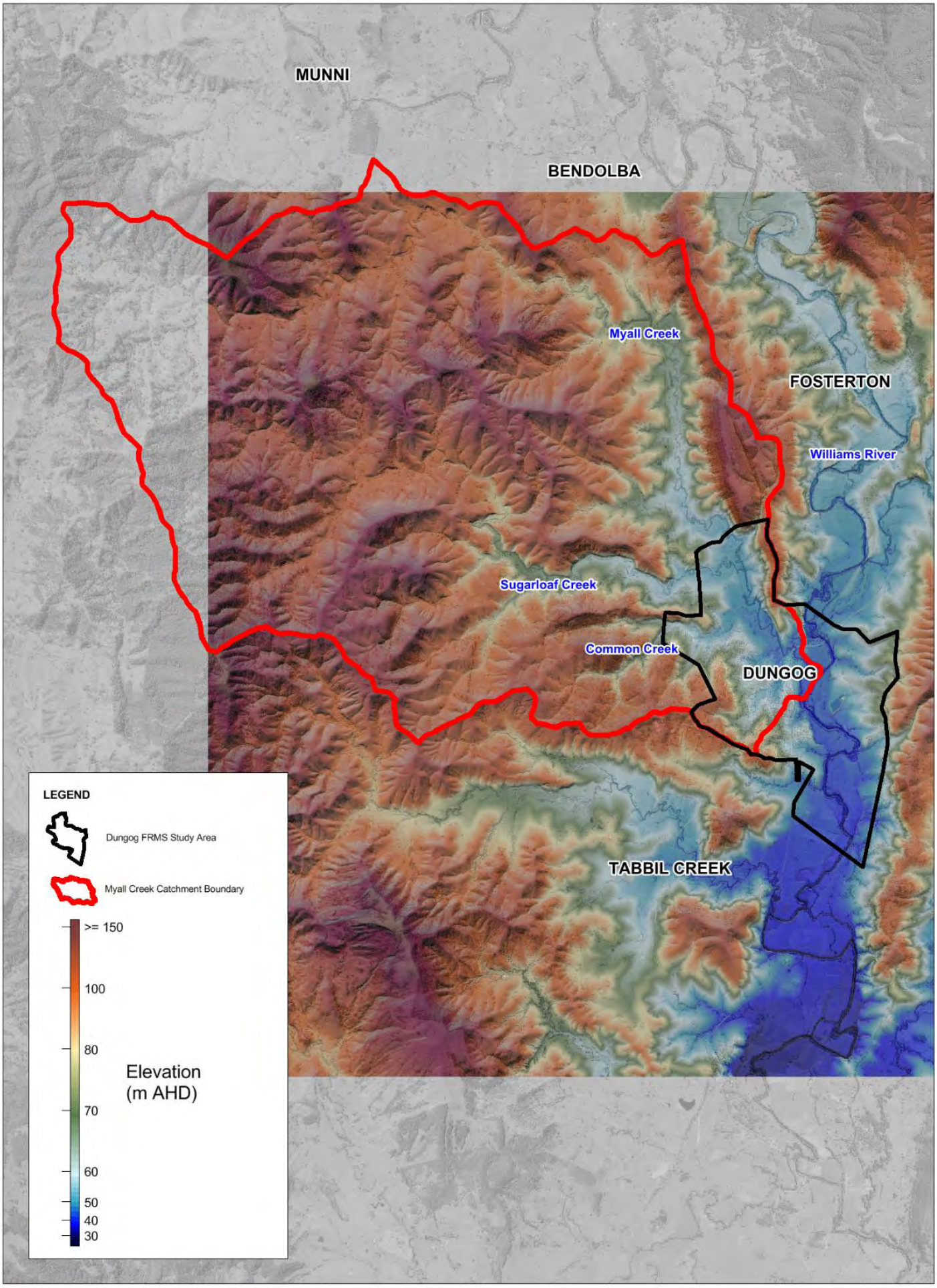
- Ensure actions arising out of the draft plan are sustainable in social, environmental, ecological and economic terms.

- Ensure that the draft floodplain risk management plan is fully integrated with the local Emergency Management Plan (Flood Plan) and other relevant catchment management plans.

- Establish a program for implementation and suggest a mechanism for the funding of the plan, which should include priorities, staging, funding, responsibilities, constraints and monitoring.

1.2 The Study Area

The town of Dungog is located in Upper Hunter Region of New South Wales approximately 60 km north of Newcastle and 70 km west of the coastline at Seal Rocks. The township of Dungog is situated at the confluence of the Williams River and Myall Creek as presented in **Figure 1-1**. Three smaller catchments also provide a source of flood risk to Dungog as detailed in **Section 2.1.** The Dungog township has a population of approximately 2200. The study area is limited to the Dungog township and includes approximately 4 km of the Williams River floodplain, approximately 3 km of the Myall Creek floodplain (including Common Creek) and the local township catchment.



Royal HaskoningDHV
Enhancing Society Together

FIGURE 1-1

STUDY AREA, LIDAR ELEVATION DATA AND MYALL CREEK CATCHMENT BOUNDARY

NORTH

0 0.75 1.5km
Approx. Scale

SCALE 1:80,000

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1.3 The Need for Floodplain Management in Dungog

Flooding in Dungog can occur from a range of flood mechanisms including the:

- Williams River;
- Myall Creek;
- Common Creek;
- The local township catchment;
- Melbee Estate catchment.

Details of these flood mechanisms are provided in **Section 2.1**. The local catchment provides a source of regular "nuisance type" flooding due to the low channel capacity and number of properties the channels run through. In terms of over floor flooding, Myall Creek provides the greatest source of flood damage in Dungog (refer **Section 4.2**) due to the tailwater formed by the floodplain constrictions at Bennett Bridge and the Railway Bridge.

The potential magnitude of flood risk that could occur in Dungog was realised during the April 2015 "superstorm" which caused three fatalities, washed away 4 houses and flooded a further 80 dwellings, many to ceiling level. While the storm was estimated to have a frequency (i.e. magnitude) of a 0.1% AEP (or 1 in 1000 year average return period) event (Royal HaskoningDHV, 2017a), the development of mitigation measures aimed at preventing future tragedy and reducing the costs of flood damages to the Dungog community is important.

Effective floodplain risk management identifies which properties or areas in Dungog are at highest risk and will determine and prioritise appropriate mitigation measures to reduce the risk. Flooding considerations are also an important constraint to the location and nature of future development in the study area. By determining the detailed flooding characteristics of the study area including the full extent of floodplain inundation for a range of design event magnitudes, the flood study outcomes provided further detail for future development planning in the catchment.

Council has commissioned this study with the desire to approach local floodplain management in a considered and systematic manner. This study comprises the final stages of that systematic approach, as outlined in the Floodplain Development Manual (NSW Government, 2005). The approach will allow for more informed planning decisions within the floodplains of Dungog.

1.4 The Floodplain Management Process

The NSW State Government's Flood Policy provides a framework to support the sustainable use of floodplains. The Policy is specifically structured to support development of mitigation measures to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any 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 Government's Floodplain Development Manual (2005).

Under the Policy, the management of flood liable 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 with their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through the following sequential stages:

1. Establish Floodplain Risk Management Committee (or Working Group) - Conducts a vital oversight role for the floodplain risk management process, acting as a focus and forum for discussion of key issues in formulating the management plan.

2. Flood Study - Determines the nature and extent of the flood problem.

3. Floodplain Risk Management Study - Evaluates management options for the floodplain in respect of both existing and proposed development.

4. Floodplain Risk Management Plan - Involves formal adoption by Council of a plan of management for the floodplain.

5. Implementation of the Plan - Construction of flood mitigation works to protect existing development, and use of flood risk management measures (such as development controls) to ensure new development is compatible with the flood hazard.

The Dungog Flood Study (Royal HaskoningDHV, 2017a) defines the existing flood behaviour and establishes the basis for future floodplain management activities.

The Dungog Floodplain Risk Management Study and Plan (this document) constitutes the third and fourth stages of the management process. It has been prepared for Dungog Shire Council to provide the basis for future management of flood liable land within the catchment.

1.5 About This Report

This report documents the Study's objectives, results and recommendations.

Section 1 introduces the study.

Section 2 provides background information including a catchment description, history of flooding and previous investigations.

Section 3 outlines the community consultation program undertaken.

Section 4 describes the flooding behaviour in the study area including a property inundation and damages assessment.

Section 5 presents a review of existing planning provisions.

Section 6 provides an assessment of relevant floodplain management measures.

Section 7 considers the requirement of a flood warning system for Dungog.

Section 8 presents the recommended measures and an implementation plan.

1.6 Design Event Terminology (AEP & ARI Explanation)

Design flood events are hypothetical floods used for floodplain risk management. They are based on having a probability of occurrence specified either as:

- Annual Exceedance Probability (AEP) expressed as a percentage; or
- Average Recurrence Interval (ARI) expressed in years.

The relationship between AEP and ARI is presented in **Table 1-1** with further descriptions of typical design event terminology provided in **Figure 1-2**.

Table 1-1: Design Event Terminology (AEP & ARI Explanation)

Annual Exceedance Probability AEP (%)	Average Recurrence Interval (ARI, 1 in X years)	Comment
Probable Maximum Flood (PMF)		A hypothetical flood or combination of floods which represent an extreme scenario.
0.2%	**500 yr**	A hypothetical flood or combination of floods likely to occur on average once every 500 years or with a 0.2% probability of occurring in any given year
0.5%	**200 yr**	As for the 0.2% AEP flood but with a 0.5% probability or 200 year return period.
1%	**100 yr**	As for the 0.2% AEP flood but with a 1% probability or 100 year return period.
2%	**50 yr**	As for the 0.2% AEP flood but with a 2% probability or 50 year return period.
5%	**20 yr**	As for the 0.2% AEP flood but with a 5% probability or 20 year return period.
20%	**5 yr**	As for the 0.2% AEP flood but with a 20% probability or approximately a 5 year return period.

Although the probability of a flood of a given size occurring remains the same from year to year (unless the flood regime is altered or new data lead to a revision of statistical estimates), the chance of such a flood occurring at least once in any continuous period increases as the length of time increases. **Table 1-2** shows the probability of experiencing various-sized floods at least once or twice in a lifetime. Over an 80 year timeframe/lifetime there is a 7.7% change of experiencing a 1 in 1000 ARI (0.1% AEP) such as the April 2015 Dungog superstorm. This puts the likelihood of such a severe and very rare event into some perspective, though thankfully for the residents of Dungog, the probability of experiencing a second 1 in 1000 ARI (0.1% AEP) magnitude event in an 80 year period is only 0.3%.

Table 1-2: Probability of experiencing a given-sized flood one or more times in 80 years

Source: Managing the floodplain: a guide to best practice in flood risk management in Australia (AEMI (2013))

Annual exceedance probability (%)	Approximate Average recurrence interval (years)	Probability of experiencing a given-sized flood in an 80-year period	
		At least once (%)	At least twice (%)
20	5	100	100
10	10	99.9	99.8
5	20	98.4	91.4
2	50	80.1	47.7
1	100	55.3	19.1
0.5	200	33.0	6.11
0.2	500	14.8	1.14
0.1	1,000	7.69	0.30
0.01	10,000	0.80	0.003

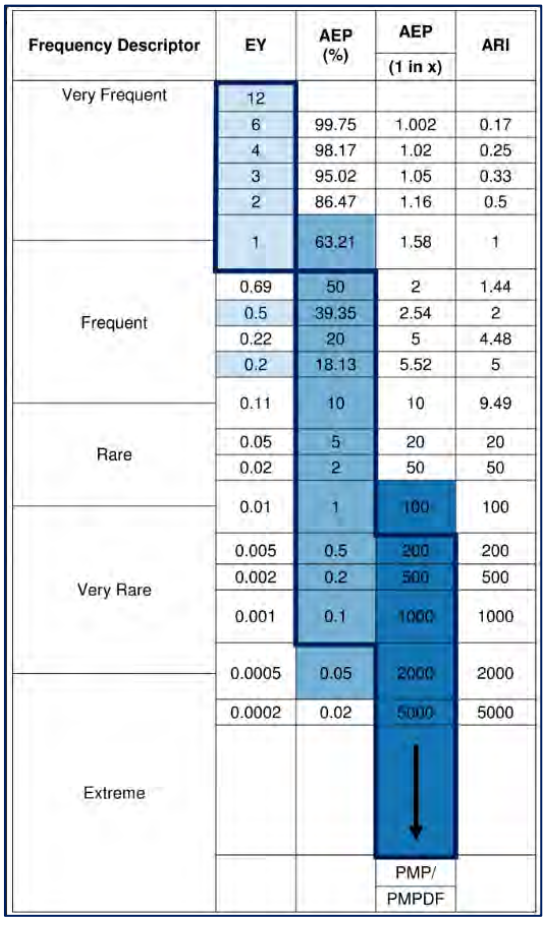

Figure 1-2: Australian Rainfall and Runoff (2016) Preferred Terminology

2 Background Information

2.1 Catchment Description and Flood Mechanisms

Dungog is located in the Upper Hunter Region of New South Wales approximately 60 km north of Newcastle and 70 km west of the coastline at Seal Rocks. The township of Dungog is situated at the confluence of the Williams River and Myall Creek as presented in **Figure 1-1**. Three smaller catchments also provide a source of flood risk to Dungog as detailed in **Table 2-1** and **Figure 2-1** and described below.

Table 2-1: Details of Dugong's Catchments

Source	Catchment Size
Williams River	670 km^2
Myall Creek	74.5 km^2
Township Catchment	1.6 km^2
Common Creek	5.0 km^2
Melbee Estate	0.25 km^2

2.1.1 Williams River Flood Mechanism

The Williams River drains some 670 km^2 of catchment upstream of Dungog and when in flood can inundate a number of low lying properties east of the railway line. The catchment is largely forested though includes some cleared rural lands. Chichester Dam is located upstream of Dungog, however, the dam is operated for water storage, not flood mitigation purposes. Large floods also result in backwater flooding of Myall Creek which can flood low lying properties in Dungog. Due to the size of the catchment, longer 12-48 hour rainfall events are required to cause significant flooding in Dungog from the Williams River catchment.

2.1.2 Myall Creek Flood Mechanism

Myall Creek drains 74.5 km^2 of catchment upstream of Dungog. Myall Creek flows to the north of Dungog before passing under Bennett Bridge and the Rail Bridge (Main Northern Railway) before discharging into the Williams River immediately east of the township. The catchment is largely cleared rural lands though includes forested areas in the upper catchment. During the April 2015 flood event, extreme rainfall in this catchment produced catastrophic flooding in Dungog resulting in three fatalities, washing four houses away and flooding some 80 dwellings, many to ceiling level. Myall Creek flooding is exacerbated by afflux (i.e. increased water levels upstream of the structure due to floodplain constriction) at the bridge structures and tailwater flooding from the Williams River, which causes flooding of low lying land to the south of Hooke Street. The critical duration of the catchment is 9 hours.

2.1.3 Town Catchment Flood Mechanism

The township of Dungog includes a small 1.6 km^2 catchment which drains into Myall Creek north of Hooke Street. There are two main (un-named) drainage lines, the larger of the two drains land between Dowling and Abelard Street and includes the catchment around the showground. The smaller catchment is to the west of Abelard Street and north of Mackay Street. The catchment is mostly low-density urban with some semi-urban areas. Detention basins are present at the

showground and sportsground. Due to the small size of the catchment, this flood mechanism typically only produces “nuisance” type flash flooding which may be exacerbated by blocked or undersized drainage infrastructure. Low-lying areas to the south of Mackay Street may be influenced by backwater flowing from Myall Creek or the Williams River.

2.1.4 Common Creek Flood Mechanism

The Common Creek is located to the north-west of Dungog and flows into Myall Creek after passing under Chichester Dam Road. Afflux due to the bridge restricting the floodplain discharge can result in flooding of a number of properties on Hillview Avenue. During high creek flows, flooding of properties on the floodplain fringe at the industrial estate located on Common Creek road can also occur.

2.1.5 Melbee Estate Flood Mechanism

A small 0.25 km^2 catchment drains the Melbee Estate through a culvert under the railway line which then drains into the Williams River. During extreme flood events, the railway embankment can be overtopped in very large events (such as the April 2015 superstorm) and cause minor flooding of three properties on Gladstone Street.

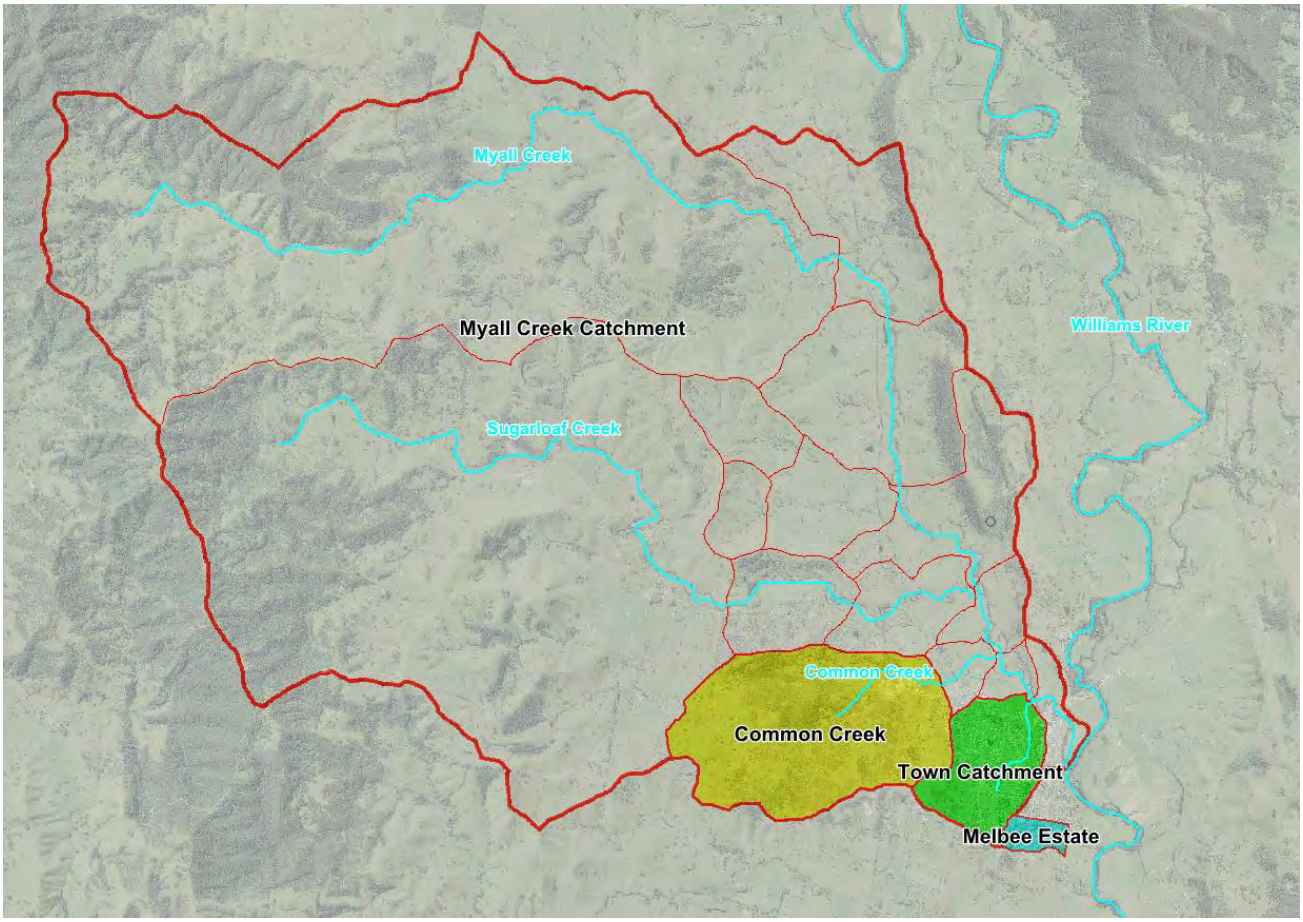

Figure 2-1: Locations of Key Catchments in Dungog

2.2 History of Flooding

The extreme flooding that devastated Dungog on the 21st of April 2015 was caused by an East Coast Low (ECL) that caused significant flooding and damage to a number of areas in the Hunter Region and Sydney and is often referred to as the April 2015 “super storm”. The storm produced catastrophic flooding in Dungog resulting in three fatalities, washing four houses away and flooded some 80 dwellings, many to ceiling level.

While it is difficult to define the probability of such an extreme event it can be characterised as having:

- Delivered a two hour burst of rainfall that was nearly twice the 1 in 100 year ARI (i.e. 1% AEP) design IFD estimate and 30 mm more than the 500yr ARI design estimate.
- Produced Myall Creek discharge that was 1.9 times the 100yr ARI discharge;
- Produced flooding in Dungog that was 1 m higher that the 1 in 500 ARI design event;
- Based on the above, the flood event is likely to have an approximate annual exceedance probability (AEP) of 0.1% or an approximate frequency of a 1 in 1000 year average recurrence interval (ARI).

Other significant floods include:

- The “Pasha Bulker storm of 8th June 2007 which flooded a number of low lying properties (on Hooke Street and Dowling Street) and had a peak flood level of 49.4 m AHD (i.e. ~ 1 in 20 year ARI).
- 6th January 2016 – flooded the former bus depot but did not inundate any houses. (< 1 in 5 yr ARI).
- Yeo (2015b) provides a summary of flood events in Dungog obtained by an archive search of the Dungog Chronicle and Maitland Mercury. Three significant events include:
    - 2-3 February, 1990 – Indicates local catchment flooding and Myall Creek flooded Reliance motors to a depth of 1m. It reached the back steps of a property near Bennett Bridge (Dowling Street), so was smaller than the 2007 flood event.
    - 13 October, 1985 – Indicates local catchment flooding (including damage to the Bennett Park Tennis Courts) and Myall Creek flooded Reliance motors to a depth of 0.6m (i.e. was smaller than the 1990 flood) and reached the verandah at 38 Brown Street.
    - 19 April, 1946 – Reportedly the largest flood in Dungog observed at the time, water reached the verandah at 38 Brown Street so is likely to be of similar magnitude to the 1985 flood. However, given that the current Bennett Bridge was constructed in the late 1960’s, the correlation between Myall Creek flow and flood level could be different for earlier flood events. Yeo (2015b) indicates that in 1979 (when Alison Court was approved), the highest observed flood level was 48.8 m AHD which is likely to be from this 1946 event. A comparison to current design flood levels (see **Table 4-2**) indicates the 1946 event was approximately a 5yr ARI (20% AEP) event.
- A number of other (predominantly Williams River) flood events are listed in **Table 2-2.** These include events in 1963, 1978, and 1990. While some information regarding the severity of these events was revealed during the community consultation process, no firm flood marks in the Dungog township could be obtained.

Table 2-2: Recorded Williams River Flow (Upstream Dungog)

Date	Gauge Level (mAHD)	DNR Stage (m)	Flow (m^3/s) (TUFLOW Rating)
18/3/1963	50.17	n/a	2250
19/3/1978	50.22	9.0	1722
4/2/1990	50.20	8.98	1705
8/6/2007	-	7.5	~730[1]
21/4/2015	-	8.7	~1450[2]
6/1/2016	-	8.0	~1000[1]

Notes: (1) flow based on comparison of levels and discharge with other similar events
(2) flow based on TUFLOW model output from calibration event
Data for events prior to 2010 sourced from Table 5-4 of BMT WBM (2009)
Flow data (DPI Rating) from http://www.bom.gov.au/waterdata/ (Williams River at Dungog (Factory Mill Race)

An analysis of the flood history of Dungog shows that in the 150 years of settlement prior to the April 2015 superstorm event, the largest recorded flood was the June 2007 "Pasha Bulker" event which produced a flood level of similar magnitude to the 5% AEP (20yr ARI). Other significant events prior to this occurred in 1990, 1985 and 1946, however, it appears that these events were likely to be 20% AEP (5yr ARI) – 10% AEP (10yr ARI) magnitude events.

2.3 Previous Studies

2.3.1 Dungog Flood Study (Royal HaskoningDHV, 2017)

The present FRMS&P included developing a Flood Study that defined flood risk in Dungog from all sources (i.e. Williams River, Myall Creek and local township catchments). A draft Dungog Flood Study report was delivered to Council in February 2017. The report detailed the results and findings of the Flood Study investigations including:

- a description of the study area;
- a summary of available historical flood related data;
- establishment and calibration of hydrologic and hydraulic models;
- the estimation of design flood behaviour for existing catchment conditions;
- sensitivity analysis of the model results to variation of input parameters; and
- providing the required mapping for future floodplain management activities.

A range of study outputs from the Dungog Flood Study are presented in **Section 4.1** including flood extents and peak flood levels. The flood models developed during the Flood Study were used to evaluate potential mitigation options assessed as part of the Floodplain Risk Management Study as described in **Section 6.4**.

2.3.2 Other Studies

A number of previous studies have been undertaken to investigate flooding in Dungog. The two most recent and useful studies are the *"Williams River Flood Study" (*BMT WBM, 2009) and the *"Post Event Flood Behaviour Analysis and Review of Flood Intelligence – Dungog Township – Myall Creek Catchment and Tributaries"* (BMT WBM, 2015). Survey information and drawings from an unpublished hydraulic analysis (undertaken in 1996) of stormwater drainage infrastructure (immediately upstream and downstream of the Dungog Showground) were also made available for this study. Information regarding culverts, and pipes and floor levels were extracted from this data set and used in the current study. A summary of these studies is presented in the Dungog Flood Study Report (Royal HaskoningDHV, 2017).

2.4 Floor Level Survey

Floor level survey was performed by Marshall Scott surveyors for all properties that may be flooded in July 2016 for this study. Existing data for six properties was derived from the 1996 hydraulic analysis of the Dungog Showground. A total of 176 properties were surveyed in these key areas for the purpose of undertaking an inundation and damages assessment (as presented in **Section 4.2**). The location of surveyed floor levels are shown in **Figure 2-2**.

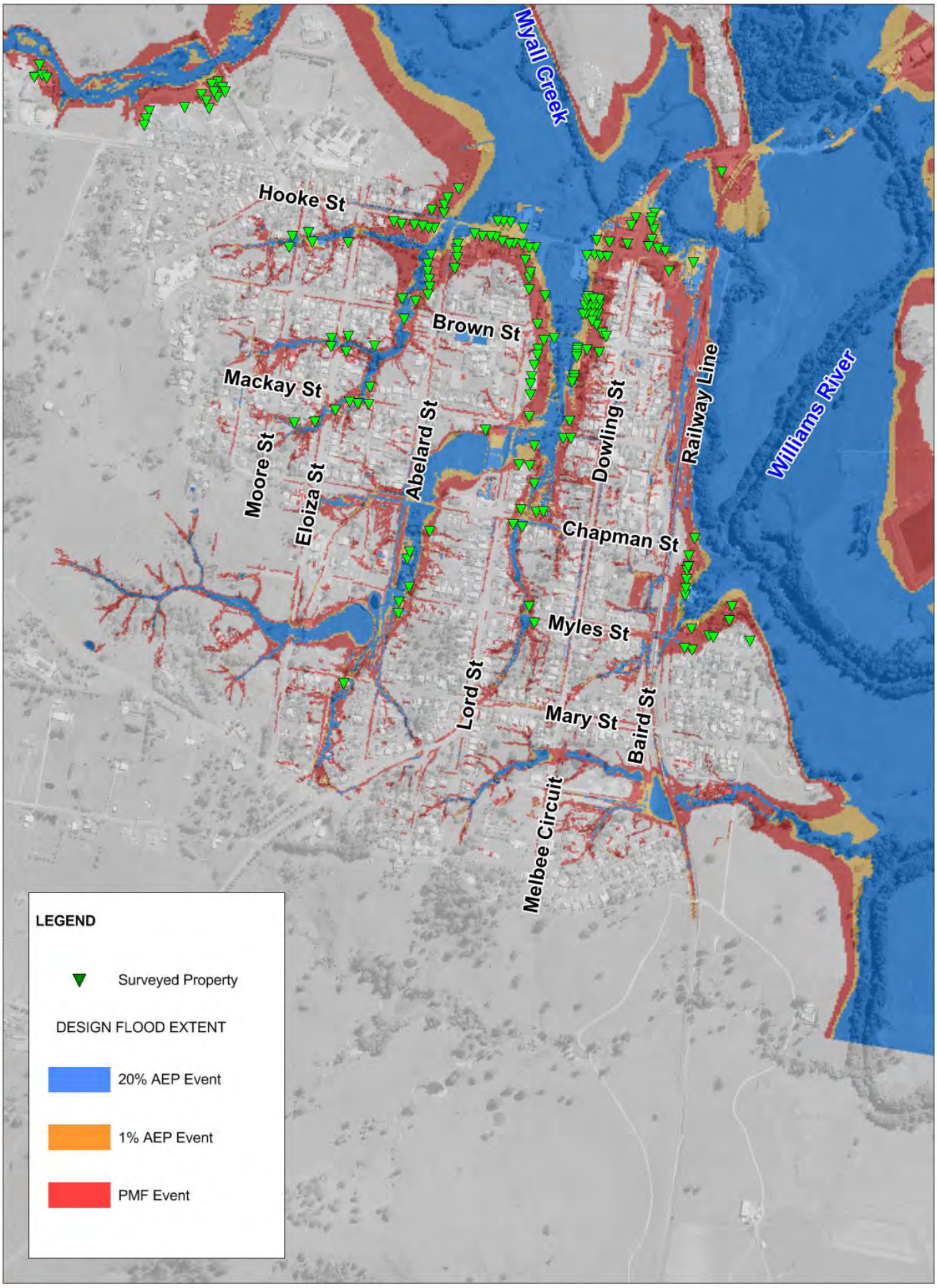

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FIGURE 2-2

FLOOD EXTENTS AND LOCATION OF PROPERTIES IN FLOOD DAMAGES DATABASE

NORTH

0 125 250m
Approx. Scale

SCALE 1:12,500

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3 Community Consultation

Community consultation is a fundamental element of the floodplain risk management process as it facilitates community engagement and ultimately aids the endorsement of the overall project.

A range of consultation and communication methods have been utilised including:

- A media release in the Dungog Chronicle at the start of the project (http://www.dungogchronicle.com.au/story/4022751/flood-plan-coming/):
- Development of a project study website providing information on the study (www.dungogfloodstudy.org);
- Development of a project study Facebook page providing information and an opportunity for feedback and engagement (www.facebook.com/DungogFloodStudy);
- An information brochure and questionnaire was delivered to all residents and businesses in Dungog informing them of the study and requesting any information on previous flood events. The survey was available online at www.surveymonkey.com/r/DungogFloodStudy.
- Discussion with individual home owners during site visits;
- A community information evening held on the 7th December 2016 at the Doug Walters (Sports Ground) Pavilion (Mackay St, Dungog), presenting the results of the Dungog Flood Study and providing an initial assessment of potential mitigation options.
- A final community consultation session was held on the 5th July 2017 at the Doug Walters (Sports Ground) Pavilion (Mackay St, Dungog), presenting the findings of the floodplain risk management study and the draft floodplain risk management plan.

3.1 Summary of Questionnaire Responses

As part of the community consultation undertaken during the FRMS&P process a study brochure and questionnaire was sent to approximately 2200 Dungog residents. 32 responses were received including 8 using the online form. 11 of the respondents reported above floor flooding in the April 2015 flood events while 9 properties experienced yard flooding and a total of 16 reported some form of flood related damage. One of the respondents also reported above floor flooding in the 8th June 2007 (Pasha Bulker) storm event. 16 respondents reported having flood insurance for their properties. 22 respondents provided suggestions for flood mitigation options which have been summarised in **Table 3-1**.

Table 3-1: Summary of Suggested Mitigation Options from Community Questionnaire Responses

Suggested Mitigation Option	No. Responses
Clean Stormwater Drains	14
Improved Drainage Network/System	7
Clean / remove vegetation from Myall Creek	6
Flood Warning System	4
Levee or Detention basin(s)	3
Education Programme	2
Government declaration of storm or flood event (for insurance reasons)	1
Increased SES presence	1
Raise or relocate homes	1

Suggested Mitigation Option	No. Responses
Improve Bridge Design	1

3.2 Community Information Session

A community information session was held on 7th December 2016 at the Doug Walters (Sports Ground) Pavilion (Mackay St, Dungog).

The primary objective of this community engagement was to inform the community of the progress of the study. Posters and a power point presentation were used to present study outputs to the community.

Overall, there was good attendance at this session in comparison to the catchment size. Feedback from the session included:

- There was general consensus that the models were able to reproduce the observed flood behaviour of the April 2015 storm event.
- A flood warning system was necessary in Dungog to reduce the potential for further tragedy and to reduce the fear and anxiety of future flood events that were a result of experiencing the severe April 2015 storm event.
- Residents who had been flooded more than once were in favour of Council purchasing their properties if no other mitigation options would be effective.

3.3 Public Exhibition of the Draft Dungog FRMS&P and Community Presentation

Public exhibition of the Draft Dungog FRMS&P was undertaken to gain the support of the local community. The report was made available digitally on the study website with links from Councils website. A hard copy was also displayed at the Council Offices for a period of one month for the public's comments. The public exhibition period was from 21 June to 21 July 2017. On the 5th July, 2017 a community presentation outlining the process and findings of the Dungog FRMS&P was held at the Doug Walters (Sports Ground) Pavilion (Mackay St, Dungog).

Only a single formal response was received during the community consultation period. Due to the nature of the response no formal reply was deemed necessary.

4 Existing Flood Behaviour, Property Inundation and Damages

4.1 Existing Flood Behaviour

Flood behaviour in Dungog was quantified during the Dungog Flood Study (Royal HaskoningDHV, 2017) which investigated flooding from all flood mechanisms including: the Williams River, Myall Creek and the Local Township catchments. Flood extents from each individual flood mechanism were combined to produce a single design flood extent which represents the magnitude of flooding for a given frequency (i.e. annual exceedance probability (AEP) or average recurrence interval (ARI)).

Design flood extents for three events including the: 20% AEP (5yr ARI), 1% AEP (100yr ARI) and Probable Maximum Flood (PMF) are presented in **Figure 4-1**. Included in **Figure 4-1** is a line indicating the limit of Dungog tailwater flooding from Myall Creek. Upstream of this line, peak flood levels are due to the local catchment flood mechanism, while downstream of the line, peak flood levels are due to Myall Creek floodwaters. The long-section flood profiles presented in **Figure 4-3** show the Dungog tailwater is formed due to the floodplain constriction at Bennett Bridge, which is further influenced by the floodplain constriction at the Myall Creek Railway Bridge. The influence of these constrictions on peak flood level during the April 2015 flood event is presented in **Figure 4-4.**

The Dungog tailwater which is part of the Myall Creek flood mechanism is the main source of flood risk in Dungog accounting for 80-90% of above floor property inundation and flood damages (refer **Section 4.2**).

Also included in the **Figure 4-1** is a line indicating the limit of flooding from the Williams River whose floodplain lies to the east of Dungog. Only a few properties in Dungog are located on the Williams River floodplain. However, coincident flooding of the Williams River and Myall Creek can result in exacerbated flood levels in the Myall Creek when small floods on the Myall Creek occur at the same time as large floods on the Williams River as presented in **Figure 4-3**.

The extent of flooding from the Common Creek catchment is also presented in **Figure 4-1**. Flooding from both the local township catchment (and Melbee Estate) is also presented in **Figure 4-1.**

Results of the Local Catchment flood mechanism without a coincident Myall Creek or Williams River flood are presented in **Figure 4-2.** The Figure shows a line indicating the flood extent due to the Myall Creek alone and shows that peak flood levels in the Dungog tailwater are due to the Myall Creek and not the local catchment.

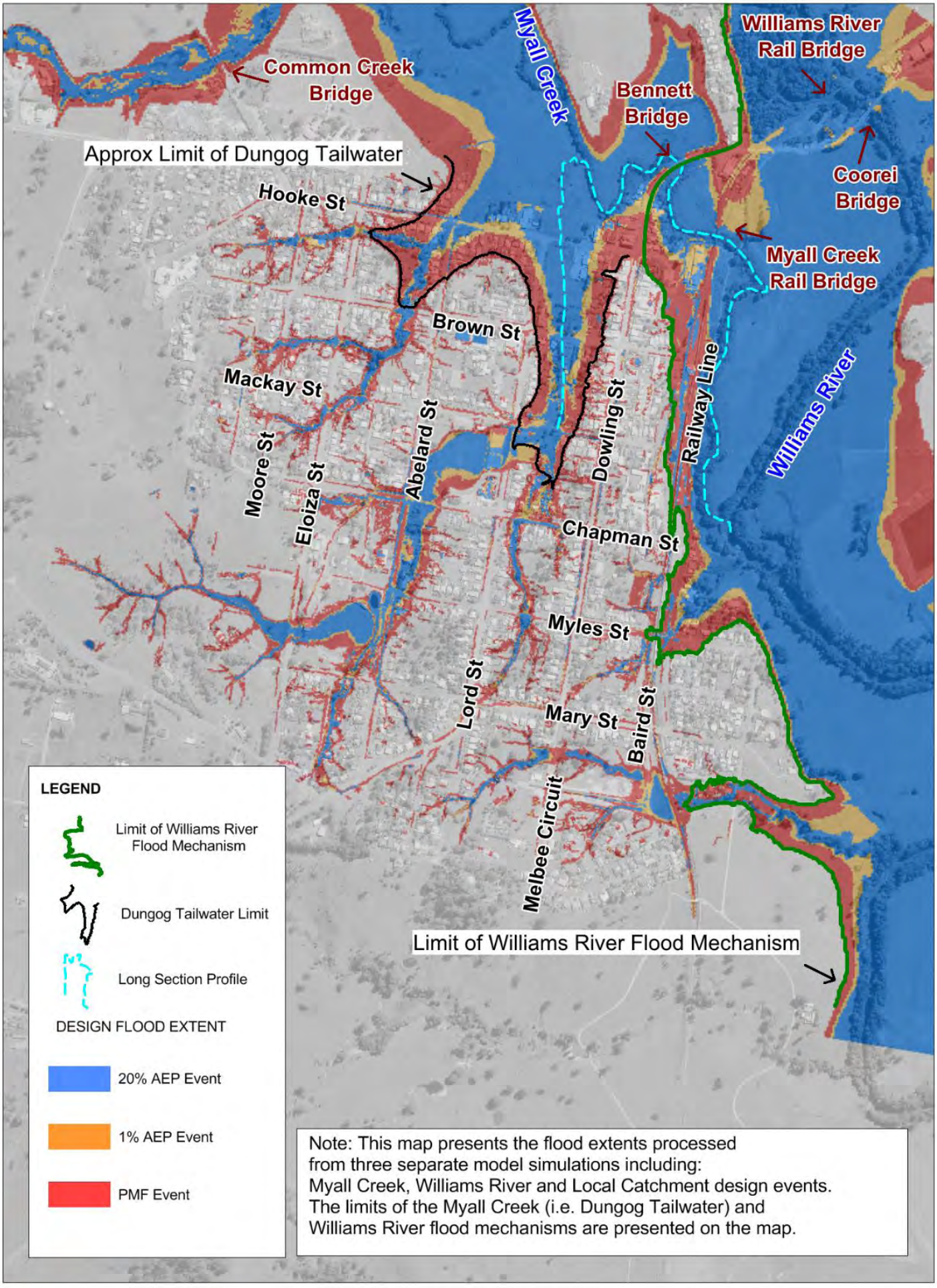

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FIGURE 4-1

COMBINED DESIGN FLOOD EXTENTS (5YR (20% AEP), 100YR (1% AEP) & PMF EVENTS)

NORTH

0 125 250m
Approx. Scale

SCALE 1:12,500

PAGE SIZE A4

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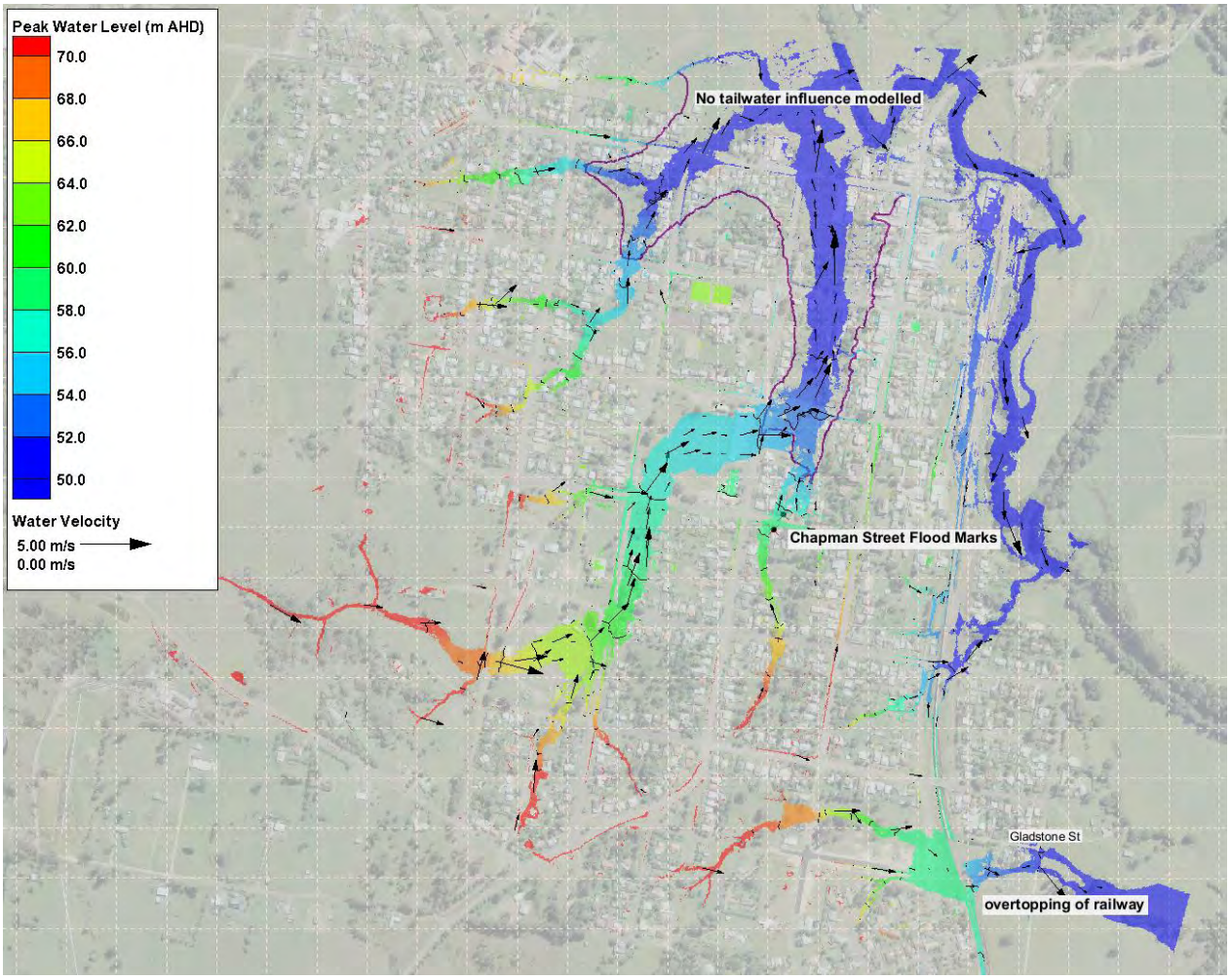

Figure 4-2: Local Catchment Peak Water Level April 2015

4.1.1 Coincident Conditions and Combined Flood Mechanism Results

A summary of the adopted coincident conditions for all three sources of flooding in Dungog is presented in **Table 4-1**. Flood profiles for the 5yr, 20yr, 100yr, 500yr and PMF from Myall Creek or Williams River sources are presented in **Figure 4-3**. With the exception of the PMF, all adopted Myall Creek design events produce the highest flood levels upstream of Bennett Bridge. The influence of the floodplain constrictions at Bennett Bridge and the Railway Bridge are clearly evident in the Myall Creek dominated design events.

Table 4-1: Adopted Design Conditions for Three Sources of Flood Mechanisms

Event	Myall Creek Event Myall Discharge / Williams Discharge)	Williams River Event (Myall Discharge / Williams Discharge)	Local Catchment
5yr	5yr / 5yr	5yr / 5yr	5yr
20yr	20yr / 5yr	5yr / 20yr	10yr
50yr	50yr / 5yr	5yr / 50yr	50yr
100yr	100yr / 10yr	20yr / 100 yr	100yr
200yr	200yr / 20yr	20yr / 200yr	200yr
500yr	500yr / 20yr	20yr / 500yr	500yr
PMF	3 x 100yr / 100yr	500yr / PMF (GTSM)	PMF (GSDM)

GSDM = Generalised short duration method, **GTSM =** Generalised tropical storm method

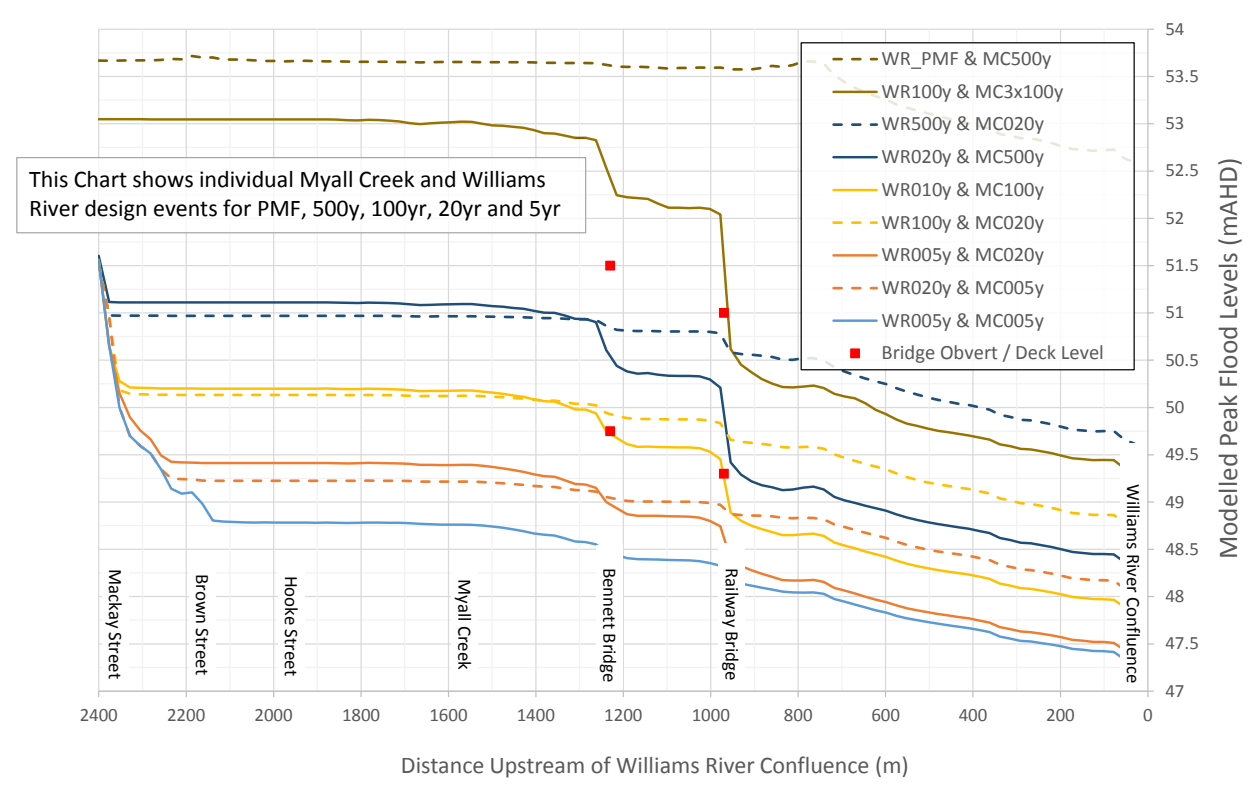

Figure 4-3: Longitudinal Profiles for a Range of Coincident Myall Creek and Williams River Design Events

Note: the location of the longitudinal section is presented in **Figure 4-1**

4.1.2 Peak Flood Levels

A summary of peak flood levels in the Dungog tailwater is presented in **Table 4-2** while flood profiles for seven design events and the April 2015 event are presented in **Figure 4-4**.

Table 4-2: Design Peak Water Levels in Dungog Tailwater (from RHDHV, 2017)

Design Conditions AEP / ARI	Hooke St Peak Flood Level (m AHD)
20% / 5yr	48.78
5% / 20yr	49.41
2% / 50yr	49.82
1% / 100yr	**50.2**
0.5% / 200yr	50.64
0.2% / 500yr	51.11
PMF	53.65
April 2015	51.98

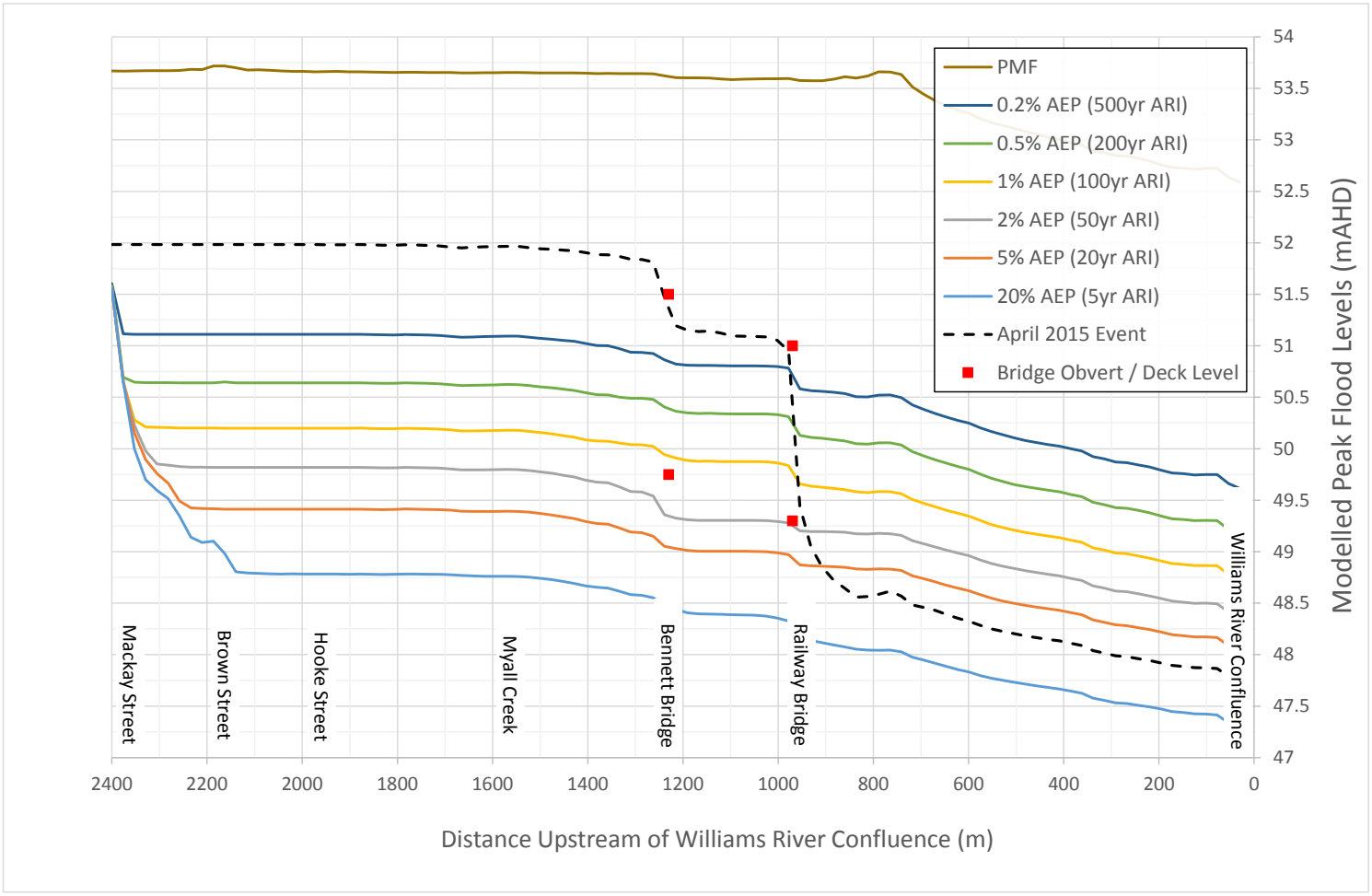

Figure 4-4: Town Drain and Myall Creek Long Section (Peak Flood Level for 7 Design Events)

4.2 Property Inundation and Flood Damages Assessment

A flood damage assessment has been undertaken to identify flood affected property, to quantify the extent of damages in economic terms for existing flood conditions (see below) and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis (as detailed in **Section 6.4**). The general process for undertaking a flood damages assessment incorporates:

- Identifying properties subject to flooding;
- Determining depth of inundation above floor level for a range of design event magnitudes;
- Defining appropriate stage-damage relationships for various property types/uses;
- Estimating potential flood damage for each property; and
- Calculating the total flood damage for a range of design events.

4.2.1 Property Database

A property database was established containing information regarding flood liable properties. The database contains the required information to carry out the flood damages assessment including:

Location Data: The locations of flood affected properties were determined by examining Council cadastre information and detailed aerial photography. Using a GIS system property data could be efficiently extracted into the property database. A total of 172 properties were identified as falling within the PMF. However, it should be noted that a small number of these properties did not experience under or above floor flooding. It should be noted that the database represents the catchment as at July 2016 when the survey was undertaken. As such it excludes any properties that were destroyed during the April 2015 event, but does include the six Alison Court properties that Council (in early 2017) agreed to demolish.

Land Use: For the purposes of the flood damage assessment, property was considered as either residential or non-residential (i.e. commercial or government). Commercial and Government (i.e. Libraries, Community Halls, etc.) properties have been identified from the property survey. Public infrastructure and utility assets (i.e. pumping stations, electricity sub-stations, etc.) have been excluded from the damages assessment.

Ground and Floor Level Data: A floor level survey of identified property within the PMF flood extent was undertaken by Marshall Scott Surveyors. The survey provided: building floor level, geographic coordinates, building classification (i.e. residential, commercial or Government), year constructed, number of stories, construction type (i.e. brick or weatherboard), foundation type (slab on ground or piers) and photographic record to identify property type. Ground level data was based on the DEM.

The distribution of surveyed properties within the study area with reference to the PMF flood extent is shown in **Figure 2-2**.

Flood Level Data: The design flood levels across the catchment were adopted from the Dungog Flood Study (Royal HaskoningDHV, 2017). The flood modelling results were used to generate a continuous flood profile across the floodplain. Flood levels calculated from the TUFLOW model were queried from TUFLOW's GIS output at each property reference point, creating a property specific flood level. The resulting flood level is then used to determine a depth of flooding above the floor level or ground level. This depth of flooding is then used to calculate a property specific flood damage estimate using the adopted damage curve.

4.2.2 *Property Inundation Assessment*

A summary of the location and frequency of above floor property inundation in Dungog is presented in **Figure 4-6** and **Table 4-3**. The assessment shows that:

- in an extreme flood (i.e. the PMF), 122 properties in Dungog are inundated above floor level. Of these properties, 89 (~70% of properties) are in the Myall Creek tailwater area, 12 ((~10% of properties) are on the Williams River floodplain, 9 are adjacent to Common Creek and 12 are affected by overland flooding from the Dungog Township local catchment.
- In the rare, 0.2% AEP (500yr ARI) event, 46 properties in Dungog are inundated above floor level. Of these properties, 41 (89% of properties) are in the Myall Creek tailwater area, 4 (9% of properties) are on the Williams River floodplain and 1 property is flooded above floor level in the Dungog Township local catchment.
- In the 1% AEP (100yr ARI) event, 22 properties in Dungog are inundated above floor level. Of these properties, 20 (91% of properties) are in the Myall Creek tailwater area, 1 is on the Williams River floodplain and 1 property is flooded above floor level in the Dungog Township local catchment.
- In the 5% AEP (20yr ARI) event, 9 properties in Dungog are inundated above floor level. Of these properties, 8 (91% of properties) are in the Myall Creek tailwater area and 1 is on the Williams River floodplain and no properties are flooded above floor level in the Dungog Township local catchment.
- With the exception of the 20% AEP (5yr ARI), in which 2 out of the 3 inundated properties are classified non-residential (i.e. commercial), in all other design events, residential properties make up 80-90% of the above floor inundated properties.
- The analysis shows that in the April 2015 event, 69 properties in Dungog were inundated above floor level. Of these properties, 59 were in the Myall Creek tailwater area, 9 are adjacent to Common Creek and 1 property experienced above floor flooding in the Dungog Township local catchment. It should be noted that this analysis does not include the 5 properties near Bennett Bridge that were destroyed during the event. It also excludes one severely flooded property on Hooke Street that was demolished shortly after the flood event.

Table 4-3: Summary of Above Floor Property Inundation by Flood Mechanism and Property Type

AEP / ARI	Study Area (i.e. Total)	Myall Creek Tailwater	Williams River	Common Creek	Dungog Township	Residential	Non-Residential
PMF	122	89	12	9	12	102	20
0.2% / 500yr	46	41	4	0	1	42	4
0.5% / 200yr	32	30	1	0	1	28	4
1% / 100yr	**22**	**20**	**1**	**0**	**1**	**18**	**4**
2% / 50yr	14	12	1	0	1	12	2
5% / 20yr	9	8	1	0	0	7	2
20% / 5yr	3	3	0	0	0	1	2
April 2015	69	59	0	9	1	60	9

For events above the 2% AEP (50yr ARI), typically a further 14-19 properties may experience below floor flooding. A summary of the number of properties that experience underfloor (or near house) flooding is presented in **Table 4-7**.

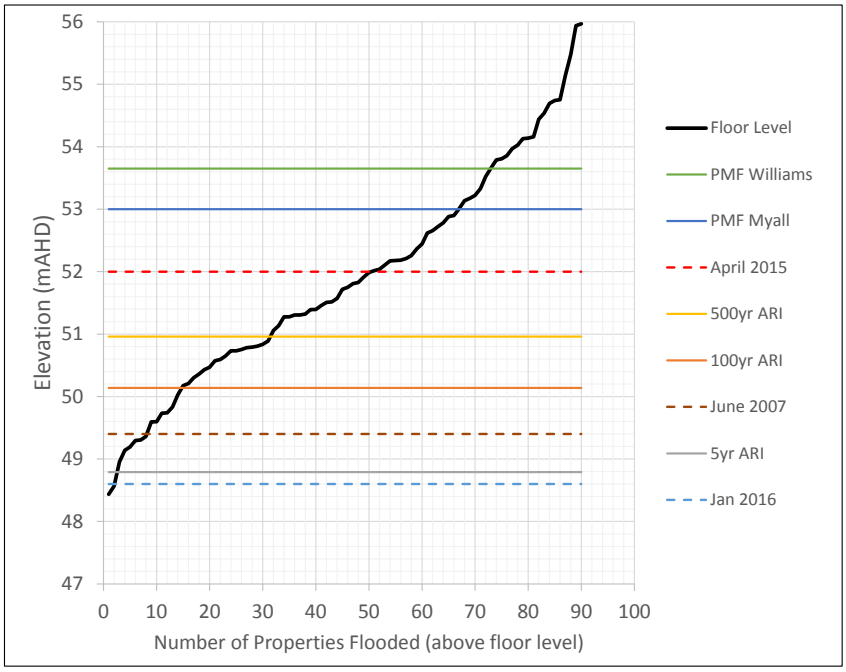

Figure 4-5: Flood Stage vs Property Floor Levels (Dungog Tailwater)

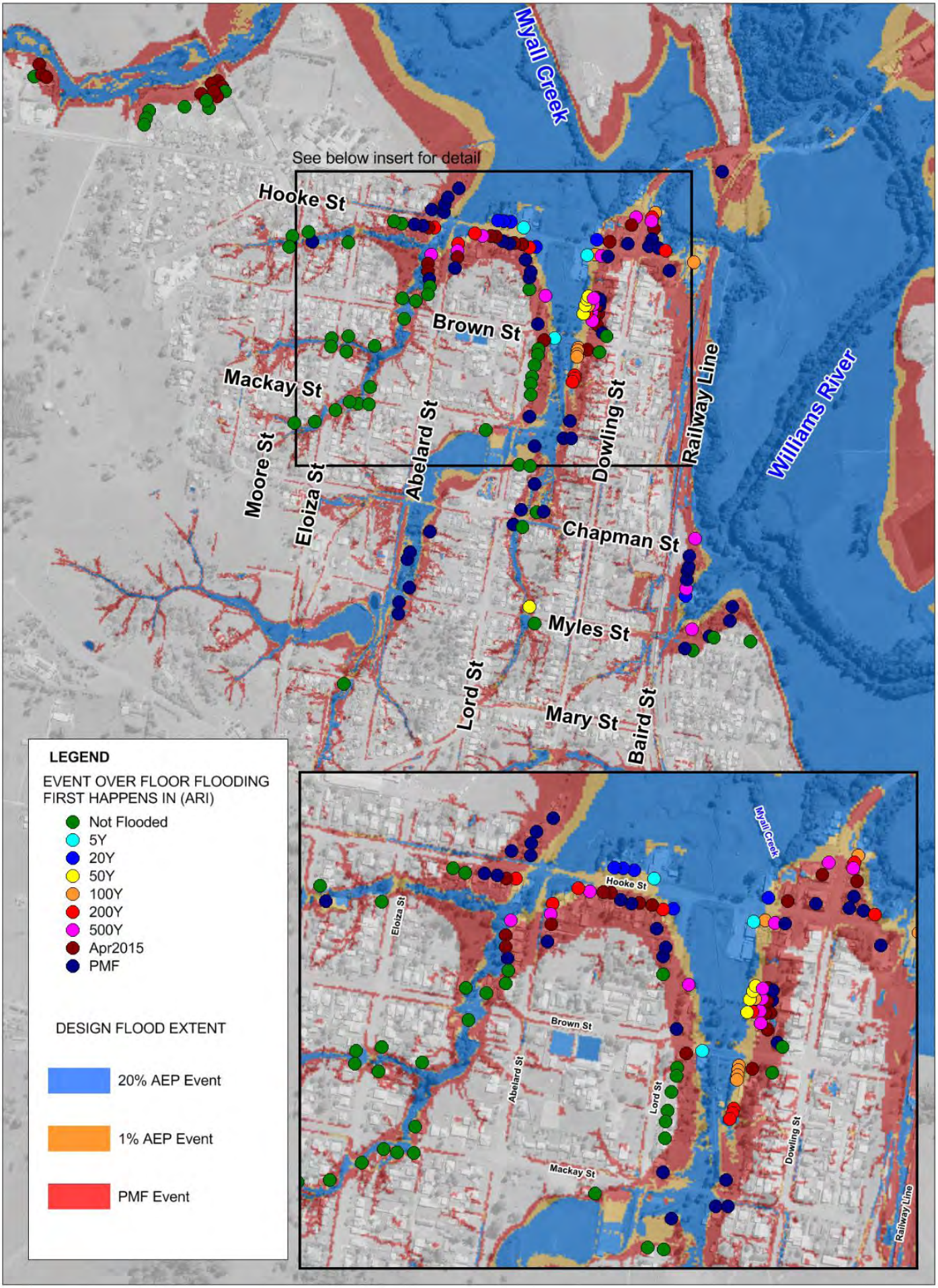

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FIGURE 4-6

LOCATION AND FREQUENCY OF ABOVE FLOOR FLOODING IN DUNGOG

NORTH

0 125 250m
Approx. Scale

SCALE 1:12,500

PAGE SIZE A4

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4.2.3 *Flood Damages Assessment*

Background

Flood damages are typically divided at the primary level, into tangible and intangible damages and at a secondary level, as direct and indirect damages. Tangible damages are those for which a monetary value can easily be assigned, while intangible damages are those to which a monetary value cannot easily be attributed and arise from social and environmental effects caused by flooding including factors such as: loss of life and injury, inconvenience, disruption of family and social activities, stress, anxiety and physical and psychological ill-health.

Tangible damages may be direct or indirect flood damages. Direct damages are directly attributed from the actions of flooding (inundation and flow, on property and structures), while indirect damages arise from the disruptions to physical and economic activities caused by flooding. Examples of indirect damages include: losses due to the disruption of business, expenses of alternative accommodation, disruption of public services, emergency relief aid and clean-up costs. This study only attempts to calculate tangible, direct damages which is appropriate for the comparison of mitigation options.

Given the variability of property and contents values, the total likely damages figure in any given flood event is approximate only and while useful to gauge the magnitude of the flood problem, it is of little value for absolute economic evaluation. Given that the primary purpose of the flood damages estimates are to evaluate the economic effectiveness of proposed mitigation options, the methods used are considered appropriate.

The Average Annual Damage (AAD) is the main comparative factor that is derived from this flood damages assessment with which to evaluate the effective of proposed mitigation options. The AAD represents the estimated tangible damages sustained every year on average over a given 'long' period of time and is determined using the full range of flood events previously considered in the FRMS. The AAD damage calculation considers that in many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain management measure (i.e. the reduction in the AAD) as presented in **Section 6**.

Damages Methodology

The estimates of flood damages for Dungog were prepared following the guidelines detailed in: 'Floodplain Risk Management Guideline: Residential Flood Damages' (DECCW, 2007).

The DECCW method utilises separate stage-discharge curves for different residential building types. In the flood damages assessment all residential properties were categorised as either slab on ground, single story high set, or two storey as per DECCW recommendations. The relevant building type was determined using the property database developed for the study.

The DECCW residential curves are based on various input data including CPI, regional cost factor, flood awareness, flood warning time, typical cost of contents, typical building footprint and insurance. For high-set houses, there is some accommodation for damages associated with flooding beneath the floor level, as this space is often used for storage. The DECCW method accounts for a combination of direct and indirect damages including allowances for clean-up costs and alternative accommodation. For this assessment, the parameters as presented in **Table 4-4** were used:

Table 4-4: Damages Assessment Parameters

Parameter	Value Adopted
Post November 2001 adjustment factor	**1.70** (average weekly earnings at February 2017)
Regional Cost Variation factor	**1.25** (Rawlinsons 2016)
Post Flood Inflation Factor	**1.50**
Flood Level Awareness	**Low**
Effective Warning Time	**0 hours** (There is no warning system on Myall Creek)

Results of Damages Assessment

The results of the damages assessment is presented in:

- **Table 4-5**, which presents a summary of flood damages ($) by flood mechanism and property type;
- **Table 4-6**, which presents the above data showing the percentage flood damages by flood mechanism and property type; and
- **Table 4-7,** which summarises the flood damages in terms of each events contribution to the annual average damage (AAD) quantity (as previously described) and also defines how many properties are inundated in a given event.
- **Table 4-8**, provides a summary of net present value (NPV) calculations which uses the AAD value to calculate the total damages over a 50 year forward timeframe in term of today's costs for a range of discount factors

A number of key points regarding flood damages for the existing conditions include:

- In the 1% AEP (100yr ARI) event, it is estimated that $2.4 Million of tangible flood damages would occur in Dungog. The majority (i.e. 90%, $2.2 Million) of these damages are attributed to the Myall Creek (i.e. tailwater) flood mechanism. In the 1% AEP event, flood damages from the Williams River are estimated to be $112,000 while the local township catchment is estimated to cause $123,000 of flood damage. In the Common Creek catchment no damages are calculated to occur as all properties were built above the 1% AEP flood level.
- In the 1% AEP (100yr ARI) event, residential properties make up 80% (i.e. $1.8 Million) with non-residential (i.e. either: Commercial, Industrial or Government) properties estimated to incur an estimated $486,300 worth of flood damages.
- With the exception of the PMF event, typically 90% of flood damages occur in the Dungog tailwater area which is due to the Myall Creek backwater flood mechanism.
- In the April 2015 superstorm, flood damages of $9.0 Million were calculated for Dungog. This is approximately half the near $18 Million flood damages predicted to occur in the PMF.
- With the exception of the 20% AEP (5yr ARI), residential properties make up 74% or more of the flood damage costs.

A summary of flood damages (AAD Contribution) and property inundation is presented in **Table 4-7** and shows:

- That the two "minor" 20% and 5% AEP (i.e. 5yr and 20yr ARI) events, which only flood up to 16 properties (and only 9 above floor level), contribute over 50% of the damages in the AAD value.
- While the PMF floods 122 properties above floor level, many to a significant depth, due to the low probability of such an event, it only contributes 10% of damages to the AAD value.

A calculation of the average annual damages (AAD) costs for Dungog shows that over a sufficiently long period of time (in which the full range of design floods occurs) flood damages average out to $230,000 per year. If there was no inflation, then at the end of a 50 year timeframe it is estimated that there would be a total of $11.5 Million damages in Dungog. As economic theory shows that todays $11.5 Million dollars, will not buy $11.5 Million dollars of goods in 50 years' time, it is important to carry out a net present values (NPV) calculation to understand the cost of covering future damages in terms of dollars now. Adopting a 7% discount rate (which is typical for this type of study and the likely future economic conditions) shows that over a 50 year time frame, the damages in today's dollars is reduced to $3.4 Million. **Table 4-8** shows the impact on the NPV calculation of adopting a higher or lower discount rate. This 7% discount rate was adopted for the assessment of mitigation option presented in **Section 6**.

Table 4-5: Summary of Flood Damages by Flood Mechanism and Property Type

AEP / ARI	Study Area (i.e. Total)	Myall Creek Tailwater	Williams River	Common Creek	Dungog Township	Residential	Non-Residential
PMF	$17,807,232	$13,925,732	$1,793,611	$962,095	$1,125,794	$15,241,416	$2,565,816
0.2% / 500yr	$5,465,815	$4,966,171	$367,540	$0	$132,104	$4,777,701	$688,114
0.5% / 200yr	$3,699,482	$3,362,719	$213,861	$0	$122,902	$3,142,883	$556,599
1% / 100yr	**$2,413,193**	**$2,174,372**	**$111,817**	**$0**	**$127,004**	**$1,926,893**	**$486,300**
2% / 50yr	$1,520,873	$1,353,904	$94,410	$0	$72,559	$1,207,045	$313,827
5% / 20yr	$872,226	$757,708	$47,059	$0	$67,459	$642,381	$229,845
20% / 5yr	$253,173	$232,773	$0	$0	$20,400	$72,559	$180,614
AAD	**$230,134**	**$203,651**	**$10,519**	**$957**	**$15,006**	**$152,390**	**$77,744**
April 2015	$9,065,789	$7,962,386	$5,100	$966,198	$132,104	$7,814,539	$1,251,250

Table 4-6: Summary of Percentage Flood Damage by Flood Mechanism and Property Type

AEP / ARI	Study Area (i.e. Total)	Myall Creek Tailwater	Williams River	Common Creek	Dungog Township	Residential	Non-Residential
PMF	$17,807,232	78%	10%	5%	6%	86%	14%
0.2% / 500yr	$5,465,815	91%	7%	0%	2%	87%	13%
0.5% / 200yr	$3,699,482	91%	6%	0%	3%	85%	15%
1% / 100yr	**$2,413,193**	90%	5%	0%	5%	80%	20%

AEP / ARI	Study Area (i.e. Total)	Myall Creek Tailwater	Williams River	Common Creek	Dungog Township	Residential	Non-Residential
2% / 50yr	$1,520,873	89%	6%	0%	5%	79%	21%
5% / 20yr	$872,226	87%	5%	0%	8%	74%	26%
20% / 5yr	$253,173	92%	0%	0%	8%	29%	71%
AAD	**$230,134**	88%	5%	0%	7%	66%	34%
April 2015	$9,065,789	88%	0%	11%	1%	86%	14%

Table 4-7: Summary of Flood Damages (AAD Contribution) and Property Inundation

AEP / ARI	Total Damages	Contribution to AAD ($)	Contribution to AAD (%)	Cumulative Contribution to AAD (%)	Properties Above Floor	Properties (Underfloor / Grounds)
PMF	$17,807,232	$23,335	10%	100%	122	138
0.2% / 500yr	$5,465,815	$13,748	6%	90%	46	65
0.5% / 200yr	$3,699,482	$15,282	7%	84%	32	50
1% / 100yr	**$2,413,193**	$19,670	9%	77%	22	41
2% / 50yr	$1,520,873	$35,896	16%	69%	14	28
5% / 20yr	$872,226	$84,405	37%	53%	9	16
20% / 5yr	$253,173	$37,976	16%	16%	3	8
AAD	-	**$230,134**	100%		-	-
April 2015	$9,065,789	-	-		69	94

Table 4-8: Summary of NPV of Damages over 50 Years for a Range of Discount Factors

Discount Factor	NPV of Damages over 50 Years
0%	$ 11,506,700
4%	$ 5,173,917
7%	$ 3,406,156
11%	$ 2,310,927

4.3 Road & Rail Inundation Assessment

An assessment of potential road and rail inundation during flood events has been undertaken to assist in the formulation of effective evacuation strategies.

Chichester Road – access for Chichester Dam and a number of small localities such as Bendolba, and Bandon Grove. The two low flooded locations on Hooke Street can be avoided by alternate routes along the higher western side of Dungog. The bridge over Common Creek has a deck level of approximately 54.5mAHD and is only flooded in the PMF. However, the bridge

crossings at Sugarloaf Creek and Myall Creek are outside the model domain so could not be assessed in this study.

Bennett Bridge Approach (Myall Creek) – low point is 49.4m AHD. In the 50yr ARI the road is just overtopped (< 100mm) and likely to be for less than 1 hour. In the 100yr ARI, the road is inundated to a depth of 0.6 m (WL = 50.0mAHD) at high velocity for 2-6 hours.

Coorei Bridge Approach (Williams River) – low point is 48.5m AHD. Inundation occurs in the 5yr ARI with the road overtopped by ~0.3-0.5m and inundation could be for 2-24 hours.

Railway (Williams River) – low point is 50.8m AHD. Inundation occurs in the 50yr ARI with the western bank overtopped by ~0.2-0.3m and inundation could be for 2-24 hours.

Railway (Myall Creek) – low point is 50.8m AHD. Inundation would only occur for events greater than the 500yr ARI Myall Creek design event, however, the Williams River crossing is more easily inundated from Williams River events.

Hooke Street (Dungog tailwater) – The lowest point on Hooke Street (between Lord and Dowling Streets) is just 46.5 m AHD and is inundated by over 2 m of water in the 5yr ARI event. There is another low area on Hooke Street at the Abelard Street intersection where the road level is 49.0mAHD and could be inundated by ~0.1m in the 5yr ARI event. As the key flood mechanism at this location is tailwater flooding from Myall Creek road closures of up to 24 hours could occur. However, the gridded road layout in Dungog, means that alternate (generally) flood free routes are available.

Brown Street (Dungog tailwater) – The lowest point on Brown Street (between Lord and Dowling Streets) is 49.0 m AHD and would just be overtopped by local catchment runoff in the 5yr ARI event. In the 100yr event this location would be inundated by over 1m of water. Again a road closure of up to 24 hours could occur, however, alternate routes are available.

Mackay Street (edge of Dungog tailwater) – The lowest point on Mackay Street (between Lord and Dowling Streets) is 51.2 m AHD so would only affected by tailwater flooding for events greater than the 500yr ARI. However, the road is inundated by 0.1-0.4m of fast moving, shallow flows from the local catchment in events which exceed the under road culvert capacity.

Local Catchment Road Closures – Other road closures in the Dungog Township catchment are possible. However, closures are likely to be limited to 1-2 hours and flow depths would generally be less than 0.5m (mostly 0.1-0.2m) though high velocity flood flows would make road crossing hazardous to all but large tractors, trucks and 4WDs. Roads higher up in the local catchment such as Mary Street and Eloiza Street would be generally less flood affected.

4.4 Hydraulic Categorisation

The Floodplain Development Manual (NSW State Government, 2005) defines three hydraulic categories; the floodway, flood storage and flood fringe. The floodway describes areas where a significant volume of water flows during floods and if only partially blocked would cause a significant increase in flood levels and/or a significant redistribution of flood flow. Floodway's are often areas with deep flows with high velocities. Flood storage describes areas on floodplains that are important for temporary storage of floodwaters during a flood. If the capacity of the flood storage area is substantially reduced by factors, such as development, flood levels in nearby

areas may rise and increase the peak discharge downstream. The flood fringe is the remaining area of flood affected land.

The Dungog Flood Study (Royal HaskoningDHV, 2017) determined the hydraulic categories for the 5% AEP, 1% AEP and PMF as presented in the Map Compendium (Appendix A).

4.5 True Flood Hazard Classification

The Draft Dungog Flood Study (Royal HaskoningDHV, 2017) defined the provisional hydraulic hazard based on the methodology outlined in Appendix L of the NSW Floodplain Development Manual (NSW State Government, 2005). This approach used a depth-velocity relationship to define areas as high and low hazard.

The current FRMS&P proposes to use the flood hazard curves proposed by Smith et al. (2014) and recommended by the Australian Emergency Management Institute (AEMI). This approach provides a range of hazard classifications which increase in severity based on the safety threat posed to vehicles, people and buildings. These classifications and the corresponding flood hazard curves are shown in **Table 4-9** and **Figure 4-7** respectively.

Table 4-9: Hazard Classifications

Hazard Classification	Description
H1	*No vulnerability constraints*
H2	Unsafe for small vehicles
H3	Unsafe for all vehicles, children and the elderly
H4	Unsafe for all people and all vehicles
H5	Unsafe for all people and all vehicles. Buildings require special engineering design and construction
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

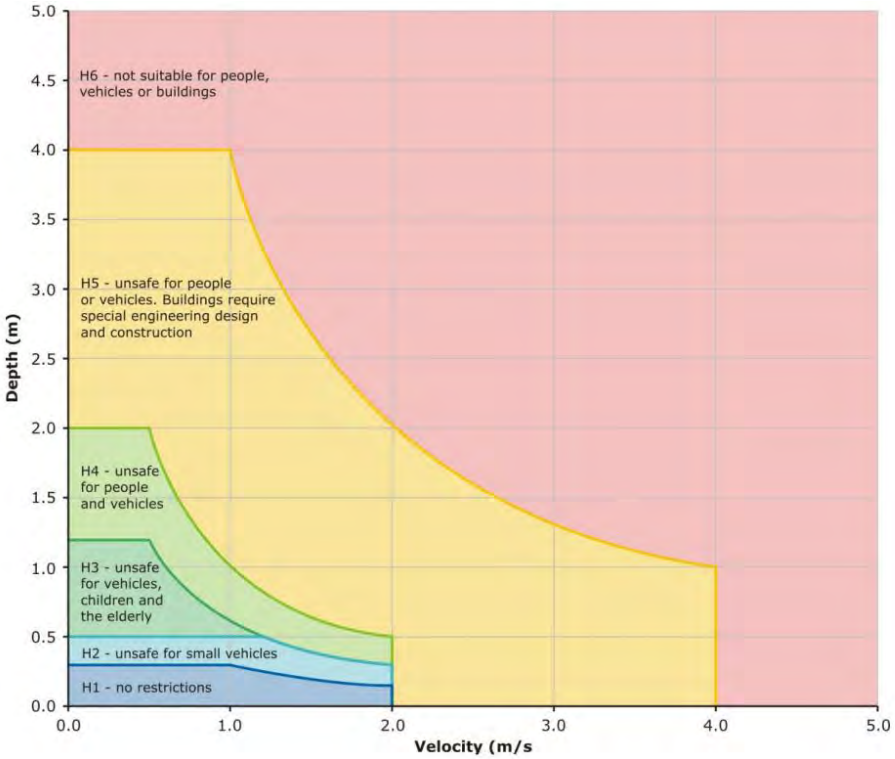

Figure 4-7: Combined Flood Hazard Curves (Smith et. al. 2014)

In conjunction with considering the hydraulic hazard using the flood depths and velocities from the hydraulic model, it is important to consider other criteria such as: size of the flood, effective warning time, flood readiness, rate of rise of floodwaters, depth and velocity of floodwaters, duration of flooding, evacuation problems, effective flood access and type of land use. These factors are assessed in **Table 4-10**.

Table 4-10: Hazard Assessment of Variables

Criteria	Weight	Comment
Size of the flood	Medium	The magnitude of a flood affects the depths and velocities produced in an event. Low flood hazard typically is associated with more frequent flood events while high hazard flows usually occur during rare (major) flood events. Typically, flood affectation in Dungog tailwater increases significantly for rare events.
Depth and velocity of floodwaters	High	The flood hazard is related to the product of depths and velocity of flood waters which are influenced by the size of the flood. In Dungog tailwater velocity is low while depths are very high. Overtopping of Dowling Street adjacent to Bennett Bridge can result in very high velocity flood flows.
Rate of rise of floodwaters	Medium	The rate of rise of floodwaters is influenced by the catchment size, soil type, slope and land use. The spatial and temporal pattern of the rainfall is also related to the rate of rise. The rate of rise in the study area for the local and Myall Creek catchments can be quite rapid due to the relatively small catchment size and shape of these catchments. The Williams River

Criteria	Weight	Comment
		catchment carries flow from a much larger upstream catchment and as such the rate of rise is considerably slower.
Duration of flooding	Low	Typically, the longer the duration of flooding, the more disruption caused to the community and greater the potential flood damages. The duration of flooding from the Williams River can be long, 12-48 hours, while flooding from the Myall Creek is shorter 6-24 hours, and local catchment flooding is likely to be 1-5 hours.
Effective warning and evacuation time	Medium	Flood warning and evacuation is subject to the rate of rise, the flood awareness of the community and availably of a flood warning system. While there is a flood warning system for the Williams River, there is currently no warning system for the Myall Creek or local catchment. While a flood warning system for the Myall Creek should be developed within 1-2 years, the local catchment is too small for a warning system to be of use.
Flood awareness and readiness of the community	Low	Flood awareness in the community is likely to be quite high due to the recent April 2015 flood event. However, ongoing community education will be required to ensure awareness and readiness are maintained in the future.
Effective flood access	Medium	Effective flood access is affected by depths and velocities of floodwaters, evacuation distance, the number of people using the evacuation route and effective communication. In the study area a number of streets could be inundated by floodwaters in larger events and consideration of evacuation timing is important. Flood access and evacuation issues are further discussed in Section 7.
Evacuation problems	Medium	Some flood prone areas are likely to experience evacuation problems in the catchments due to the rapid rate of rise of a flood event, the limited flood warning time and the demographics of the community. These problems could be further exacerbated by the time of day during which flooding occurs. However, in general most flood affected properties have relatively short evacuation distances. Evacuation is further discussed in Section 7.
Type of development	Medium	The type of development will influence factors such as the level of flood awareness, the mobility of occupants and population density. Long term residents are likely to have a higher level of flood awareness than those visiting the area. Further, mobility and evacuation is more difficult for a school, child care facility or aged care home.

An assessment of the variables presented in **Table 4-10** did not significantly change the flood hazard classifications using the AEMI classifications which are less influenced by these factors than the hazard classifications outlined in Appendix L of the NSW Floodplain Development Manual (NSW State Government, 2005). True flood hazard maps for the 5% AEP, 1% AEP and PMF events are presented in **Figure 4-8**, **Figure 4-9** and **Figure 4-10** respectively.

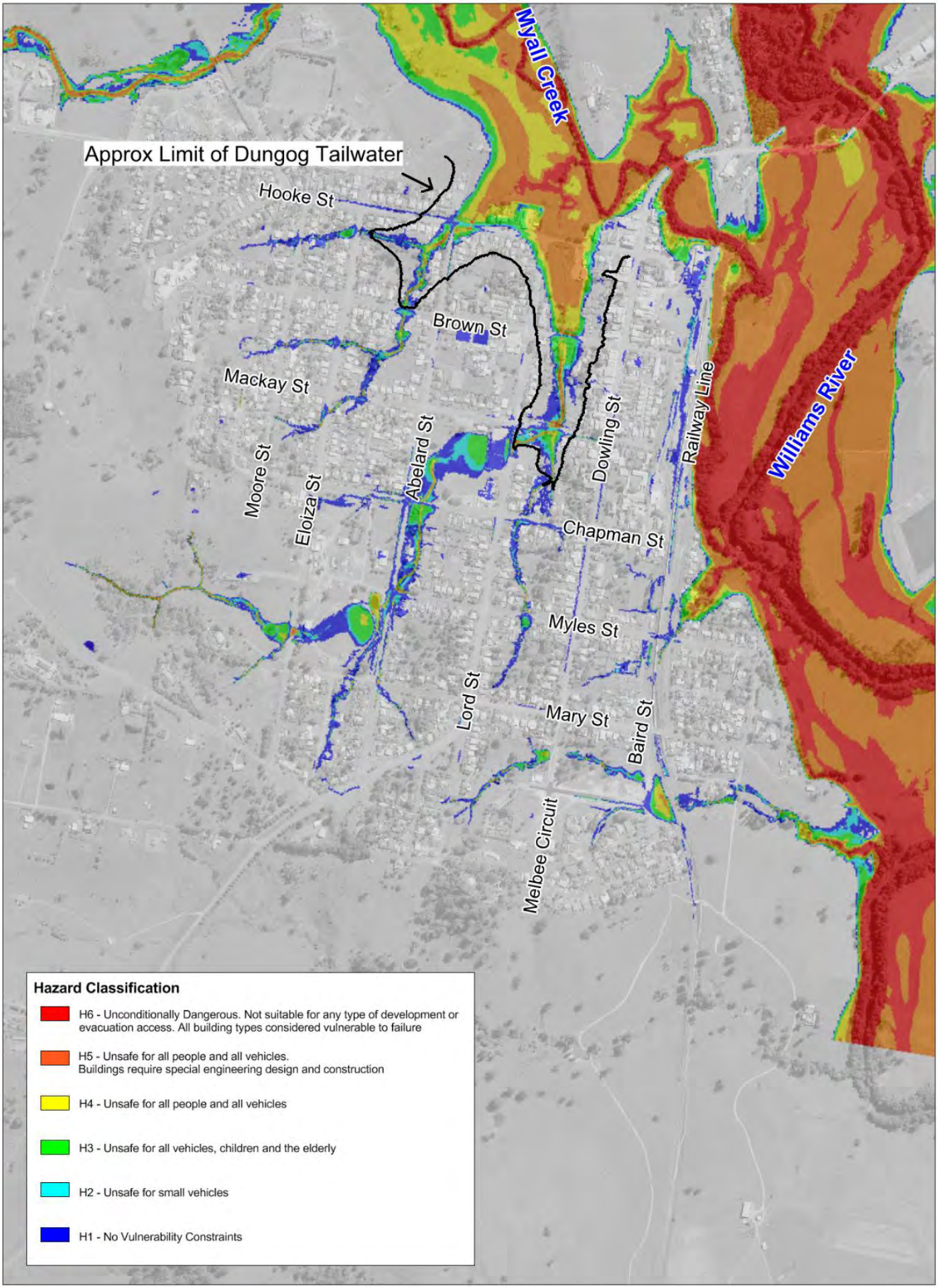

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FIGURE 4-8

COMBINED TRUE FLOOD HAZARD
5% AEP (20yr ARI)

NORTH

0 125 250m
Approx. Scale

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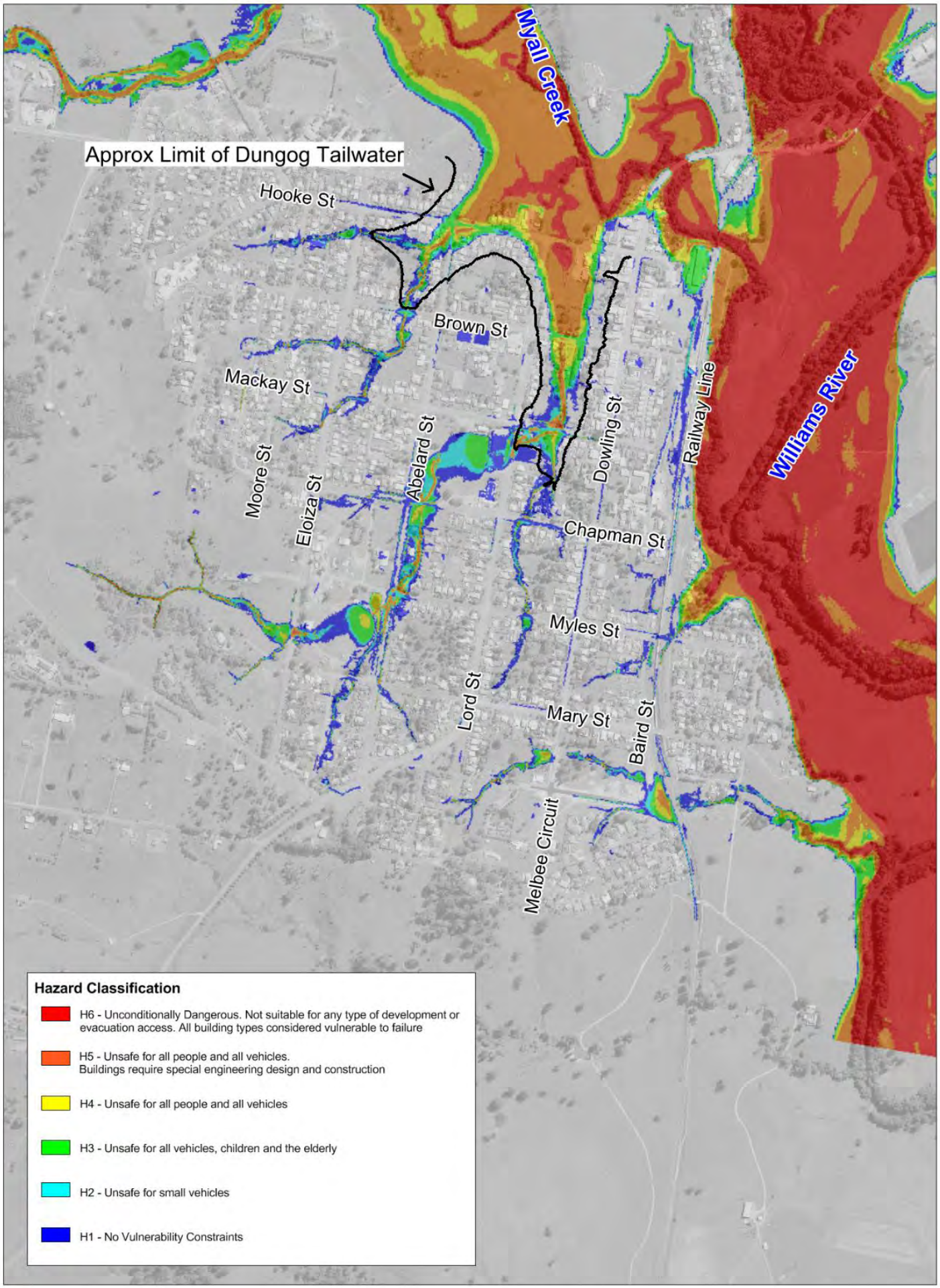

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FIGURE 4-9

COMBINED TRUE FLOOD HAZARD
1% AEP (100yr ARI)

NORTH

0 125 250m
Approx. Scale

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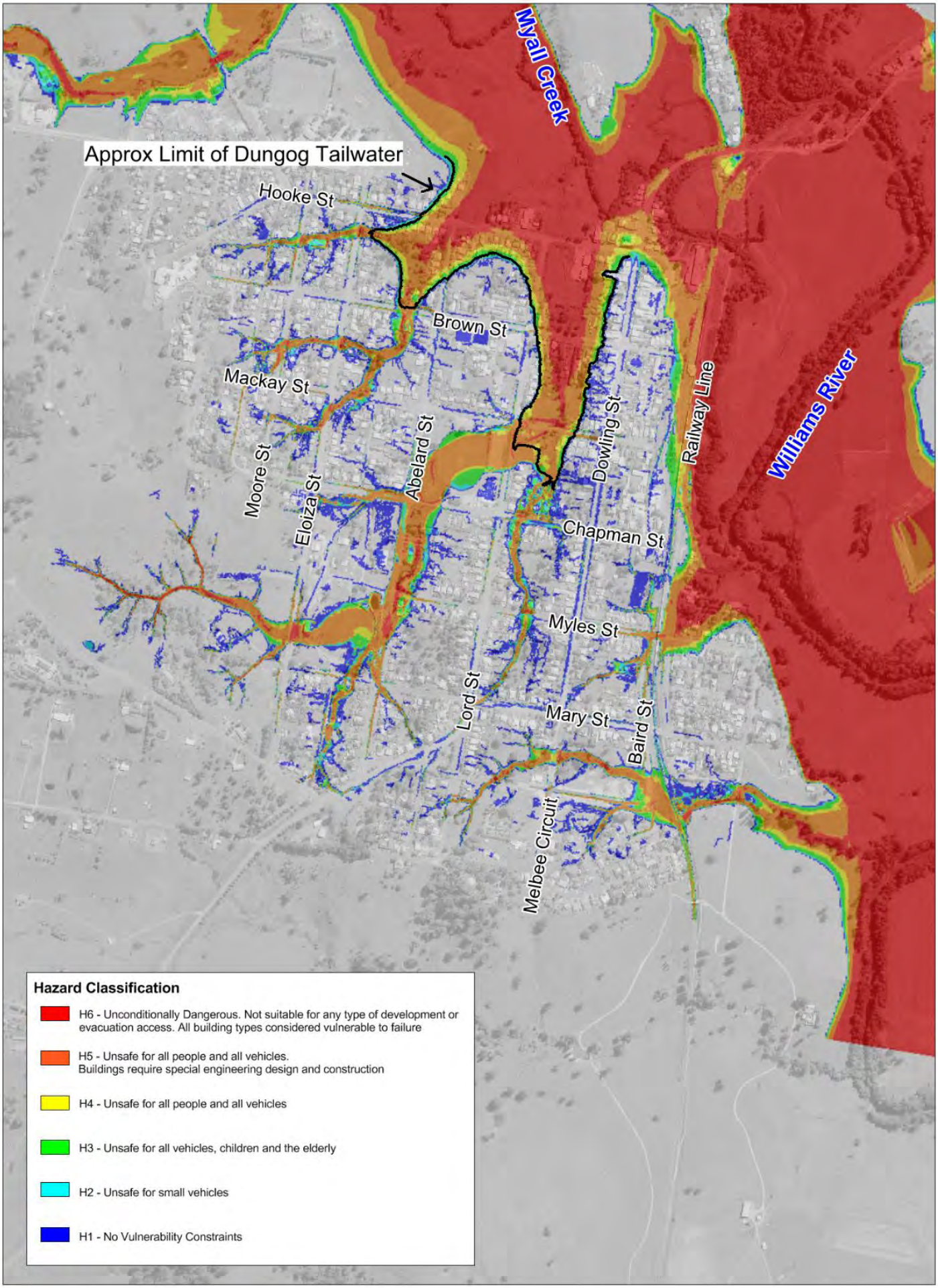

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FIGURE 4-10

COMBINED TRUE FLOOD HAZARD
PMF (EXTREME EVENT)

NORTH

0 125 250m
Approx. Scale

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4.6 Access and Evacuation Constraints (ERP Classification)

A key part of emergency planning and effective evacuation is identifying the barriers to flood access and implementing plans to overcome this. The majority of the study area has ease of egress to higher flood free areas, however the access routes to a number of key locations are likely to become inundated rapidly by floodwaters and as such encounter some evacuation difficulties. These key locations are listed below:

- ***Area 1:*** Properties between 44 and 62 Hooke Street may need to evacuate up the driveway of 60 Hooke Street (towards the grounds of the St Joseph Catholic School) due to road inundation.
- ***Area 2:*** the units at 30 Brown Street (Johnsons Flats) are raised above the floodplain, which means these units should be evacuated early to avoid the residents becoming trapped while "sheltering in place".

The NSW SES in collaboration with OEH developed the Flood Emergency Response Planning (ERP) classifications (NSW State Government, 2007) to categorize communities according to the ease of evacuation. These guidelines assist the planning and implementation of response strategies. These classifications are determined by analysis of inundation of land, road and overland evacuation routes. Communities are classified as Flood Islands, Rising Road Access, Overland Escape Route, Trapped Perimeter Areas or Indirectly Affected areas.

The Flood ERP Guidelines present these classifications in relation to operational functions such as resupply, rescue and evacuation shown in **Table 4-11**.

Table 4-11: Response Required for Difference Flood ERP Classifications

Classification	Response Required		
	Resupply	Rescue / Medivac	Evacuation
High Flood Island	Yes	Possibly	Possibly
Low Flood Island	No	Yes	Yes
Area with Rising Road Access	No	Possibly	Yes
Areas with Overland Escape Routes	No	Possibly	Yes
Low Trapped Perimeter	No	Yes	Yes
High Trapper Perimeter	Yes	Possibly	Possibly
Indirectly Affected Areas	Possibly	Possibly	Possibly

ERP classifications were determined for areas within the 1% AEP and PMF extents in the Study Area. These classifications are shown in **Figure 4-11** for the 1% AEP and **Figure 4-12** for the PMF event.

In the 1% AEP event, egress to flood free land is available for most of the study area. These areas will have flood free access to emergency services and other vital facilities. Of note are the two isolated areas classified as Low Flood Islands, previously described. Emergency Services (such as the SES) should be aware of the risk of isolation of these areas and the necessary actions (such as evacuation and/or shelter-in-place) outlined in their Local Flood Plan.

In the PMF event, the same two areas of the study area are classified as Low Flood Islands. These locations are subject to isolation and, subsequently, inundation from flood waters. The rapid rise of very rare to extreme events means that if these areas are not evacuated early, residents who opt to shelter in place may not survive as above ceiling flooding could occur for a number of properties.

Because the final magnitude of an flood event cannot be known until after the event, and the rate of rise is the Dungog tailwater is very high, the evacuation of areas identified in the PMF ERP Classification should occur in all significant flood events (where water levels in the Dungog tailwater are likely to exceed 48.0 m AHD (see **Table 7-2**)).

While the emergency response planning classifications detail broad areas requiring evacuation, this information should be used along with the property inundation assessment provided in **Section 4.2.2**. **Figure 4-6** shows the design flood event a property is first inundated in so provides very useful information to prioritise and schedule property evacuations.

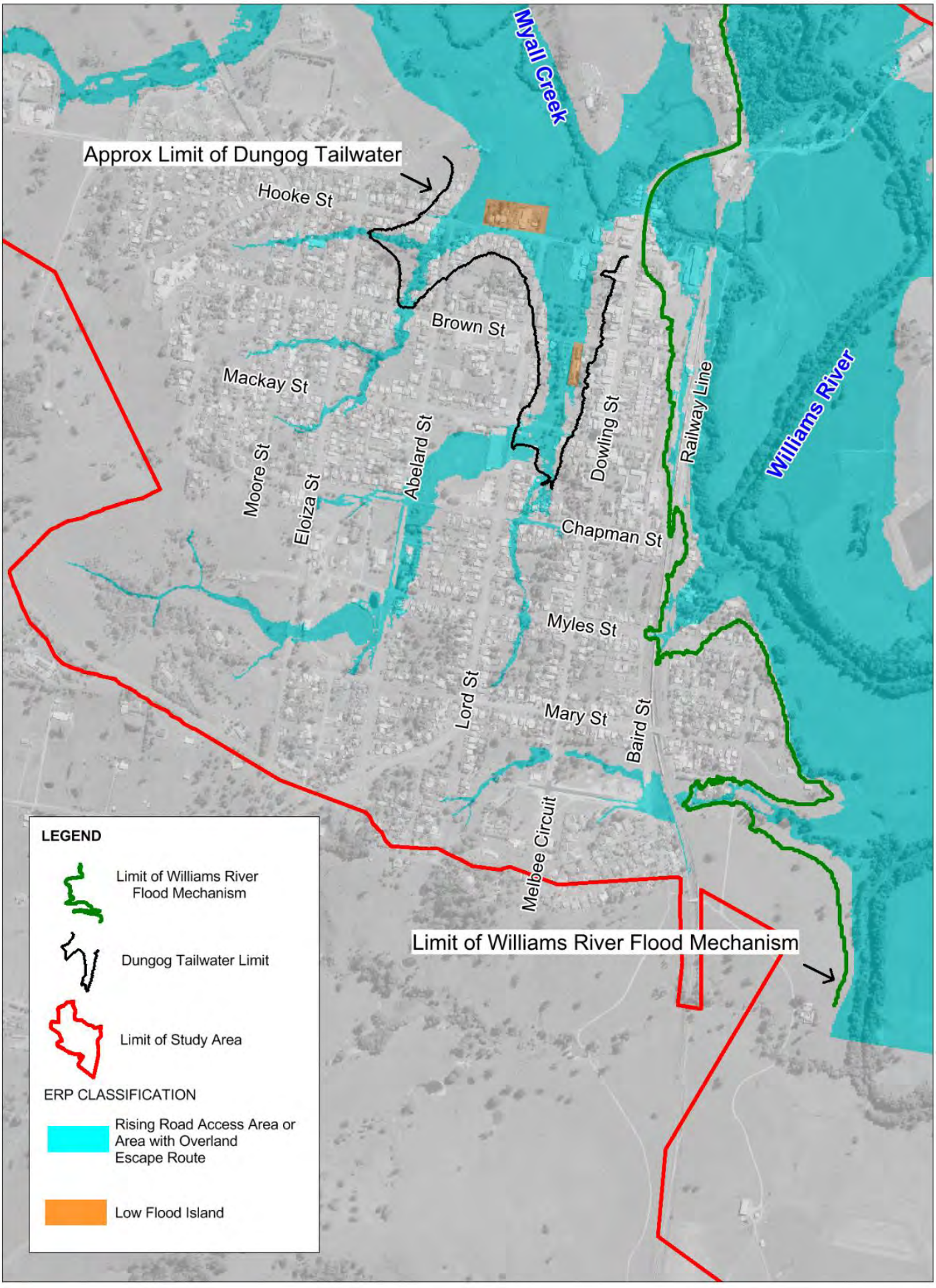

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FIGURE 4-11

ERP CLASSIFICATION
1% AEP (100yr ARI) EVENT

NORTH

0 125 250m
Approx. Scale

SCALE 1:12,500

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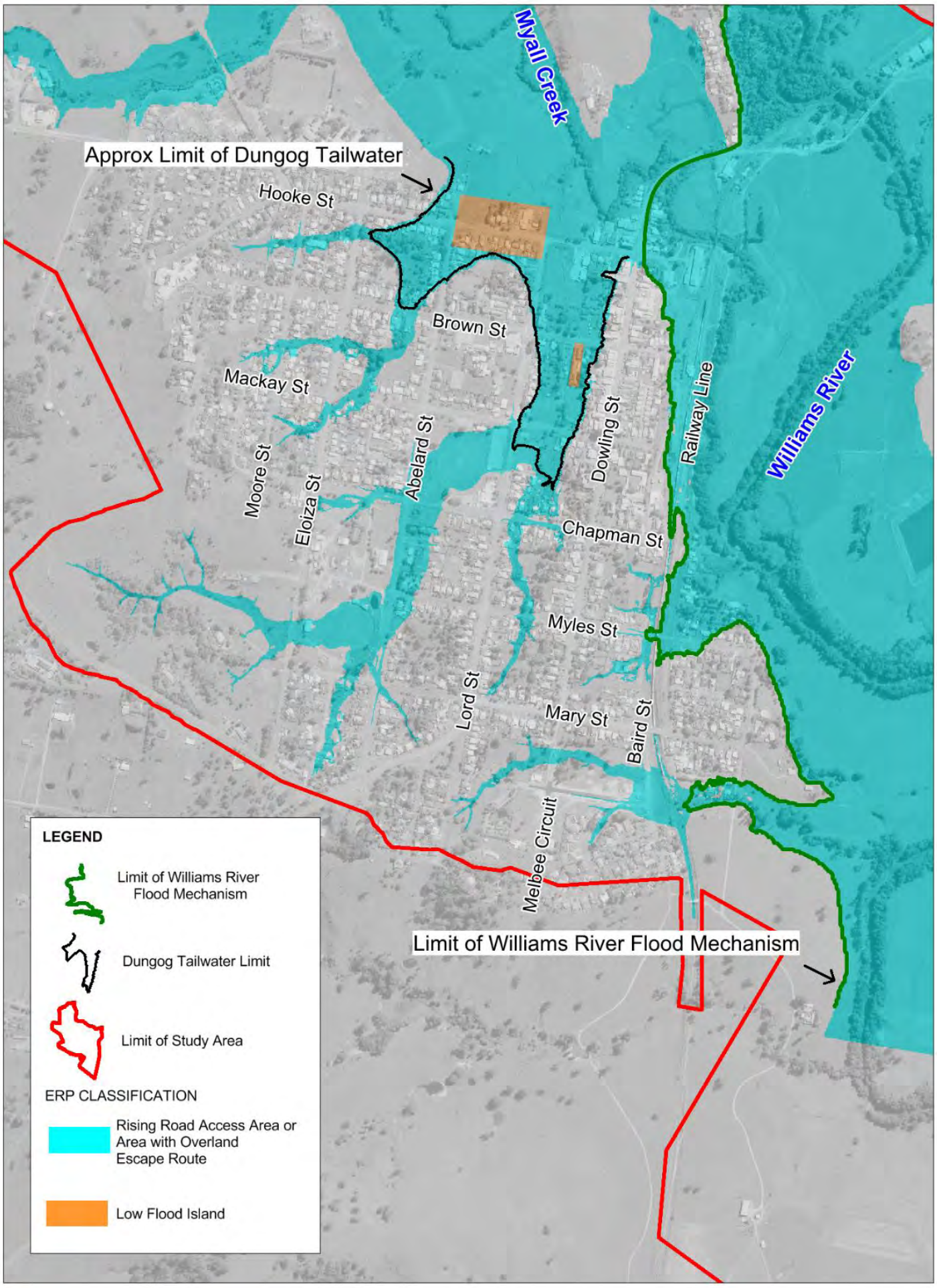

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FIGURE 4-12

ERP CLASSIFICATION PMF (EXTREME EVENT)

NORTH

0 125 250m
Approx. Scale

SCALE 1:12,500

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5 Review of Existing Planning Provisions

Within New South Wales, land use planning and development follows the following hierarchy, in decreasing order of seniority:

- Environmental Planning and Assessment Act (EPA Act)
- State Environmental Planning Policies (SEPP)
- Local Environmental Plans (LEPs)
- Development Control Plans (DCPs)

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of Dungog (as well as across the wider LGA).

In the Dungog LGA, development is controlled through the Dungog Local Environment Plan (LEP) and various Development Control Plans (DCPs). The LEP is a planning instrument which designates land use and development in the LGA, while DCPs regulate development with specific guidelines and parameters.

A review of existing planning controls has been undertaken with the objective to:

- review the existing planning and development control framework relevant to the formulation of planning instruments and the assessment of development applications in flood affected areas, and
- make specific planning recommendations in regards to flood risk management, including an outline of suggested planning controls (refer **Section 5.4**).

5.1 Local Environment Plan

A Local Environmental Plan (LEP) is prepared in accordance with Part 3 Division 4 of the EP&A Act 1979 and operates as a local planning instrument that establishes the framework for the planning and control of land uses. The LEP defines zones, permissible land uses within those zones, and specific development standards and special considerations with regard to the use or development of land.

The Dungog Local Environment Plan 2014 (LEP 2014) (Dungog Shire Council, 2014) has been prepared in accordance with the NSW State Government's Standard Instrument (Local Environmental Plans) Order 2006, which requires local Council's to implement a Standard Instrument LEP. The State Government has created the Standard Instrument LEP to assist in streamlining the NSW Planning system.

5.1.1 Flood Planning (Clause 6.3)

Clause 6.3 of the Dungog Local Environment Plan 2014 relates to development on flood liable land. The LEP provisions incorporate general considerations in regard to development of flood liable land. These provisions require the approval process to consider the impact of proposed development on local flood behaviour, the impact of flooding on the development and the requirements of adopted Floodplain Risk Management Plans that are applicable. Specifically Clause 6.3 states:

1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to:

(a) land identified as "Flood planning area" on the Flood Planning Map, and

(b) other land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

(5) In this clause, **flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

5.1.2 Stormwater management (Clause 6.4)

Clause 6.4 of the Dungog Local Environment Plan 2014 relates to stormwater management. The LEP provisions incorporate general considerations in regard to stormwater impacts. These provisions require the approval process to consider the impact of stormwater on the environment or adjacent properties. Specifically Clause 6.3 states:

(1) The objective of this clause is to minimise the impacts of urban stormwater on land to which this clause applies and on adjoining properties, native bushland and receiving waters.

(2) This clause applies to all land in residential, business and industrial zones.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is designed to maximise the use of water permeable surfaces on the land having regard to the soil characteristics affecting on-site infiltration of water, and

(b) includes, if practicable, on-site stormwater retention for use as an alternative supply to mains water, groundwater or river water, and

(c) avoids any significant adverse impacts of stormwater runoff on adjoining properties, native bushland and receiving waters, or if that impact cannot be reasonably avoided, minimises and mitigates the impact.

5.1.3 Land Use

The Dungog LEP 2014 identifies a number of land use zones including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning. The land use zones under the Dungog LEP 2014 are as follows:

- Rural Zones: RU1 Primary Production, RU3 Forestry and RU5 Village;
- Residential Zones: R1 General Residential and R5 Large Lot Residential;
- Business Zones: B2 Local Centre and B4 Mixed Use;
- Industrial Zones: IN1 General Industrial;
- Special Purpose Zones: SP2 Infrastructure;
- Recreation Zones: RE1 Public Recreation and RE2 Private Recreation;
- Environment Protection Zones: E1 National Parks and Nature Reserves, E3 Environmental Management and E4 Environmental Living; and
- Waterway Zones: W1 Natural Waterways.

Within the Study area there are four main land use zones as described below and shown in **Figure 5-1**.

R1 – General Residential - This zone is generally intended to provide for the housing needs of the community and to enable other land uses that provide facilities or services to meet the day to day needs of residents.
B2 – Local Centre – This zone is generally intended to provide a range of retail, business, entertainment and community uses that serve the need of people who live in, work in and visit the local area. The catchment area located within this zone also contains some residential development.
RE1 – Public Recreation – This zone is generally intended to be used for public open space or recreational purposes and provide a range of recreational settings and activities and compatible land uses.
E3 – Environmental Management – This zone is generally intended to: protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values; provide for a limited range of development that does not have an adverse effect on those values; and promote the rural amenity and scenic landscape values of the area and prevent the silhouetting of unsympathetic development on ridgelines.

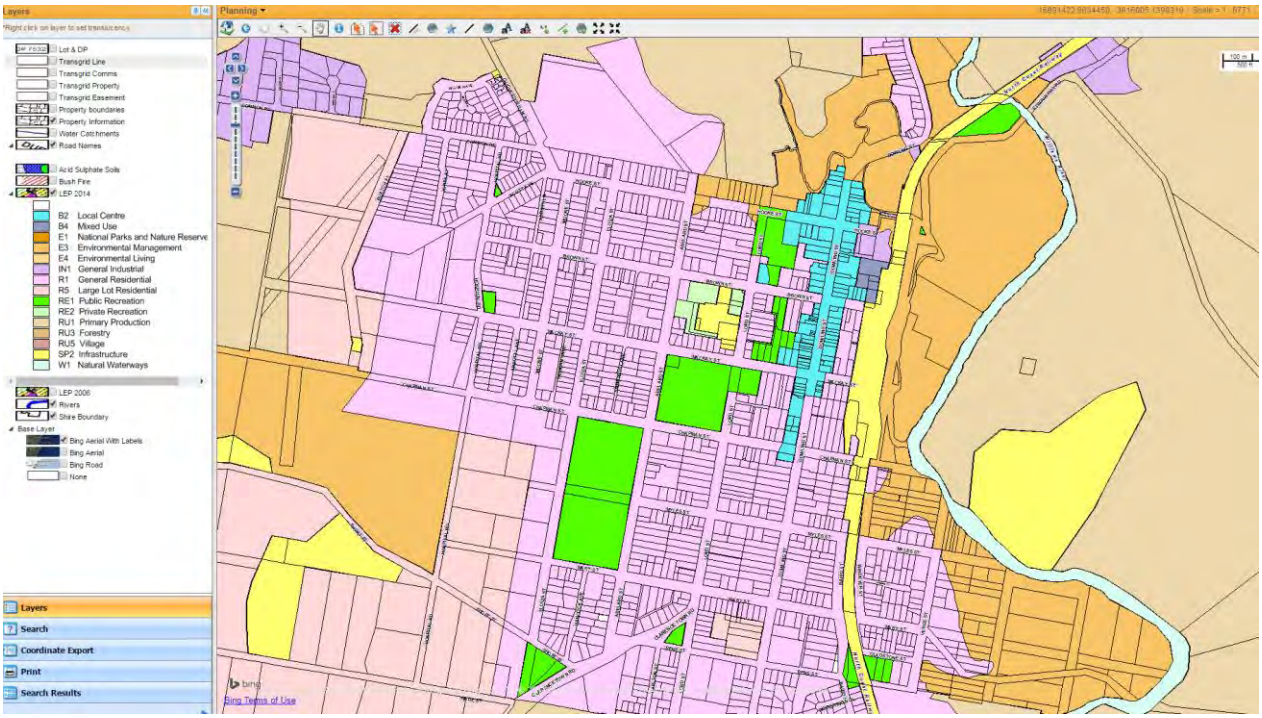


Figure 5-1: Dungog Land Use Zones (LEP 2014)

A review of the LEP 2014 land use zones in relation to flooding indicates that the LEP is yet to be updated to consider the properties (to the south of Bennett Bridge) that were washed away during the April 2015 major flood event, that have subsequently been purchased by Council. It is recommended that these areas are rezoned with a land use compatible with the high flood risk experience in this location.

5.1.4 Flood Planning Maps

The existing LEP 2014 Flood Planning Map is presented in **Figure 5-2**. It appears that the currently adopted flood planning area is based on the Williams River Flood Study (BMT WBM, 2009). The flood planning area should be updated based on the current Dungog Flood Study when the LEP is next revised. It is recommended that the flood maps are moved from the LEP to a location (i.e. document or online map server) that can be more easily updated.

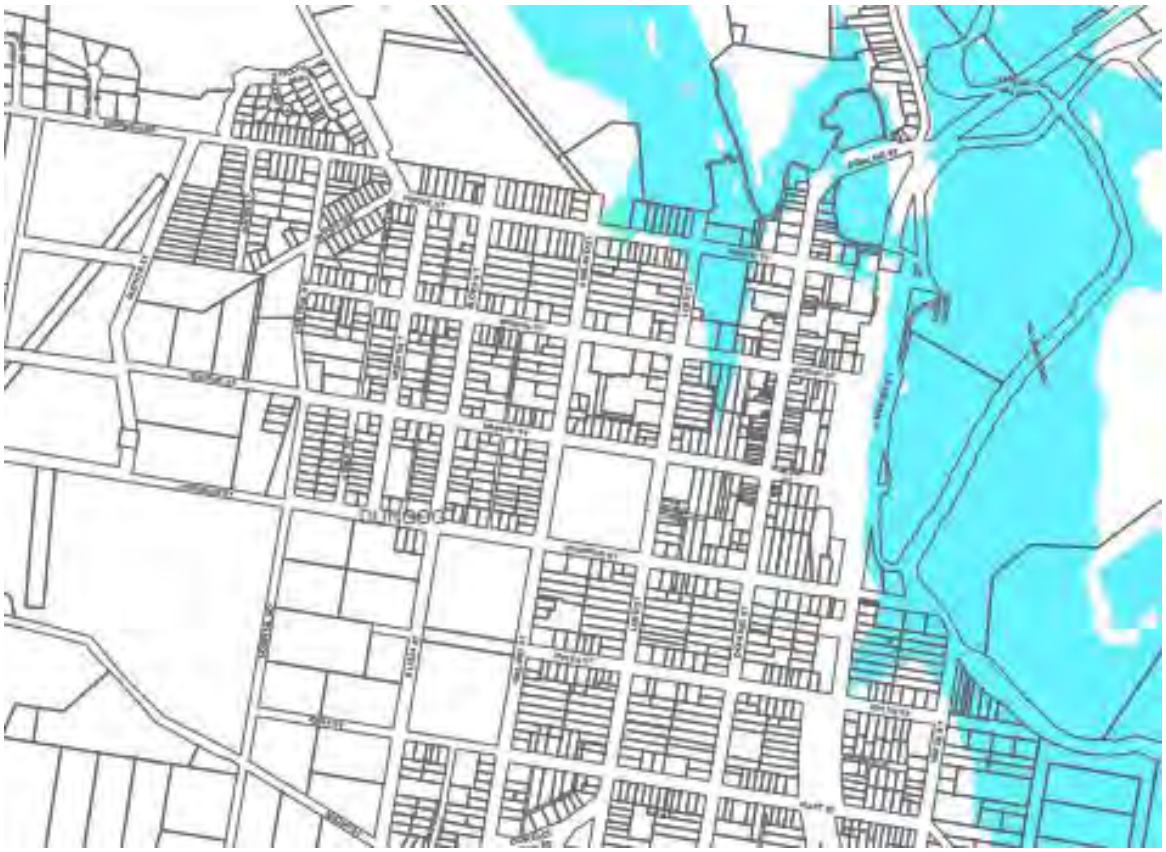


Figure 5-2: Dungog Flood Planning Area Map (LEP 2014 – FLD_009AC)

5.2 Development Control Plan

A draft of the proposed update to the “Managing our Floodplains” section (currently Section 8 of Part C of the Dungog Development Control Plan No 1 (Dungog Shire Council (2004)), was provided to RHDHV by Dungog Council for review. The draft is expected to replace the existing plan which was adopted in May 2004.

The DCP floodplain management policy is used to assess development proposals to determine if they are permissible and the required controls.

The policy looks at:

- The land use category of the proposed development,
- The part/type of the floodplain the development is proposed,
- The required controls (i.e. minimum building levels and building materials) to make the development permissible.

The policy also specifies the required information used to assess a development application. The policy provides details on permissible fencing requirements and guidance on the required documentation for house raising applications.

The adopted land use categories are defined in Schedule 1 and include:

1. Essential community facilities
2. Critical utilities
3. Subdivision and filling
4. Residential
5. Commercial or Industrial
6. Recreation or agriculture
7. Minor development

The adopted floodplain management zones used in the floodplain management matrix (Schedule 2) are defined in the below table.

FLOODPLAIN MANAGEMENT ZONES	CRITERIA
1. Floodway and Excessive Depth Zone	Floodway or depth > 4m in 1% AEP event
2. High Risk (Velocity and Depth) Zone	Remaining area where provisional hazard is high in 1% AEP event
3. Isolated Islands Zone	Remaining area where evacuation is possible only through Zones 1 or 2
4. Low Risk Zone	Remaining area below extreme flood level

The definition of these zones are presented in the Paterson River Floodplain Management Study Report (Bewsher Consulting, 2001). While the DCP notes that,

"the name of the floodplain management zone may vary between flood studies, however the zone shall be taken to mean the equivalent zone which meets the Criteria listed in column 2."

An examination of the Clarence Town FRMS (BMT WBM, 2014) indicates that in some instances there is no directly comparable zone. Also these floodplain management zones do not appear to be in agreement with those specified in the Department of Planning Circular PS 07—03 (see Section 5.3.1). It is recommended that floodplain management zones presented in SCHEDULE 4 - OTHER FLOODPLAIN AREAS PLANNING MATRIX CONTROLS of the current DCP be adopted.

The adopted flood planning level definitions are presented in Schedule 3 as defined in the below table. It should be noted that the adoption of the 0.5% AEP FPL for the Paterson River floodplain do not appear to be in agreement with the guidance provided in Department of Planning Circular PS 07—03 (see Section 5.3.1) which states that unless there are exceptional circumstances, the FPL should be defined as the 1% AEP (with appropriate freeboard).

Location	Flood Planning Level
Paterson River Floodplain	0.5% AEP level
All other Floodplains	1% AEP level plus 500mm freeboard

The adopted planning matrix is defined in Schedule 2 of the draft DCP, and provides information regarding suitable land uses and the required development control considerations. Considering that both the adopted floodplain management zones and FPL are not in agreement with the guidance provided in Department of Planning Circular PS 07—03 (see Section 5.3.1) it is likely that this schedule will need to be updated to be more in line with Schedule 4 of the existing DCP which is presented in **Figure 5-3**.

This matrix of planning controls is used to define development controls within the floodplain (as defined in Councils DCP 1 – Managing Our Floodplains) and define suitable provisions for the following (assuming the recommended 1% AEP flood level plus 0.5m freeboard provision is incorporated into the DCP):

- Restricting development in high hazard areas of the floodplain;
- Specifying minimum floor levels;
- the use of flood compatible building components below a certain level;
- that structures located in high flood risk areas are structurally sound;
- that development does not increase flood behaviour elsewhere;
- maximising opportunities for people to safely evacuate;
- maximising opportunities for flood awareness; and
- other specific considerations regarding the management and design of the property.

There are however, some recommendations for additions to the development control matrix including:

- Lowest habitable floor levels should be elevated above finished ground level.
- Proponents encouraged to construct at higher levels with available flood level information across a range of design flood magnitudes (up to Extreme Flood Level (i.e. PMF)).

SCHEDULE 4 - OTHER FLOODPLAIN AREAS PLANNING MATRIX CONTROLS

Development Control Consideration	FLOODPLAIN MANAGEMENT BAND																		
	OUTER FLOODPLAIN ABOVE 1% AEP FLOOD (PLUS 0.5 FREEBOARD) TO EF							FLOOD FRINGE BETWEEN HIGHHAZARD AREA TO 1% AEP FLOOD (PLUS 0.5m FREEBOARD)							FLOODWAY HIGH HAZARD AREA					
	Essential Comm. Facilities	Critical Utilities	Subdivision and Filling	Residential	Commercial or Industrial	Recreation or Agriculture	Minor Development	Essential Comm. Facilities	Critical Utilities	Subdivision and Filling	Residential	Commercial or Industrial	Recreation or Agriculture	Minor Development	Essential Comm Facilities	Critical Utilities	Subdivision & Filling	Residential	Commercial or Industrial	Recreation or Agric	Minor Development
Floor Level	3	3									2	2 or 5	1	4						1	4
Building Components	2	2									1	1	1	1						1	1
Structural Soundness	2	2								1	1	1	1	1						1	1
Flood Affection	2	2	2		2					1	2	2	2	2						1	1
Evacuation/ Access	2	2	3		3					1,3	3	3	3							1,3	3
Flood awareness	2	2	2	2	2	2	2			1,2	2	2	2	2						2	2
Management and Design	1	1	4							4	1,2,3	1,2,3	1,2,3	1,3						1,2,3	1,2,3

Unsuitable land use

Not relevant

EF REFERS TO THE PROBABLE MAXIMUM OR EXTREME FLOOD

FLOOR LEVEL

1. All Floor levels to be equal to or greater than the 5% AEP Flood level plus 0.5m (Freeboard) unless determined by a risk assessment
2. Floor levels (excluding non-habitable residential floorspace) to be equal to or greater than the 1% AEP flood plus 0.5m (freeboard) and other floor levels equal to or greater than the 1% AEP flood (no freeboard).
3. All floor levels to be equal to or greater than the EF level.
4. Floor levels to be as close to the design floor level as practical and no lower than the existing floor level when an addition to an existing building.
5. Floor levels of shops and offices to be as close to the 1% AEP flood level plus 0.5 m (freeboard) as practical or more than 30% of floor area or equivalent storage space to be above the 1% AEP flood level plus 0.5 m (freeboard), or premises to be flood proofed (eg. Flood shutters for the shops) below the design floor level.

FLOOD COMPATIBLE BUILDING COMPONENTS

1. All structures to have flood compatible building components below or at the 1%AEP Flood Level plus 0.5m (freeboard)
2. All structures to have flood compatible building components below or at the EF Level

STRUCTURAL SOUNDNESS

1. Engineers certificate to confirm any structure subject to a flood up to and including the 1% AEP flood level can withstand the force of flood water, debris and buoyancy.
2. Engineers certificate to confirm any structure subject to a flood up to and including the EF level can withstand the force of flood water, debris and buoyancy.

FLOOD EFFECT ON OTHERS

1. Engineers report required to prove that the development of an existing allotment will not increase flood affection elsewhere.
2. The impact of the development on flood affection elsewhere to be considered.

EVACUATION ACCESS

1. Reliable access for pedestrians required during a 1% AEP flood.
2. Reliable access for pedestrians and vehicles required at or above the EF level.
3. Consideration required regarding an appropriate flood evacuation strategy & pedestrian / vehicular access route for both before and during a flood.

FLOOD AWARENESS

1. Restrictions to be placed on title advising of minimum floor levels required relative to the flood level.
2. S149(2) certificates to notify of applicability of this DCP

MANAGEMENT AND DESIGN

1. Flood plan required where floor levels are below the design floor level.
2. Applicant to Demonstrate that there is an area where goods may be stored above the 1% AEP flood level plus 0.5m (freeboard) during floods.
3. Applicant to provide controls where necessary to prevent the discharge of pollution during floods, including compliance with the 'Environmental and Health Protection Guidelines – On-site Sewage Management for Single Households' dated February 1998 and published by the State Government.
4. Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken without any significant flood effect elsewhere and can access an appropriate pedestrian / vehicular route as part of a flood evacuation strategy if required.

Figure 5-3: Planning Matrix Controls in Current Dungog DCP

5.3 Flood Planning Level Considerations

Department of Planning Circular PS 07—03 (see Section 5.3.1) and associated guideline on development controls on low risk flood areas states:

"unless there are exceptional circumstances, councils should adopt the 100-year flood as the FPL for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood."

If Dungog Council was to adopt a different FPL to the above, approval would have to be sought from the Department of Natural Resources (DoNR) and the Department of Planning (DoP). Given the severity and impact of the flooding that occurred during the April 2015 event, it is anticipated that the DoNR and DoP would accept this as an "exceptional circumstance" and consider a higher than normal FPL. However, it could be argued that, provided that a suitable flood warning system can be developed and safe evacuation paths established, it is possible that the 1% AEP, with 0.5m freeboard may be sufficient for Dungog.

A summary of relevant and historic FPL and flood levels is provided in **Table 5-1.** It shows that a "standard" FPL of 50.7 m AHD is applicable for the Hooke Street (backwater area). If a flood of similar magnitude to the April 2015 "superstorm" occurred again, this would result in water depths of 1.3m occurring in habitable areas of new developments. This is considered a "survivable depth" for most people. However, this 1.3m depth is not considered a "survivable depth" for mobility impaired (i.e. wheelchair bound) or elderly residents. Therefore, given the high portion of older residents in Dungog, it is strongly recommended that a higher FPL than the "standard" 100yr ARI with 0.5m freeboard is adopted in the Dungog tailwater.

Table 5-1: Summary of Historic Flood Planning Levels (FPL) in Dungog

Year	Hooke St FPL (m AHD)	Comments
1979	49.8	Minimum Floor Level of Alison Court (Approved in 1979 and constructed in 1980's. Based on the observed "Top Flood Level" of 48.8mAHD (Yeo, 2015a)
1989/2004	52.0	An FPL for Dungog of 52.0mAHD is presented in the "Managing our Floodplains" Chapter (Adopted May 2004) of the Dungog Shire Wide DCP No 1. See below note (a) for details regarding this level.
2009	50.10	Williams River Flood Study (BMT WBM, 2009), 1% AEP Williams River and Tributaries + 0.5m
November 2015	50.90	Dungog Post Event Flood Behaviour Analysis (BMT WBM, 2015), 1% AEP Myall Creek with 5% AEP Williams River + 0.5m
2017	50.70	Dungog Flood Study (RHDHV, 2017), 1% AEP Myall Creek with 10% AEP Williams River + 0.5m
Observed April 2015 Flood Level	**52.0 (FL not FPL)**	**This event was extreme and is estimated be approximately a 0.1% AEP/ 1000yr ARI.**

Note (a): The level at Dungog is depicted on the map at around the 52m AHD level but there is no textural annotation attached to the map give an exact recorded level. The recurrence interval is not known for this flood and it is assumed to be a 'highest observed' flood. The map is dated 11th July 1989.

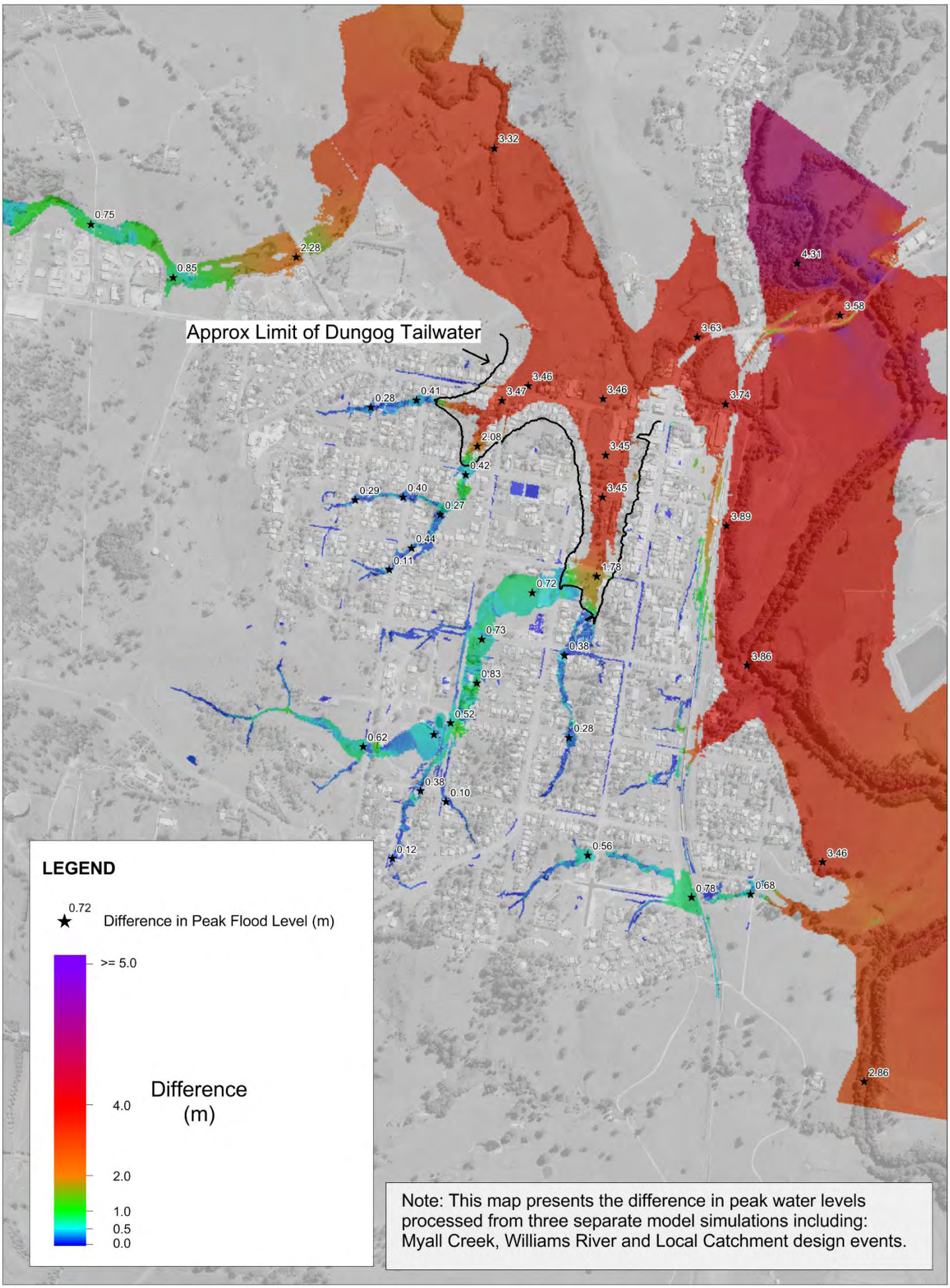
A summary of peak design flood levels from Royal HaskoningDHV (2017) for the Hooke Street tailwater for a number of design flood events is shown in **Table 5-2**.

Table 5-2: Design Peak Water Levels in Dungog Tailwater (Hooke Street)

Design Conditions AEP / ARI	Peak Flood Level (m AHD)
1% / 100yr	**50.2 (FPL = 50.7 (i.e. with 0.5 freeboard))**
0.5% / 200yr	50.64
0.2% / 500yr	51.11
PMF	53.65
April 2015	51.98

While the Department of Planning Circular PS 07—03 means that the setting of a higher FPL may be difficult, it is recommended that Council seek the adoption of a FPL based on the 500yr ARI level of 51.1 m AHD. A free-board of up to 0.5m (i.e. FPL of 51.6 m AHD) should be considered to further increase the survivability for mobility impaired (i.e. wheelchair bound or elderly) residents. It is recommended that Council adopts this higher FPL until the effectiveness of the proposed flood warning system (as presented in **Section 7**)) is fully assessed. If a future Council review finds that the flood warning system is able to effectively reduce the risk to life in severe events, the reduction of the FPL towards the more typical 1% AEP with 0.5m freeboard could be considered.

Further justification of the benefit of applying for a higher than standard FPL in the Dungog tailwater is due to the specific flood behaviour in this area, due to the floodplain constrictions at Bennett Bridge and the Myall Creek Rail Bridge. The difference in peak flood levels in the PMF (i.e. extreme flood) and the 1% AEP (100yr ARI) flood are presented in **Figure 5-4**. The figures shows that in the Dungog tailwater the PMF is nearly 3.5 m higher than the 100yr ARI flood levels, while in the local catchment flood areas, the PMF levels are only 0.1 to 0.8 m higher than the 100yr ARI flood levels. A further example of how rare (i.e. > 100yr ARI magnitude) floods in the Dungog tailwater area could result in risk to life is presented in **Figure 5-5** which maps the difference in peak flood levels in the 0.2% AEP (500yr ARI) and the 1% AEP (100yr ARI). The figure shows that in the Dungog tailwater, the 500yr event is nearly 0.9 m higher than the 100yr ARI flood levels, while in the local catchment flood areas, the 500yr levels are only 0.01 to 0.2 m higher than the 100yr ARI flood levels. These two figures highlight the difference in flood behaviour in extreme events on the local catchment and the Dungog tailwater area.



Royal HaskoningDHV
Enhancing Society Together

FIGURE 5-4

DIFFERENCE BETWEEN PEAK FLOOD LEVELS (PMF AND 100YR ARI (1% AEP) EVENT)

NORTH

0 125 250m
Approx. Scale

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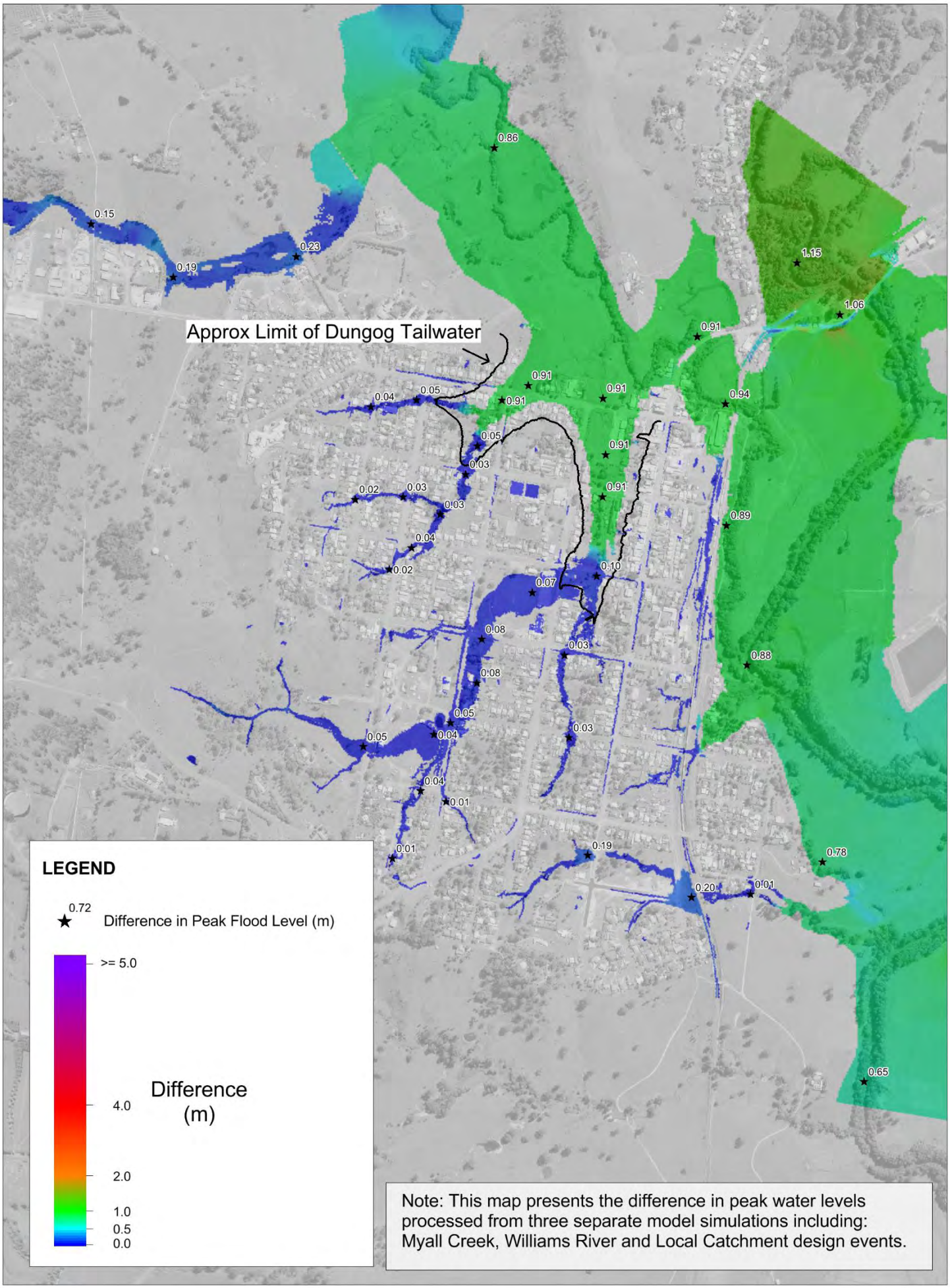

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FIGURE 5-5 **DIFFERENCE BETWEEN PEAK FLOOD LEVELS (500yr (0.2%AEP) AND 100YR ARI (1% AEP) EVENT)**

NORTH

0 125 250m
Approx. Scale

SCALE 1:20,000 PAGE SIZE A4

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5.3.1 Department of Planning Circular PS 07—03 (2007)

The circular and (NSW Government Department of Planning, 2007) provides an overview of a new guideline (on development controls on low risk flood areas) to the Floodplain Development Manual and changes to the Environmental Planning and Assessment Regulation 2000 and section 117 Direction on flood prone land.

Relevant sections from the Guideline are shown below.

Categories of Flood Prone Land

To balance protection of existing and future inhabitants from flood hazard and the potential danger and damage associated with use of the flood prone land, the Manual promotes the appropriate use of flood prone land by breaking it down into areas dependent upon frequency of inundation, their hydraulic function (floodways in which floodwaters are conveyed, flood storage areas where flood waters are temporarily stored during flood events, and flood fringe areas) and flood hazard (a minimum of two categories, high and low). These categories assist councils in determining appropriate development limits and controls to reflect the variation in flood risk across flood prone land and the associated consequences on residents and their property. Key categories are:

1. Floodways: Floodways are the areas of the floodplain which are essential to convey flood waters. Development of these areas would have significant adverse impacts upon flood behaviour which in turn may result in adverse effects on other development and the community. Development of floodways would also expose occupants and their property to significant levels of flood danger and damage.

2. Below the residential FPL: The area of the floodplain where residential development is subject to flood related development controls, i.e. below the residential FPL (as determined in accordance with the Floodplain Development Manual). These are the areas of the floodplain where development limits and controls are used to reduce the frequency of exposure of people and property to flood risk and the associated danger and damage. Development controls in this area need may limit the area that can be developed and may include minimum fill levels, minimum floor levels, the requirement to use flood compatible building materials and need to address emergency management issues as outlined in (3) below.

3. Above the residential FPL: The area of flood prone land above the residential FPL and therefore these are areas where residential development is not subject to flood related development controls. These areas generally have a low risk of flooding and are sometimes known as low flood risk areas. As such, they are areas where no development controls should apply for residential development but the safety of people and associated emergency response management needs to be considered and may result in:

- *Restrictions on types of development which are particularly vulnerable to emergency response, for example developments for aged care.*
- *Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event. Examples include evacuation centres and routes, hospitals and major utility facilities.*

Standards for Flood Controls for Residential Development

Councils are responsible for determining the appropriate flood planning levels for land within their local government area. Whilst the flood used to determine the residential FPL is a decision of the local council, the Manual highlights that FPLs for typical residential development would generally be based around the 100 year flood plus an appropriate freeboard (typically 0.5m).

This Guideline confirms that, unless there are exceptional circumstances, councils should adopt the 100 year flood as the FPL for residential development. In proposing a case for exceptional circumstances, a Council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood.

Unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land with a low probability of flooding, that is, land above the residential FPL (low flood risk areas).

Justification for variations to the above should be provided in writing to, and agreed by, the Department of Natural Resources and the Department of Planning prior to exhibition of a draft local environmental plan or a draft development control plan that proposes to introduce flood related development controls on residential development.

5.4 Review of Floodplain Management Aspects of Dungog Planning Policy's

A review of the floodplain management aspects of current or proposed Dungog Planning Policy (i.e. LEP 2014 and the DCP) indicates that the LEP appears to be in line with regulatory requirements, however, it could be improved by considering the following points:

- The LEP is yet to be updated to consider the properties (to the south of Bennett Bridge) washed away during the April 2015 storm that have subsequently been purchased by Council. It is recommended that these areas are rezoned with a land use compatible with the high flood risk experienced at this location.
- Mapping is currently based on the Williams River Flood Study (BMT WBM, 2009) and should be updated to use output from the current Dungog Flood Study (Royal HaskoningDHV, 2017).
- While the stormwater management policy in Clause 6.4 of the Dungog LEP 2014, reduces the likelihood of future developments generating additional runoff, the policy could be strengthened by requiring new developments to introduce stormwater controls that result in no increase in peak offsite discharge.

A review of the floodplain management aspects of the current or proposed Dungog DCP indicates the DCP is not in line with regulatory requirements (i.e. the Department of Planning Circular PS 07—03). It should be improved by considering the following points:

- Adoption of the floodplain planning control matrix provided in Schedule 4 of the current DCP (**Figure 5-3**).
- Adoption of the 1% AEP (+ 0.5m freeboard) FPL for all floodplains excluding the Dungog tailwater (where the April 2015 event provides sufficient evidence for the adoption of a higher FPL of up to 51.6 m AHD) which would provide for reduced risk to life in Dungog during extreme events.

- Adoption of the “Child care centres and Housing for Aged and Disabled persons” in the “Essential Community Facilities or Sensitive Land User” as per the proposed, not the current DCP. This is required due to the difficulties posed by evacuation of these facilities during flood events.

In addition to the above points the following should be considered:

- Lowest habitable floor levels should be elevated 0.2 m above finished ground level.
- Proponents encouraged to construct at higher levels with available flood level information across range of design flood magnitudes (up to Extreme Flood Level).
- Quantifying a practical/sensible limit on increases in flood affection. i.e. minor increases in local flooding of up to 0.1 m within 10 m of a development that do not impact on an existing or planned building will be considered. Outside of this immediate area, changes of up to 2 cm will be considered on a merits based approach.
- It is recommended that the flood maps are moved from the LEP to a location (i.e. document or online map server) that can be more easily updated.

6 Assessment of Floodplain Management Measures

6.1 Identifying Floodplain Risk Management Measures

The Floodplain Development Manual (NSW State Government, 2005) states that the purpose of a FRMS&P is to identify, assess and compare various flood risk management options to mitigate flood affectation and as such lower the overall flood damages and/or risk to life in the area considered by the study. This process involves assessing the flood impacts of management options for existing, future and continuing flood risk on flood behaviour and hazard and the social, economic, ecological and cultural costs and benefits of options. Assessment of these factors forms the basis for robust decision making in the management plan. The following sections assess a range of flood mitigation options to mitigate and manage flood risk in Dungog.

6.2 Risk Management Measures Categories

Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories:

Flood modification measures: modify the flood's physical behaviour (i.e. depth, velocity) and includes flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatments.

Property modification measures: modify property and land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (i.e. zoning) or voluntary purchase.

Response modification measures: modify the community's response to flood hazard by informing flood-affected property owners and users about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

6.3 Potential Floodplain Risk Management Measures

The following Sections provide a first pass assessment of options by determining if they would be applicable/suitable to the flooding characteristics of Dungog.

Section 6.3.1 provides a list of options that were considered applicable/suitable, and subjected to a detailed assessment as part of this FRMS.

Section 6.3.2 provides a list of options that were considered not be applicable/suitable, and require no further assessment in this FRMS.

Section 6.3.3 provides a list of options that were considered to be potentially effective flood mitigation options and may warrant further investigation in future studies if funding is available.

6.3.1 *List of potential flood mitigation options assessed in this FRMS*

The following mitigation options were considered applicable/suitable for reducing flood risk in Dungog, and were therefore the subject of a detailed assessment as part of this FRMS. Please refer to the appropriate report sections for detailed descriptions and assessment outcomes for each option.

Flood modification measures

O1) Major Myall Creek (Road and Rail) Bridge Modifications – Section 6.4.1

O2) Minor Myall Creek (Road and Rail) Bridge Modifications – Section 6.4.2

O3) Myall Creek Levee with Pumps – Section 6.4.3

O4) Myall Creek Levee with Diversion Culverts – Section 6.4.4

O5) Vegetation Removal with Scour Protection – Section 6.4.5

O6) Dungog Showground Detention Basin Augmentation – Section 6.4.6

O7) Dungog North-West Detention Basin – Section 6.4.7

Property modification measures

O8) Voluntary House Raising – Section 6.4.8

O9) Voluntary House Purchase – Section 6.4.9

O10) Flood Resistant Surfacing for Bennett Park Tennis Courts – Section 6.4.10

Response modification measures

O11) Flood Warning System - The development of a flood warning system for Dungog is presented in detail in Section 7.

6.3.2 *List of potential flood mitigation options not recommended for further investigation in this FRMS*

This section provides a list of options that were considered not be applicable/suitable, and require no further assessment in this FRMS.

NRO1) Myall Creek Levee: A levee protecting Dungog from Myall Creek backwater flooding was investigated. Initial investigations show that pumping or culverted outfalls are required to prevent flooding from the impounded catchment. While a Myall Creek Levee in isolation was not further investigated, a Myall Creek Levee, in conjunction with pumping or a diversion culvert was investigated (refer Section 6.4.3 and 6.4.4).

NRO2) Williams River Levee: A levee protecting a small number of properties from Williams River Flooding (to the east of Windeyer Street) is not considered financially viable due to the low

number of properties receiving benefit. Due to the adequate warning time for Williams River events and ease of evacuation in this location, it is considered a relatively low risk flood area.

NRO3) Myall Creek Detention Basins: Due to the size of the Myall Creek catchment and the impact of Williams River backwater, detention basins would not be practical or effective.

NRO4) Williams River Dam Operations: Chichester Dam is operated by Hunter Water for the purposes of water supply. If the Dam was also operated for flood mitigation purposes, the large and branched catchment size means that the flood benefit for Williams River events would only be relatively small. Also this option would have negligible impact on Myall Creek events such that changes to Chichester Dam operations would not be practical or effective.

NRO5) Increased Hooke Street Culvert Capacity: Increasing the capacity of the either set of Hooke Street culverts would have no impact on peak flood levels as the key flood mechanism in this area is not due to the local Dungog catchment, but rather backwater flooding in Myall Creek. Council may wish to examine the influence of the Hooke Street culvert and operation of the gross pollutant trap during more frequent minor local catchment flood events as part of a self-funded drainage improvement programme.

6.3.3 Potential flood mitigation options recommended for future investigations

This section provides a list of flood mitigation options that were considered to be potentially effective and may warrant further investigation in future studies if funding is available.

FRO1) Increased Cross-Road Drainage Capacity: Increasing the capacity of other cross-road drainage infrastructure was investigated in a preliminary desktop assessment. The initial assessment shows that at all locations, the road crest is low enough such that for larger events peak flood levels are governed by the road elevation and not culvert capacity. However, some improvement in local drainage may be realised for lower recurrence interval events should the culverts be upgraded. Because this option would only have a minor benefit for 1-2 properties immediately upstream of the culvert, the benefit/cost was unlikely to be greater than 1. This meant that while the option was not investigated in the FRMS it may be worth considering in future studies by Council.

FRO2) Increased Drain Clearance and Maintenance: Prevention of drain blockage by a more regular drain clearance and maintenance program has also been investigated in a preliminary desktop assessment. Again, the initial assessment shows that at all locations, the road crest is low enough such that for most events, peak flood levels are governed by the road elevation and not drainage capacity and there are sufficient overland flow paths available to supplement the formal drainage network should blockage occur. This meant that while the option was not investigated in the FRMS it may be worth considering in future studies by Council as it may reduce the occurrence of “nuisance” type flooding.

FRO3) Redirect Overflow to protect Bennett Park Tennis Courts: The synthetic grass surface of the Bennett Park Tennis Courts has been damaged by flood waters on at least two occasions. While an option for preventing future damage by upgrading the court surface is presented in **Section 6.4.10** an alternate mitigation measure would raising the bund on the eastern side of Bennett Park. The bund is currently 54.5 m AHD though there are a number of short sections of the bund that ALS data indicates could be 100-150 mm lower. Raising the bund to 55.0 m AHD, to increase the storage volume of the detention basin, would protect the courts by diverting flows to the north. However, as the basin is located near the end of the local

catchment there is no significant benefit to above floor inundation by enhancing the Bennett Park detention volume. In order to protect the tennis courts, provision of a 4m wide, 70m long outlet channel at RL 49.2 m AHD around the southern end of the courts linking back in to the existing drainage swale may be adequate for most of the smaller events. This would require a maximum excavation depth of 0.5m so would require the removal of 140m^2 of material, and re-surfacing the gravel road access in to Bennett Park. Costs of the works is likely to be $200,000 to $300,000. This is significantly more than the costs of replacing the existing synthetic grass surface with a flood resistant hardcourt surface such as synpave (see **Section 6.4.10**) so would only be considered if the tennis court substrate required replacing such that it made surface upgrade options prohibitively expensive.

6.4 Description and Assessment of Floodplain Management Measures

Flood modification measures

Flood Modification Measures refer to physical modifications on the floodplain which alter the flood behaviour and ultimately reduce the flood affectation (flood levels or velocities) in particularly vulnerable areas.

6.4.1 O1) Major Myall Creek (Road and Rail) Bridge Modifications

Overview

In order to reduce the afflux of water levels through the road and rail bridge crossings of Myall Creek, significant increases in the available waterway area have been investigated. Increased waterway opening could be achieved through the use of banks of: 3.6m wide x 3m high flood relief culverts (FRC). For the major bridge modifications, 27 FRC culverts would be used at Bennett Bridge and 20 for the Railway Bridge. Ground works (excavation) would be required to improve conveyance and improve channel approach conditions.

Figure 6-1 provides details of key components of the required works. The flood model was updated to include these features and a suite of design runs was simulated to determine the impact of this mitigation option on flood behaviour and property inundation and damages.

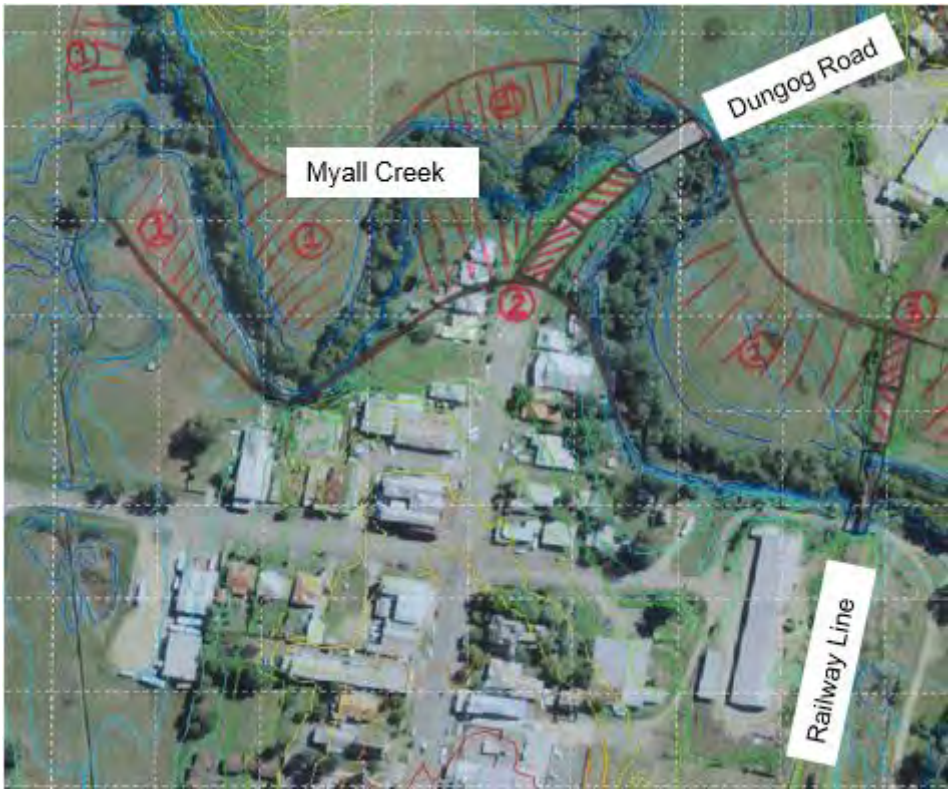

Figure 6-1: Outline Details of O1 - Major Myall Creek (Road and Rail) Bridge Modifications

NB: 1) Ground excavation works to improve conveyance and approach conditions.
2) Two banks (total 27) of flood relief culverts (3.6w x 3.0h) to increase available conveyance at Bennett Bridge crossing.
3) Two banks (total 20) of flood relief culverts (3.6w x 3.0h) to increase available conveyance at the Rail Bridge crossing.

Results

This option results in a significant reduction in peak flood levels in the Dungog tailwater area as presented in **Table 6-1**. For most events, a reduction in peak flood level of 0.3-0.5m is achieved, while during the April 2015 event, a reduction of 1.37m (from 51.98mAHD down to 50.61mAHD) would be expected. Because the PMF event is heavily influenced by the Williams River flood level, this option has a minimal impact on peak flood levels in the PMF.

This option significantly reduces flood affectation in the Dungog tailwater as presented in **Table 6-1.** There is a 54% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.8 Million. However, the cost of constructing this mitigation option is $6.8 Million (a cost breakdown for this measure can be found in **Appendix C**). The calculated benefit/cost (B/C) ratio for this option is 0.27. Since the B/C ratio is less than one, this option would not be recommended for implementation or further investigation.

Table 6-1: Change in Flood Levels, Property Affectation and Damages for Mitigation Measure - O1

Major Myall Creek (Road and Rail) Bridge Modifications

Event	Peak Flood Level (m AHD)[1]	Reduction in Peak Flood Levels (m)[2]	No. Properties No Longer Flooded Over Floor[3]	No. Properties No Longer Yard or Under Floor Flooded[3]	Reduction in Damages for Event
PMF	53.18	0.04	0	0	$ 95,696
0.2% / 500yr	50.7	0.41	9	11	$ 1,339,635
0.5% / 200yr	50.25	0.39	8	4	$ 960,463
1% / 100yr	49.84	0.36	6	8	$ 768,018
2% / 50yr	49.31	0.51	5	13	$ 751,061
5% / 20yr	49.03	0.38	6	3	$ 489,121
20% / 5yr	48.51	0.27	3	3	$ 227,673
April 2015	50.61	1.37	31	36	$ 4,900,152
Reduction in Annual Average Damages (AAD)					**$ 123,308**
Reduced Damages (Over 50 years)					**$ 1,825,054**
Cost of Mitigation Option					**$ 6,800,000**
Benefit/Cost					**0.27**
Reduction in Damages (%)					**54%**

Notes: 1) Peak flood levels and reduction in flood levels are for the Dungog tailwater area.
2) Reduction in peak flood levels is compared to the base case in the Dungog tailwater area.
3) Reduction in the number of properties is compared to the base case.

6.4.2 O2) Minor Myall Creek (Road and Rail) Bridge Modifications

Overview

In order to reduce the afflux of water level through the road and rail bridge crossing of Myall Creek, a more economically viable increase in the available waterway area (i.e. span duplication) was investigated. Increased waterway opening could be achieved through the use of banks of, 3.6m wide x 3m high flood relief culverts (FRC). For the minor bridge modifications, 14 FRC would be used at Bennett Bridge and 10 FRC would be used for the Railway Bridge. Again, ground works (excavation) would be required to improve conveyance and improve channel approach conditions. Such a scheme should also be considered if any future upgrade or repair of the road or rail bridge is planned.

Figure 6-2 provides details of key components of the required works. The flood model was updated to include these features and a suite of design runs was simulated to determine the impact of this mitigation option on flood behaviour and property inundation and damages.

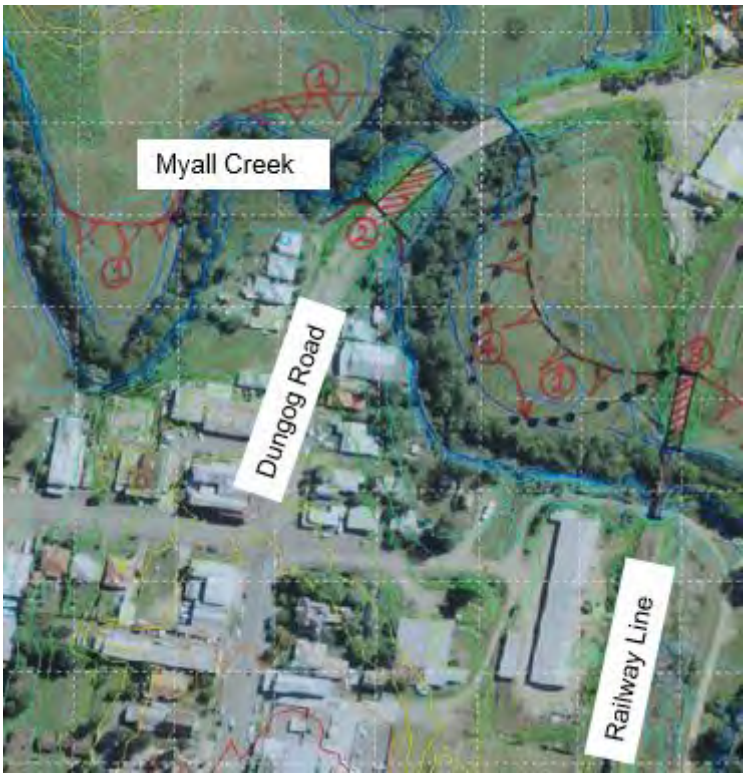

Figure 6-2: Outline Details of O2 - Minor Myall Creek (Road and Rail) Bridge Modifications

Notes: 1) Ground excavation works to improve conveyance and approach conditions.
2) One bank (total 14) of flood relief culverts (3.6w x 3.0h) to increase available conveyance at Bennett Bridge crossing.
3) One bank (total 10) of flood relief culverts (3.6w x 3.0h) to increase available conveyance at the Rail Bridge crossing.

Results

This option produces a slightly smaller flood level reduction compared to O1 (major bridge modifications) and results in a significant reduction in peak flood levels in the Dungog tailwater as presented in **Table 6-2**. For most events a reduction in peak flood level of 0.2-0.5m is achieved, while during the April 2015 event, a reduction of 1.16m (from 51.98mAHD down to 50.82mAHD) would be expected. Because the PMF event is heavily influenced by the Williams River flood level, this option has a minimal impact on peak flood levels in the PMF.

This option significantly reduces flood affectation in the Dungog tailwater as presented in **Table 6-2**. There is a 45% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.5 Million. However, the cost of constructing this mitigation option is $4.4 Million (a cost breakdown for this measure can be found in **Appendix C**).

The calculated benefit/cost (B/C) ratio for this option is 0.35. Since the B/C ratio is less than one, this option would not be recommended for implementation on purely economic grounds. However, considering the high reduction in damages and water levels in an extreme Myall River event (such as the April 2015 superstorm), such a mitigation option could be considered as it would reduce the potential risk to life. Also as the scheme significantly reduces flood damages for such an extreme event (by $4.15 Million), the B/C for an extreme event is close to one. If future studies reveal that climate change has significantly altered the severity and intensity of storms in the Dungog region, such a scheme may be considered to reduce the impact of severe events. Also, such as scheme should also be considered if any future upgrade or repair of the road bridge or rail bridge is planned.

Table 6-2: Change in Flood Levels, Property Affectation and Damages for Mitigation Measure – O2

Minor Myall Creek (Road and Rail) Bridge Modifications

Event	Peak Flood Level (m AHD)[1]	Reduction in Peak Flood Levels (m)[2]	No. Properties No Longer Flooded Over Floor[3]	No. Properties No Longer Yard or Under Floor Flooded[3]	Reduction in Damages for Event
PMF	53.18	0.04	0	0	$ 116,322
0.2% / 500yr	50.72	0.39	9	11	$ 1,254,106
0.5% / 200yr	50.3	0.34	8	4	$ 888,497
1% / 100yr	49.89	0.31	6	6	$ 641,517
2% / 50yr	49.34	0.48	5	13	$ 711,915
5% / 20yr	49.07	0.34	6	3	$ 489,121
20% / 5yr	48.57	0.21	2	2	$ 145,571
April 2015	50.82	1.16	24	30	$ 4,149,403
Reduction in Annual Average Damages (AAD)					**$ 102,623**
Reduced Damages (Over 50 years)					**$ 1,518,896**
Cost of Mitigation Option					**$ 4,400,000**
Benefit/Cost					**0.35**
Reduction in Damages (%)					**45%**

Notes: 1) Peak flood levels and reduction in flood levels are for the Dungog tailwater area.
2) Reduction in peak flood levels is compared to the base case in the Dungog tailwater area.
3) Reduction in the number of properties is compared to the base case.

6.4.3 O3) Myall Creek Levee with Pumps

Overview

A levee protecting Dungog from Myall Creek backwater flooding has been investigated. In order to prevent catchment flooding from behind the levee, one option is to provide a large pump to pump stormwater runoff out against the backwater flood level outside the Levee. A number of pump sizes were investigated with a 5 m^3/s capacity pump being selected as an appropriate compromise between cost and performance. A flood levee crest level of 52.0 m AHD was selected so that it was capable of protecting Dungog from an extreme event such as the April 2015 "superstorm".

Figure 6-3 provides details of key components of the required works. The flood model was updated to include these features and a suite of design runs was simulated to determine the impact of this mitigation option on flood behaviour and property inundation and damages.

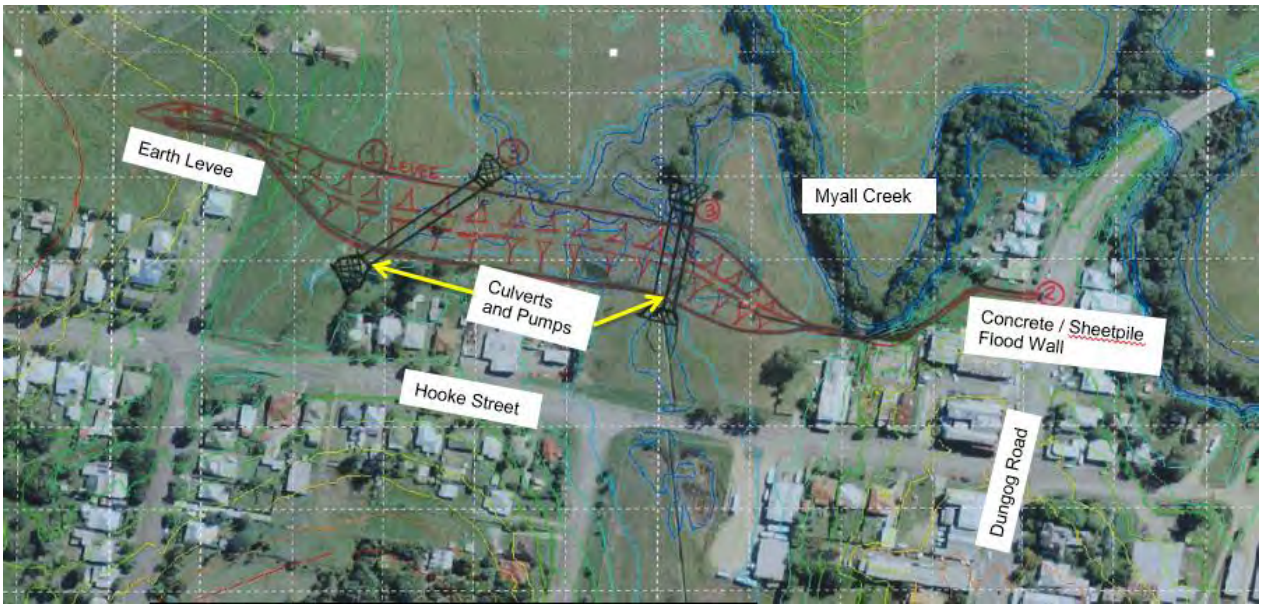

Figure 6-3: Outline Details of O3 - Myall Creek Levee with Pumps

Notes: 1) A ~400m long flood defence earth levee with crest at 52.0 m AHD (up to 5 m high) with 1V:3H batters
2) A 150m long concrete or Sheetpile flood wall near Dungog Road
3) Local drainage flow relief culvert with non-return "Flap" valve. Pumps with 5m^3/s capacity.

Results

This option produces a very significant reduction in peak flood levels in the Dungog tailwater area as presented in **Table 6-3**. For most events, a reduction in peak flood level of greater than 1m is achieved. However, for the April 2015 event, a reduction of only 0.5m (from 51.98mAHD down to 50.48mAHD) occurs due to the high volume of local catchment runoff in this extreme event. Because the PMF event overtops the levee, there is no reduction in peak flood levels in the PMF, however, it would increase the available evacuation timeframe.

This option significantly reduces flood affectation in the Dungog tailwater as presented in **Table 6-3.** There is a 71% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $2.4 Million. However, the cost of constructing this mitigation option is $8.0 Million (a cost breakdown for this measure can be found in **Appendix C**). The calculated benefit/cost (B/C) ratio for this option is 0.3. Despite the ability for this option to nearly

completely eliminate flooding in the Dungog tailwater for all but the severest of events, as the B/C ratio is less than one, this option would not be recommended for implementation or further investigation. This option also has significant ongoing operational cost and may cause additional local catchment flooding if pumps were to fail during a storm event.

Table 6-3: Change in Flood Levels, Property Affectation and Damages for Mitigation Measure – O3

Myall Creek Levee with Pumps

Event	Peak Flood Level (m AHD)[1]	Reduction in Peak Flood Levels (m)[2]	No. Properties No Longer Flooded Over Floor[3]	No. Properties No Longer Yard or Under Floor Flooded[3]	Reduction in Damages for Event
PMF	53.22	0.00	0	0	$ 0
0.2% / 500yr	50.12	0.99	18	19	$ 2,508,775
0.5% / 200yr	49.59	1.05	18	16	$ 2,030,388
1% / 100yr	49.16	1.04	13	18	$ 1,525,932
2% / 50yr	48.79	1.03	9	17	$ 1,079,171
5% / 20yr	48.31	1.10	8	9	$ 710,648
20% / 5yr	47.13	1.65	3	3	$ 227,673
April 2015	51.48	0.50	9	14	$ 1,688,104
Reduction in Annual Average Damages (AAD)					**$ 162,589**
Reduced Damages (Over 50 years)					**$ 2,406,433**
Cost of Mitigation Option					**$ 8,000,000**
Benefit/Cost					**0.30**
Reduction in Damages (%)					**71%**

Notes: 1) Peak flood levels and reduction in flood levels are for the Dungog tailwater area.
2) Reduction in peak flood levels is compared to the base case in the Dungog tailwater area.
3) Reduction in the number of properties is compared to the base case.

6.4.4 O4) Myall Creek Levee with Diversion Culverts

Overview

A levee protecting Dungog from Myall Creek backwater flooding has been investigated. In order to prevent catchment flooding from behind the levee, a diversion culvert conveying water downstream of Bennett Bridge would be required. This option would be cheaper than the pumping option and does not have the maintenance or operational issues associated with pumping. An option where the diversion culvert discharged downstream of the Rail Bridge was also investigated, however, the increase in cost was not justified by the slight reduction in flood

levels. A levee crest level of 52.0 m AHD was selected so that it was capable of protecting Dungog from an extreme event such as the April 2015 “superstorm”.

Figure 6-4 provides details of key components of the required works. The flood model was updated to include these features and a suite of design runs was simulated to determine the impact of this mitigation option on flood behaviour, property inundation and damages.

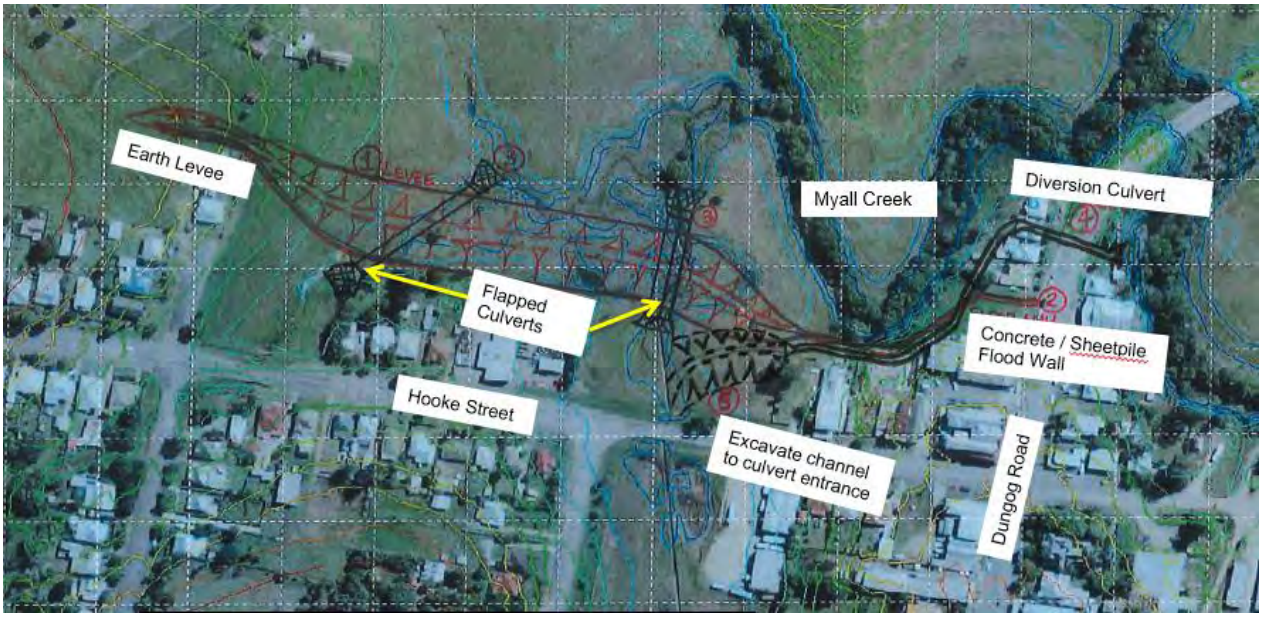

Figure 6-4: Outline Details of O4 - Myall Creek Levee with Diversion Culvert

Notes:
1) A ~400m long flood defence earth levee with crest at 52.0 m AHD (up to 5 m high) with 1V:3H batters
2) A 150m long concrete or Sheetpile flood wall near Dungog Road
3) Local drainage flow relief culvert with non-return “Flap” valve.
4) 200m long diversion culvert 3.6W x 3.0H would convey flow downstream of Bennett Bridge
5) To reduce the culvert length a channel would be excavated to the culvert entrance.

Results

This option produces a very significant reduction in peak flood levels in the Dungog tailwater as presented in **Table 6-4**. For most events a reduction in peak flood level of 0.3-0.7m is achieved, while during the April 2015 event a reduction of 0.78m (from 51.98mAHD down to 51.2mAHD) is expected. Because the PMF event overtops the levee, this option has no impact on peak flood levels in the PMF, however, it would increase the available evacuation timeframe.

This option significantly reduces flood affectation in the Dungog tailwater as presented in **Table 6-4.** There is a 56% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.9 Million. However, the cost of constructing this mitigation option is $7.0 Million (a cost breakdown for this measure can be found in **Appendix C**). The calculated benefit/cost (B/C) ratio for this option is 0.27. Despite the ability for this option to significantly reduce flooding in the Dungog tailwater for all but the PMF event, as the B/C ratio is less than one, this option would not be recommended for implementation or further investigation.

Table 6-4: Change in Flood Levels, Property Affectation and Damages for Mitigation Measure – O4

Myall Creek Levee with Diversion Culvert

Event	Peak Flood Level (m AHD)[1]	Reduction in Peak Flood Levels (m)[2]	No. Properties No Longer Flooded Over Floor[3]	No. Properties No Longer Yard or Under Floor Flooded[3]	Reduction in Damages for Event
PMF	53.22	0.00	0	0	$ 5,655
0.2% / 500yr	50.4	0.71	16	16	$ 1,976,962
0.5% / 200yr	50.05	0.59	9	8	$ 1,313,909
1% / 100yr	49.84	0.36	5	6	$ 676,713
2% / 50yr	49.23	0.59	6	12	$ 838,142
5% / 20yr	49.05	0.36	6	3	$ 489,121
20% / 5yr	48.46	0.32	3	3	$ 227,673
April 2015	51.2	0.78	16	18	$ 2,661,019
Reduction in Annual Average Damages (AAD)					**$ 127,274**
Reduced Damages (Over 50 years)					**$ 1,883,747**
Cost of Mitigation Option					**$ 7,000,000**
Benefit/Cost					**0.27**
Reduction in Damages (%)					**56%**

Notes: 1) Peak flood levels and reduction in flood levels are for the Dungog tailwater area.
2) Reduction in peak flood levels is compared to the base case in the Dungog tailwater area.
3) Reduction in the number of properties is compared to the base case.

6.4.5 O5) Vegetation Removal with Scour Protection

Overview

Community consultation indicated that several residents believe that flooding is exacerbated by instream vegetation along Myall Creek. Investigations into vegetation removal, combined with adequate scour protection were undertaken. Without adequate scour protection, vegetation removal would result in severe channel erosion which could ultimately reduce the stability of Bennett and/or the Railway Bridge.

Figure 6-5 provides details of key components of the required works. The flood model was updated to include these features and a suite of design runs was simulated to determine the impact of this mitigation option on flood behaviour, property inundation and damages.

Figure 6-5: Outline Details of O5 - Myall Creek Vegetation Removal and Scour Protection

Notes: 1) Vegetation clearance and channel stabilisation works along an 800m length of Myall Creek

Results

This option produces a reasonable reduction in peak flood levels in the Dungog tailwater area as presented in **Table 6-5**. For most events a reduction in peak flood level of 0.2-0.4m is achieved, while during the April 2015 event a reduction of 0.37m (from 51.98mAHD down to 51.61mAHD) would be expected. Because the PMF event is heavily influenced by the Williams River flood level, this option has a minimal impact on peak flood levels in the PMF.

This option reduces flood affectation in the Dungog tailwater as presented in **Table 6-5.** There is a 40% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.33 Million. The costs of constructing this mitigation option is $3.5 Million (a cost breakdown for this measure can be found in **Appendix C**). The calculated benefit/cost (B/C) ratio for this option is 0.38. Despite the ability for this option to reduce flooding in the Dungog tailwater for all but the PMF event, as the B/C ratio is less than one, this option would not be recommended for implementation or further investigation.

Table 6-5: Change in Flood Levels, Property Affectation and Damages for Mitigation Measure – O5

Myall Creek Vegetation Removal and Scour Protection

Event	Peak Flood Level (m AHD)[1]	Reduction in Peak Flood Levels (m)[2]	No. Properties No Longer Flooded Over Floor[3]	No. Properties No Longer Yard or Under Floor Flooded[3]	Reduction in Damages for Event
PMF	53.21	0.01	0	0	$ 5,655
0.2% / 500yr	50.9	0.21	1	6	$ 504,940
0.5% / 200yr	50.43	0.21	3	3	$ 496,935
1% / 100yr	49.99	0.21	5	3	$ 364,756
2% / 50yr	49.45	0.37	4	11	$ 581,513
5% / 20yr	49.1	0.31	6	3	$ 443,060
20% / 5yr	48.56	0.22	2	2	$ 145,571
April 2015	51.61	0.37	7	13	$ 1,456,008
Reduction in Annual Average Damages (AAD)					**$ 90,248**
Reduced Damages (Over 50 years)					**$ 1,335,738**
Cost of Mitigation Option					**$ 3,500,000**
Benefit/Cost					**0.38**
Reduction in Damages (%)					**39%**

Notes: 1) Peak flood levels and reduction in flood levels are for the Dungog tailwater area.
2) Reduction in peak flood levels is compared to the base case in the Dungog tailwater area.
3) Reduction in the number of properties is compared to the base case.

6.4.6 O6) Dungog Showground Detention Basin Augmentation

Overview

The benefit of augmenting the existing detention basins at the Dungog Showground to reduce the impact of downstream overland flooding has been investigated. Additional flood detention storage within the Dungog Showgrounds could be provided by increasing the height of the existing bund wall from 63 to 64.5m AHD as presented in **Figure 6-6**. This option was schematised into the local Dungog Catchment model and a number of design runs were used to investigate the performance of this mitigation measure.

Figure 6-6: Outline Details of O6 - Dungog Showground Detention Basin Augmentation

Notes: 1) extend basin embankment and increase embankment crest level from 63 to 64.5 mAHD
2) existing detention basin
3) existing drainage network.

Results

This option produces a 10cm reduction in peak water levels (and hence depths) along the overland flow path and channel between Abelard and Chapman Street. However, as this option will not influence the level of flooding in the Dungog tailwater (which is caused by Myall Creek flooding) and the majority of damages are caused by tailwater flooding, there is not sufficient economic justification for this measure and it has not been investigated further in this study. Again, Council may wish to further investigate this option as part of a local drainage improvement study.

6.4.7 O7) Dungog North-West Detention Basin

Overview

The benefit of constructing detention basins in the upstream catchment areas north of Mackay Street and west of Abbott Lane has been investigated. The proposed detention basin would be formed by constructing an earth embankment with a crest level of 65 mAHD (i.e. 2-2.5 high embankment) along Abbot Lane and excavating the upstream land to 63 m AHD (i.e. up to 4m depth). A 0.5 m diameter outlet pipe would be used to drain the basin. Details of the basin are presented in **Figure 6-7**. This option was schematised into the local Dungog Catchment model

and a number of design runs were used to investigate the performance of this mitigation measure.

Figure 6-7: Outline Details of O7 - Dungog North-West Detention Basin

Notes: 1) earth embankment with a crest level of 65 mAHD
2) excavate land to a 63 m AHD
3) 0.5 m diameter pipe with inlet structure.
4) existing drainage network.

Results

This option produces a 5-10cm reduction in peak water levels (and hence depths) along the overland flow path and channel between Abbot Lane and Eloiza Street. However, as this option will not influence the level of flooding in the Dungog tailwater area (which is caused by Myall Creek flooding) and the majority of damages are caused by tailwater flooding, there is not sufficient economic justification for this measure and it has not been investigated further in this study. Again, Council may wish to further investigate this option as part of a local drainage improvement study.

Property modification measures

6.4.8 O8) Voluntary House Raising

Description

Voluntary House Raising (VHR) has been widely used in NSW as a means of reducing above floor flood inundation. The application of VHR is limited since it is not suitable for all building types (primarily only for single storey non-brick buildings on piers). VHR, where suitable, is cost effective because it does not require significant quantities of new material and does not "sterilise" land. It should be noted that VHR is unlikely to be approved in high hazard areas and can cause evacuation problems.

Overview

A key advantage of VHR is the potential to eliminate above floor inundation and the resulting flood damages. An analysis of at-risk properties potentially eligible for VHR in the study found 7 properties that would be suitable for VHR. One property was located in the local (overland flow) catchment, 5 properties were located in the Dungog tailwater area and one property was located on the Williams River floodplain. Included in the analysis of VHR, is the demolition (DEMO) of 6 Council owned Alison Court properties that have been considered for demolition as it was deemed that the independent senior living units should not be allowed in the newly designated FPA (flood planning area). It should be noted that the demolition of the six Council owned properties may be eligible for funding under the NSW OEH Voluntary Purchase scheme. VHR was represented in the damage analysis by raising the floor level of the property to the 1% AEP (100yr ARI) + 0.5m level. For the 6 Alison Court properties, both the floor level and the ground level was raised to 55mAHD to prevent any damages being calculated for the 6 properties that are to be demolished.

Results

This option will have a negligible effect on flood levels. However, by targeting the properties that are frequently flooded (and hence result in a high contribution to AAD), a significant reduction in flood damages is achieved as presented in **Table 6-6.** There is a 31% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.03 Million. The cost of this mitigation option is $0.47 Million (assuming 7 x $50,000 for VHR and 6 x $20,000 for demolition). The calculated benefit/cost (B/C) ratio for this option is 2.2. **Given that the B/C ratio is considerably higher than one, this option would be recommended for implementation or further investigation.**

Table 6-6: Change in Property Affectation and Damages for Mitigation Measure – O8

Voluntary House Raising and Demolish 6 Alison Court Units

Event	Peak Flood Level (m AHD)	Reduction in Peak Flood Levels (m) [2]	No. Properties No Longer Flooded Over Floor[1]	No. Properties No Longer Yard or Under Floor Flooded[1]	Reduction in Damages for Event
PMF	53.22	n/a	6	6	$ 106,611
0.2% / 500yr	51.11	n/a	7	6	$ 1,136,715
0.5% / 200yr	50.64	n/a	13	7	$ 1,213,776
1% / 100yr	50.2	n/a	12	5	$ 990,774

2% / 50yr	49.82	n/a	11	6	$ 810,501
5% / 20yr	49.41	n/a	6	2	$ 357,171
20% / 5yr	48.78	n/a	1	1	$ 27,454
April 2015	51.98	n/a	7	7	$ 1,145,814
Reduction in Annual Average Damages (AAD)					**$ 69,548**
Reduced Damages (Over 50 years)					**$ 1,029,369**
Cost of Mitigation Option					**$ 470,000**
Benefit/Cost					**2.19**
Reduction in Damages (%)					**30%**

Notes: 1) Reduction in the number of properties is compared to the base case.
2) This option will not change peak flood levels.

6.4.9 O9) Voluntary House Purchase

Description

Voluntary Purchase (VP) refers to the acquisition and demolition of severely flood affected residential properties which pose a significant risk to life during flood events. Typically, these properties are frequently inundated by high hazard flows. These properties are generally removed from the floodplain and rezoned to a high hazard flood compatible use, such as open public space. The removal of these properties may also restore the hydraulic capacity of the floodplain if the properties are located in a “floodway”.

Overview

An advantage of VP is that it eliminates flood damages and also risk to life. An analysis of at-risk properties potentially eligible for VP in the study found 3 properties (out of the 7 considered for VHR) that may be suitable for VP. The 3 properties are all located in the Dungog tailwater area and though they can experience high hazard from depth, the low velocities experienced in this location means that they are not considered to be in a floodway (refer Map Compendium Figure “Hyd Cat 1%” of Royal HaskoningDHV (2017)). While the properties are considered (for the 1% AEP (100yr ARI)) to be in a high hazard area using the NSW FDM definitions, they are only considered to be H4 using the newer AEM guidelines. To be eligible for VP, properties normally must be in an H5 or H6 area, though may be considered in an H4 area. In larger events such as the 200yr ARI, an H5 hazard would occur, so VP should still be considered for these 3 properties.

Included in the analysis of VP is the 4 remaining properties considered for VHR and the 6 Council owned Alison Court properties that have been considered for demolition, (as it was deemed that independent senior living units should not be allowed in the newly designated FPA). VHR was represented in the damage analysis by raising the floor level of the property to the 1% AEP (100yr ARI) + 0.5m level. For the 3 VP properties and 6 Alison Court properties, both the floor level and the ground level were raised to 55mAHD to prevent any damages being calculated for the 9 properties.

Results

This option will have a negligible effect on flood levels. However, by targeting the properties that are frequently flooded (and hence result in a high contribution to AAD) a significant reduction in flood damages is achieved as presented in **Table 6-7.** There is a 36% reduction in AAD, which, over a 50 year period, is expected to reduce flood related damages by $1.22 Million. However, the cost of this mitigation option is $1.22 Million (assuming: 3 x $300,000 for VP, 4 x $50,000 for VHR and 6 x $20,000 for demolition). The calculated benefit/cost (B/C) ratio for this option is 1.00. **Given that the B/C ratio is unity, this option could be recommended for implementation or further investigation on economic grounds.** It should be noted that consideration for VP is not solely based on economic grounds and that VP schemes may be approved based on consideration of risk to life. Because VHR may increase the likelihood of residents sheltering in place during large events, there is the potential for increased risk to life during a severe event if residents can no longer be safely evacuated. **In order to reduce risk to life this option should be considered in preference to O8.**

Table 6-7: Change in Property Affectation and Damages for Mitigation Measure – O9

Voluntary Purchase, Voluntary House Raising and Demolish 6 Alison Court Units

Event	Peak Flood Level (m AHD)	Reduction in Peak Flood Levels (m) [2]	No. Properties No Longer Flooded Over Floor[1]	No. Properties No Longer Yard or Under Floor Flooded[1]	Reduction in Damages for Event
PMF	53.22	n/a	9	9	$ 526,936
0.2% / 500yr	51.11	n/a	10	9	$ 1,462,547
0.5% / 200yr	50.64	n/a	13	10	$ 1,380,550
1% / 100yr	50.2	n/a	12	8	$ 1,129,038
2% / 50yr	49.82	n/a	11	9	$ 920,255
5% / 20yr	49.41	n/a	6	5	$ 438,416
20% / 5yr	48.78	n/a	1	1	$ 27,454
April 2015	51.98	n/a	10	10	$ 1,604,643
Reduction in Annual Average Damages (AAD)					**$ 82,203**
Reduced Damages (Over 50 years)					**$ 1,216,665**
Cost of Mitigation Option					**$ 1,220,000**
Benefit/Cost					**1.00**
Reduction in Damages (%)					**36%**

Notes: 1) Reduction in the number of properties is compared to the base case.
2) This option will not change peak flood levels

6.4.10 O10) Flood Resistant Surfacing for Bennett Park Tennis Courts

Description

The synthetic grass surface of the Bennett Park Tennis Courts has been damaged by flood waters on at least two occasions. Yeo (2015a) found that the tennis courts were damaged by a storm that occurred on the 13th October, 1985. The courts were again damaged in the April 2015 superstorm. An ABC news article (http://www.abc.net.au/news/2016-04-20/dungog-tennis-court-april-2016/7336974) shows that the courts were repaired within a year with synthetic grass. Given that the courts have been damaged twice by floods and once by cockatoos (as reported in the Dungog Chronicle in 18 September 2012 (http://www.dungogchronicle.com.au/story/342033/courts-back-to-new-again/)), it is suggested that the costs of replacing the synthetic grass surface with a more durable and flood resilient hard court surface (such as synpave or a bonded short-pile synthetic grass) be investigated.

Overview

The synthetic grass surface of the Bennett Park Tennis Courts is damaged during flood events when the sand covering the courts is washed away by flood waters. Once the sand is washed away the synthetic grass surface is easily washed away, as the weight of the sand is the mechanism that holds the court down. It is understood that the costs of replacing the synthetic grass courts are in the order of $20,000 per court (i.e. $120,000 for the six courts).

Discussions with tennis court installers show two potentially more flood resistant alternatives are available. Synthetic short pile (low sand) courts can be adhered (using a glue like substance) to the substrate. Costs are typically $22,000/court, though this assumes a suitable substrate is already in place. Assuming only minor repairs to the substrate are required, an allowance of $150,000 to $180,000 for this option is reasonable. A cheaper option would be to convert the courts to a hard court surface such as synpave. Costs are typically $10,000/court, though this assumes a suitable substrate is already in place. Assuming only minor repairs to the substrate are required, an allowance of $80,000 to $100,000 for this option is reasonable.

Results

To prevent ongoing costs from the repair of flood damaged synthetic grass tennis courts, more flood resistant surfaces should be investigated. Cost for replacing the courts with a hardcourt synpave surface are likely to cost $80,000 to $100,000 assuming only minor repairs to the substrate are required. However, if the tennis court owners are unwilling to change to a hardcourt surface, a short pile synthetic grass surface that is glued to the substrate is likely to cost $150,000 to $180,000, assuming only minor repairs to the substrate are required.

These changes should only be considered if/when the existing court surface is damaged. The replacement of damaged assets with more flood resilient options, as opposed to a like for like replacement, is preferred by the Insurance Australia Group (IAG) who represents major insurance agencies in Australia.

6.4.11 Summary of Peak Flood Levels and Damages for Mitigation Measures

A summary of peak flood levels for the 5 mitigation options that will reduce flood levels in the Myall Creek Backwater (i.e. Hooke Street) are shown in **Table 6-8.**

Table 6-8: Design Peak Water Levels (m AHD) in Dungog Tailwater (Hooke Street) for a Range of Mitigation Measures

Design Conditions AEP / ARI	BC Existing / Base Case	O1 Major Bridge Upgrade	O2 Minor Bridge Upgrade	O3 Levee with Pumping	O4 Levee with Diversion Culvert	O5 Channel Vegetation Clearance
20% / 5yr	48.78	48.51	48.57	47.13	48.46	48.56
5% / 20yr	49.41	49.03	49.07	48.31	49.05	49.10
2% / 50yr	49.82	49.31	49.34	48.79	49.23	49.45
1% / 100yr	**50.2**	**49.84**	**49.89**	**49.16**	**49.84**	**49.99**
0.5% / 200yr	50.64	50.25	50.30	49.59	50.05	50.43
0.2% / 500yr	51.11	50.70	50.72	50.12	50.40	50.90
PMF*	53.22	53.18	53.18	53.22	53.22	53.21
April 2015	51.98	50.61	50.82	51.48	51.20	51.61

Notes: Williams River PMF for scenario events is limited to 10,000 m^3/s. The PMF estimate for the Flood Study was 11,361m^3/s which produces an equivalent flood level of 53.65m AHD. The adopted lower flow for the PMF allows the model to be run at a more reasonable time step and is suitable for the comparison of mitigation options. This slightly lower PMF rate was used for all damage calculations in the Section and is why the AAD is slightly (<1%) lower than that presented in Section 4.

A summary of flood damages and benefit / cost (B/C) ratios for the base case (do nothing) and 7 mitigation options is presented in **Table 6-9.** Because mitigation options O6 and O7 (local catchment detention basins) do not influence peak flood levels in the Dungog tailwater area and only produce a localised minor reduction in flood level, no cost / benefit analysis was undertaken for these options.

Table 6-9: Summary of Damages and B/C Ratios for a Range of Mitigation Measures

Option	AAD	NPV of Damage	Cost Of Option	Option Benefit Relative to Base Case	Benefit/Cost Relative to Base Case	Reduction in Damages (%)
Base Case for Comparison	$228,998	$3,389,341	n/a	n/a	n/a	n/a
O1 - Major Bridge Upgrade	$105,690	$1,564,287	$6,800,000	$1,825,054	0.27	54%
O2 - Minor Bridge Upgrade	$126,375	$1,870,445	$4,400,000	$1,518,896	0.35	45%
O3 - Levee with Pumping ($5m^3/s$)	$66,409	$982,908	$8,000,000	$2,406,433	0.30	71%
O4 - Levee with Diversion Culvert	$101,724	$1,505,594	$7,000,000	$1,883,747	0.27	56%
O5 - Channel Vegetation Clearance	$138,750	$2,053,602	$3,500,000	$1,335,738	0.32	39%
08 - VHR 7 properties, DEMO 6 Properties	$159,449	$2,359,971	$470,000	$1,029,369	**2.19**	30%
09 - VP 3 properties, VHR 4 properties, DEMO 6 Properties	$146,795	$2,172,676	$1,220,000	$1,216,665	**1.00**	36%

Key points regarding the options assessment include:

- O3 (Levee with pumping) produces the highest flood damages saving of $2.4 Million (a 71% reduction in damages compared to the Base Case). However, due to the high cost of implementing this option ($9.0 Million) the resulting benefit/cost (B/C) ratio is only 0.3.
- An analysis of mitigation options O1-O5 shows that they result in a significant reduction in flood damages (between $1.33 and $2.4 Million). However, due to the high cost of implementing such measures, all B/C ratios are significantly below 1 and hence would not be considered for implementation on an a solely economic basis.
- For the O2 (Minor Bridge Upgrade) mitigation option, using the AAD approach, the calculated benefit/cost (B/C) ratio for this option is only 0.35 (due to the high cost of the scheme ($4.4 Million)). However, this mitigation measure is able to provide a 1.16 m reduction in peak flood levels for an extreme event such as the April 2015 superstorm. This reduction in peak flood level produces a $4.15 Million reduction in flood damages and hence, the B/C for this extreme event is close to one. If future studies reveal that climate change has significantly altered the severity and intensity of storms in the Dungog region, such a scheme may be considered to reduce the impact of severe events.
- Mitigation option O8 (VHR for 7 properties, demolition of 6 properties) produces the highest B/C ratio (2.2) but the lowest overall reduction in damages of just over $1.0

Million (a 30% reduction in flood damages). Given that the B/C ratio is considerably higher than one, this option would be recommended for implementation or further investigation.

- Mitigation option O9 (VP of 3 properties, VHR for 4 properties, demolition of 6 properties) produces a B/C ratio of 1.0 and hence this option could be recommended for implementation or further investigation on economic grounds. It should be noted that consideration for VP is not solely based on economic grounds and that VP schemes may be approved based on consideration of risk to life. Because VHR may increase the likelihood of residents sheltering in place during large events, there is the potential for increased risk to life during a severe event if residents can no longer be safely evacuated. **In order to reduce risk to life this option should be considered in preference to O8.**
- Because none of the "flood modification measures" (O1-O7) are recommended for implementation, Dungog will still experience flood related risk to life and property issues during severe flood events. In order to mitigate against this risk to life, a flood warning system (as presented in **Section 7**) is recommended.
- Mitigation O10 (Flood Resistant Surfacing for Bennett Park Tennis Courts) should only be considered if/when the existing court surface is next damaged.

6.4.12 Summary of Potential Mitigation Measures

A summary of all the mitigation measures considered in the FRMS is presented in **Table 6-10.**

Table 6-10: Risk Management Option – Assessment Summary and Analysis

Measure	Description	Priority	Benefit	Comments & Concerns	Responsibility for Implementation, Costs and Funding
FLOOD MODIFICATION MEASURES					
O1 - Major Bridge Upgrade (Section 6.4.1)	Option 1 investigated a major increase (i.e. approximate tripling) in floodplain width at Bennett Bridge and the Myall Creek Rail Bridge.	**Very Low** Effective but too costly	B/C = 0.27 Option 1 reduces flood damages by 54% and would have reduced peak flood levels in the April 2015 event by 1.4m.	Option 1 is estimated to cost $6.8 Million and would require significant ground works and excavation which would have a negative environmental effect.	Council and/or NSW RMS would be responsible for costs and implementation of Option 1. Limited funding may be available through the NSW Floodplain Management Program or other Federal Grants Programs.
O2 - Minor Bridge Upgrade (Section 6.4.2)	Option 2 investigated a minor increase (i.e. approximate doubling) in floodplain width at Bennett Bridge and the Myall Creek Rail Bridge.	**Low** Effective but costly	B/C = 0.35 Option 2 reduces flood damages by 45% and would have reduced peak flood levels in the April 2015 event by 1.2m.	Option 2 is estimated to cost $4.4 Million and would require significant ground works and excavation which would have a negative environmental benefit. If future studies reveal that climate change has significantly altered the severity and intensity of storms in the Dungog region, such a scheme may be considered to reduce the impact of severe events	Council and/or NSW RMS would be responsible for costs and implementation of Option 2. Limited funding may be available through the NSW Floodplain Management Program or other Federal Grants Programs.
O3 - Myall Creek Levee with Pumps (Section 6.4.3)	Option 3 investigated a levee protecting Dungog from Myall Creek. Pumps with a $5m^3/s$ capacity would be required to reduce the impact of local catchment flooding behind the levee.	**Very Low** Effective but too costly	B/C = 0.3 Option 3 reduces flood damages by 71% and would have reduced peak flood levels in the April 2015 event by 0.5m.	Option 3 is estimated to cost $8.0 Million and would require significant ongoing maintenance and testing to ensure effectiveness during flood events. Significant ground works and excavation which would have a negative environmental effect	Council would be responsible for costs and implementation of Option 3. Limited funding may be available through the NSW Floodplain Management Program or other Federal Grants Programs.
O4 - Myall Creek Levee with Diversion Culvert (Section 6.4.4)	Option 4 investigated a levee protecting Dungog from Myall Creek. In order to prevent catchment flooding from behind the levee, a diversion culvert conveying water downstream of Bennett Bridge would be required.	**Very Low** Effective but too costly	B/C = 0.3 Option 4 reduces flood damages by 56% and would have reduced peak flood levels in the April 2015 event by 0.8m.	Option 4 is estimated to cost $7.0 Million. Significant ground works and excavation which would have a negative environmental effect	Council would be responsible for costs and implementation of Option 4. Limited funding may be available through the NSW Floodplain Management Program or other Federal Grants Programs.
O5 - Myall Creek Channel Vegetation	Option 5 investigated clearing the vegetation from the Myall Creek Channel. In order to	**Very Low** Only moderately	B/C = 0.3 Option 5 reduces flood damages by	Option 5 is estimated to cost $3.5 Million. Significant vegetation removal and ground works which would have a negative environmental effect	Council would be responsible for costs and implementation of Option 5. Limited funding may be available through the NSW

Measure	Description	Priority	Benefit	Comments & Concerns	Responsibility for Implementation, Costs and Funding
Clearance (Section 6.4.5)	prevent adverse channel erosion and morphologic change, bank stabilisation would be required.	effective and costly	39% and would have reduced peak flood levels in the April 2015 event by 0.4m.		Floodplain Management Program.
O6 - Dungog Showground Detention Basin Augmentation (Section 6.4.6)	Option 6 investigated additional flood detention storage within the Dungog Showgrounds by increasing the height of the existing bund wall	**Low** No influence on Dungog tailwater flood levels	Option 6 was able to reduce peak flood levels along the drainage path d/s of the showgrounds by ~10cm. However, this option would not influence over floor flood damages.	This option could reduce flood levels and the magnitude of "nuisance flooding" to a number of properties along Abelard Street. Council may wish to further investigate this option as part of a local drainage improvement study.	Council staff time or budget would be required to further investigate this option.
O7 - Dungog North-West Detention Basin (Section 6.4.7)	Option 7 investigated constructing a detention basin in the upstream catchment area north of Mackay Street and west of Abbott Lane.	**Low** No influence on Dungog tailwater flood levels	Option 7 was able to reduce peak flood levels along the drainage path d/s of the basin by 5-10cm. However, this option would not influence over floor flood damages.	This option could reduce flood levels and the magnitude of "nuisance flooding" to a number of properties. Council may wish to further investigate this option as part of a local drainage improvement study.	Council staff time or budget would be required to further investigate this option.
PROPERTY MODIFICATION MEASURES					
O8 – Voluntary House Raising (Section 6.4.8)	Option 8 investigated VHR for 7 properties and the demolition of 6 Alison Court properties.	**Medium-High**	B/C = 2.2 Potential to significantly reduce damage costs to properties that are most frequently flooded.	The VHR of 7 properties and demolition of 6 properties is estimated to cost $470,000 and is the most cost effective flood risk management option available in Dungog. However, as three properties are in a high risk area, VP should be considered for these properties unless the residents are unwilling to move. Council has already agreed to demolish the 6 Alison Court properties as they acknowledge that the land use is not compatible with the flood risk.	Recommendation for a Voluntary House Raising Feasibility Assessment to be conducted. 2:1 Funding may be available through the NSW Floodplain Management Program, with the resident liable for paying 1/3 the cost of raising.
O9 – Voluntary House Purchase (Section 6.4.9)	Option 9 investigated VP for 3 properties, VHR for 4 properties and the demolition of 6 Alison Court properties.	**High**	B/C = 1.0 VP would remove residents from an area which is subject to hazardous flood conditions in rare events. VHR would significantly reduce damage costs to properties that are most frequently flooded.	The Voluntary Purchase Scheme is a costly measure (estimated at $1.2 Million), however, due to the high flood risk and willingness of property owners for VP, this option is highly recommended. Council has already agreed to demolish the 6 Alison Court properties as they acknowledge that the land use is not compatible with the flood risk. This option would significantly reduce flood damages in Dungog.	Recommendation for a Voluntary Purchase Feasibility Assessment to be conducted. 2:1 funding may be available through the NSW Floodplain Management Program, with Council liable for paying 1/3 the cost of the purchased property.
O10 – Bennett Park Tennis Court Surface	Option 10 investigated future replacement of the synthetic grass tennis court surface with a	**Medium**	Future re-surfacing costs could be avoided by changing the surface to a more flood resilient material. This	Provided the existing substrate is suitable upgrading the 6 courts to a synpave hard court surface is likely to cost $100,000. This is cheaper than the typical replacement cost of $120,000	Courts are owned by Dungog Tennis Association though it is understood that Council has previously loaned them the

Measure	Description	Priority	Benefit	Comments & Concerns	Responsibility for Implementation, Costs and Funding
Protection (Section 6.4.10)	more flood resilient surface.		would only need to be done next time the courts are damaged.	for the existing synthetic grass surface. If a change of surface is not acceptable, than a flood resilient, bonded short-pile grass surface would cost ~$180,000.	money for court repairs. The insurance status of the Courts should be investigated.
RESPONSE MODIFICATION MEASURES					
O11 - Flood Warning System (see Section 7)	Option 11 investigated the development of a flood warning system for Myall Creek.	**Very High**	A flood warning system is strongly recommended to reduce risk to life from rapidly rising floodwaters that are capable of inundating a number of low lying properties to above ceiling level in severe events.	A suitable flood warning system for Dungog is estimated to cost $50,000 to $100,000. Ongoing annual monitoring costs of ~$5,000 are likely to be required. A significant benefit of flood warning system is in intangibles including reduced fear in the community and also reduced likelihood of flood related loss of life. The method of warning delivery would have to be tailored to the range of residents living on the floodplain.	Council submitted an application in April 2017 for OEH Floodplain Grants for a flood warning system for Dungog. 2:1 funding is likely to be available through the NSW Floodplain Management Program, with Council liable for paying 1/3 the cost of the system.
EM1 - Emergency Management Planning	Effective emergency management planning involves the collaboration of emergency services including the SES and other rescue services to develop a Local Flood Plan.	**High**	An update to the Local Flood Plan will ensure that informed decisions can be made during a flood event and allow for flood preparedness to increase efficiency and reduce risk to residents and emergency services.	Requires effective communication with the community and stakeholders.	The NSW SES are responsible for developing and maintaining a Local Flood Plan for the study area.
EM2 - Community Flood Education	A community flood education program would maintain flood awareness.	**Medium**	Increasing flood preparedness and maintain awareness in the community would ensure that communities are informed and ultimately reduce the damages during a flood event.	Community members are likely to ignore flood information if too much is given. Communication needs to be direct and concise.	Council in partnership with the SES are responsible for community education. To reduce costs, this information can be incorporated with other information such as in the local paper or with Council Rates.
PLANNING and FPL CONSIDERATIONS					
P1 - Adopt non-standard FPL for Dungog tailwater	Recent flood history shows that adoption of the standard FPL is not appropriate in the Dungog tailwater area.	**Very High**	An FPL based on the 500yr ARI with 0.5m freeboard, could prevent tragedy should another large flood occur in Dungog.	Adoption of a high FPL would only benefit new developments and does not reduce the risk to existing properties. Adopting the higher FPL could also inhibit the adoption of VHR.	Council staff time would be required to negotiate the higher than standard FPL with DoP.
P2 - Update LEP for purchased properties near Bennett Bridge	Update the LEP where Council purchased the five properties (destroyed during the April 2015 superstorm) adjacent to Bennett Bridge,	**High**	Council will need to update the LEP to ensure that future develop considers the high flood risk at this locations.	If an appropriate land use zoning is not adopted in this area, risk to life and increases in flood damages could result.	Council staff time would be required to implement and update to the LEP.

7 Detailed Assessment of a Flood Warning System for Dungog

7.1 Response Modification Measures

Flood response measures encompass various means of modifying the response of the population to the flood threat. These measures aim to reduce risk to life and property during a flood event by improving factors such as flood warning and prediction, emergency management planning and community flood education.

7.1.1 Flood Warning Systems

Overview

A flood warning system provides advice on imminent flood events allowing residents to take action to minimise the flood impacts. Typically, flood warning systems integrate factors such as rainfall, river flows and weather forecasts to predict the severity and timing of flooding, then distribute warning messages to agencies such as the SES and to community members where necessary.

Flood warning systems are most effective on large river systems where there is significant warning time providing residents and emergency services with ample time to prepare. There is currently a formal flood warning service for the Williams River provided by the Bureau of Meteorology (BoM) as discussed below.

On smaller systems such as the Myall Creek, flood warning systems are typically harder to implement and unless they are based on forecast data, result in less warning time than large systems. However, given the relatively small number of properties and short evacuation distances, a warning system for the Myall Creek could still be effective in reducing risk to life. Information regarding development of a suitable warning system for Myall Creek flooding is provided below.

Smaller overland flow catchments, such as the local township catchment study area, are typically subject to flash flooding from short intense bursts of rainfall and tend to be difficult to provide effective warning time because of their rapid onset. The implementation of a specific flood warning system for the local township catchment is considered unnecessary given the low risk to life from this flood mechanism. Details of the existing BoM thunderstorm warnings are provided below.

Description of Available BoM Flood Warnings

The Bureau's Flood Warning Service provides:

- Early advice of possible flooding if flood producing rain is expected in the near future.
- A generalised flood warning that flooding is occurring or is expected to occur in a particular region. No information on the severity of flooding or the particular location of the flooding is provided in this instance. These warnings are issued for areas where no specialised warnings systems have been installed. As part of its Severe Weather Warning Service, the Bureau also provides warnings for severe storms that may cause flash flooding. In some areas the Bureau has implemented local monitoring systems (in collaboration with local councils) to assist with flash flood warning.
- Warnings of minor, moderate or major flooding in areas where specialised warning systems have been installed. In these areas, the flood warning message will identify the river valley,

the locations expected to be flooded, the likely severity of the flooding and when it is likely to occur.

- Predictions of expected river height at a town or other important locations and the time that this height will be reached. This particular service is the most useful because it allows local emergency authorities and people in the flood threatened zone to determine the area and likely depth of flooding. This type of warning can only be provided for locations with specialised flood warning systems and for which flood forecasting models are available.

The specialised flood warning system on the Williams River is described below. While a flash flood warning for the local township catchment is considered unnecessary, a warning system for Myall Creek is strongly recommended to reduce risk to life from rapidly rising floodwaters that are capable of inundating a number of low lying properties to above ceiling level in severe events (such as the April 2015 superstorm).

Existing BoM Williams River Flood Warnings

The Bureau of Meteorology (BoM) currently provides a formal flood warning service for the Williams River and provides an estimate of peak flood levels. An example of a BoM flood warning for the Williams River is presented in **Figure 7-1**.

Flood classifications in the form of locally defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected. These levels are used by the NSW State Emergency Service (SES) and the Bureau of Meteorology (BoM) in flood bulletins and flood warnings.

The BoM/SES classifies major, moderate and minor flooding according to the gauge height values at Williams River (Dungog) (Station Number: 061267) as detailed below. The flood classification levels are described by:

Minor flooding (4.9 m, ~46.2mAHD): flooding which causes inconvenience such as closing of minor roads and the submergence of low-level bridges. The lower limit of this class of flooding, on the reference gauge, is the initial flood level at which landholders and/or townspeople begin to be affected in a significant manner that necessitates the issuing of a public flood warning by the BoM.

Moderate flooding (7.6 m, ~48.9mAHD): flooding which inundates low-lying areas, requiring removal of stock and/or evacuation of some houses. Main traffic routes may be flooded.

Major flooding (8.5 m, ~49.8mAHD): flooding which causes inundation of extensive rural areas, with properties, villages and towns isolated and/or appreciable urban areas flooded.

A comparison of the Major flood level classification to the flood model results (Royal HaskoningDHV, 2017) indicates that a Major flood level would have a design magnitude (frequency) of between a 5yr ARI (20% AEP) and 10yr ARI (10% AEP) event. An examination of the floor level database indicates that no properties (on the Williams River floodplain) are flooded from a Williams River event below a 20yr ARI (5% AEP) event in the Dungog . This indicates that the existing BoM flood warnings for the Williams River provide a suitable warning system for this flood mechanism within the Dungog township.

Australian Government Bureau of Meteorology, New South Wales

Final Flood Warning for the Williams River

At Dungog

Issued at 1:55 pm EDT on Saturday 18 March 2017
Flood Warning Number: 3

Rainfall has eased since 11:00 am Saturday morning over the Williams river valley, however further rainfall is forecast for the next 24 hours.
The Williams River at Dungog is expected to peak below the minor flood level.
The situation is being closely monitored and warnings and predictions will be issued if necessary.

Williams River:
The Williams River at Dungog is approaching a peak below the minor flood level

Flood Safety Advice:
FloodSafe advice is available at www.ses.nsw.gov.au

For emergency assistance call the SES on telephone number 132 500.
For life threatening emergencies, call 000 immediately.

Next issue:
This is a final warning, no further warnings will be issued for this event.

Latest River Heights:
Williams River at Dungog, 3.77, Steady, 12:45 PM SAT 18/03/17
Williams River at Mill Dam Falls, 1.48, Rising, 01:00 PM SAT 18/03/17
Allyn River at Halton, 2.01, Rising, 01:00 PM SAT 18/03/17
Paterson River at Gostwyck Bridge, 1.65, Rising, 01:00 PM SAT 18/03/17

This advice is also available by dialling 1300 659 218. Warning, rainfall and river information are available at www.bom.gov.au/nsw/flood. The latest weather forecast is available at www.bom.gov.au/nsw/forecasts.

Figure 7-1: Example BoM Flood Warning for the Williams River

From http://weather.news.com.au/warning/?id=IDN36639

Recommended Development of Myall Creek Flood Warning System

Development of a flood warning system for Myall Creek is strongly recommended to reduce risk to life from rapidly rising floodwaters that are capable of inundating a number of low lying properties to above ceiling level in severe events (such as the April 2015 superstorm). A graph comparing the number of floor levels at a given elevation, compared to a range of historic and design flood levels is presented in **Figure 7-2**. The figure shows that while there are less than 20 properties (in the Dungog tailwater area) that would experience over floor flooding in the 100yr ARI (1% AEP) design flood (50.2 m AHD), in the April 2015 flood, these properties would have been flooded to above or near ceiling level and a total of 50 properties would experience above floor flooding.

The topography of Dungog means that evacuation paths (to safe higher ground) are less than 250m long. In general, evacuation routes to high ground are straight forward (i.e. walk uphill to high ground); however, there are two locations where evacuation should proceed with caution:

- Properties between 44 and 62 Hooke Street may need to evacuate up the driveway of 60 Hooke Street (towards the grounds of the St Joseph Catholic School), as the crest of the roadway along Abelard Street is 49.2 m AHD, while the Lord Street intersection is significantly lower.
- While floor levels for the units at 30 Brown Street are above 50.0 m AHD, the driveway at the front of the properties is only 49.0 m AHD, which means these units should be evacuated early. Local catchment flooding may cause minor (up to ~0.3m) inundation of this area prior to the development of tailwater flooding from the Myall Creek. Because these units are typically occupied by retirees (i.e. residents are mostly aged over 55), evacuation assistance may be required for occupants.

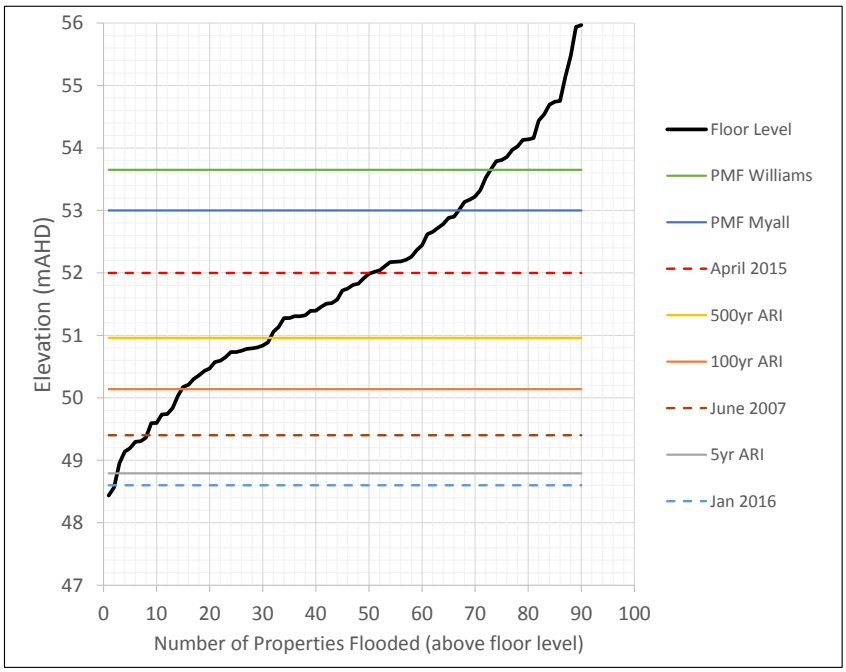

Figure 7-2: Flood Stage vs Property Floor Levels (Dungog Tailwater)

Options for Rainfall based Flood Warning System

The absence of an accurate, telemetered water level gauge in the Myall Creek tailwater means that unless a suitable water level gauge is installed, flood warnings would need to be based on observed or predicted rainfall.

BoM operates two rainfall gauges in the Myall Creek catchment at: Dungog Post Office (61017) and Upper Myall Creek (61415). Warnings based on a specified rainfall depth in a given time could be defined to generate a number of warning levels. An example of this rainfall depth, warning type is presented in **Table 7-1.** It should be noted that the below table would need to be checked and refined prior to adoption. Due to the potential for high spatial variation in the catchment and the availability of only two rainfall gauges, the installation of additional gauges or the use of synthetic gauges based on interrogation of rainfall radar data would be recommended. However, as described below, the development of a water level based warning system is recommended over a rainfall based system, so additional rainfall gauges are low priority, though would enhance the forecast accuracy and may increase available warning times of a flood level based system.

Table 7-1: Example of Rainfall Depth (mm) vs Warning Type for Myall Creek Catchment

Rain Duration	Warning to Council and NSW SES	Warning for Evacuation	Immediate Evacuation
Short duration intense rain events (assumes wet catchment (i.e. >50mm in previous 24 hours))			
1 hour	40	50	60-70
2 hour	60	80	90-100
Longer duration events (warnings should consider likelihood of future rainfall (i.e. radar or meteye))			
9 hour	100	120	140-160
24 hour	150	200	250-300

Recommendations for Water Level based Flood Warning System

Due to the spatial variability in rainfall and influence of initial and continuing losses on flood levels, a water level based flood warning system is likely to be more reliable than one based on rainfall alone. A list of relevant feature elevations and suggested flood warning levels is presented in **Table 7-2**. It should be noted that these suggested levels are preliminary in nature and should be refined by a more detailed study prior to adoption. A water level gauge located near the Hooke Street drain would be required to raise the earlier (lower) warning levels.

Table 7-2: Feature Elevations and Flood Level Warning Types

Feature	Level (mAHD)
Hooke St Channel Invert	45.2
Hooke St Top of bank	46.0
Hooke Street road crest	46.5
Warning to Council & SES	**46.5**
Alert to residents	**46.5**
Alert to residents – Evacuate now	**48.0**
2 Commercial Properties on Hooke St Flooded	48.5
Alert to Council and NSW SES – properties are being inundated	**48.5**
First above floor property flooding (Hooke St)	49.0
Evacuation of 7 units at 31 Brown St becomes difficult	49.0
2 lowest Alison Court floor levels	49.6
Alert to Council and NSW SES – flood level has dropped below Hooke St	**46.5**

Water level (i.e. rates of rise) for the April 2015 and the design 1% AEP (100yr ARI) flood events are presented in **Figure 7-3** and **Figure 7-4.** In the April 2015 event, flood levels increased by 3.0m in 2.5 hours, with a peak rate of rise of nearly 1m in 30 minutes being observed. In the 1% AEP (critical 9 hour duration) event, flood levels are predicted to increase by 3.0m in 3.5 hours, with a peak rate of rise of 1m in 45 minutes at the start of the event.

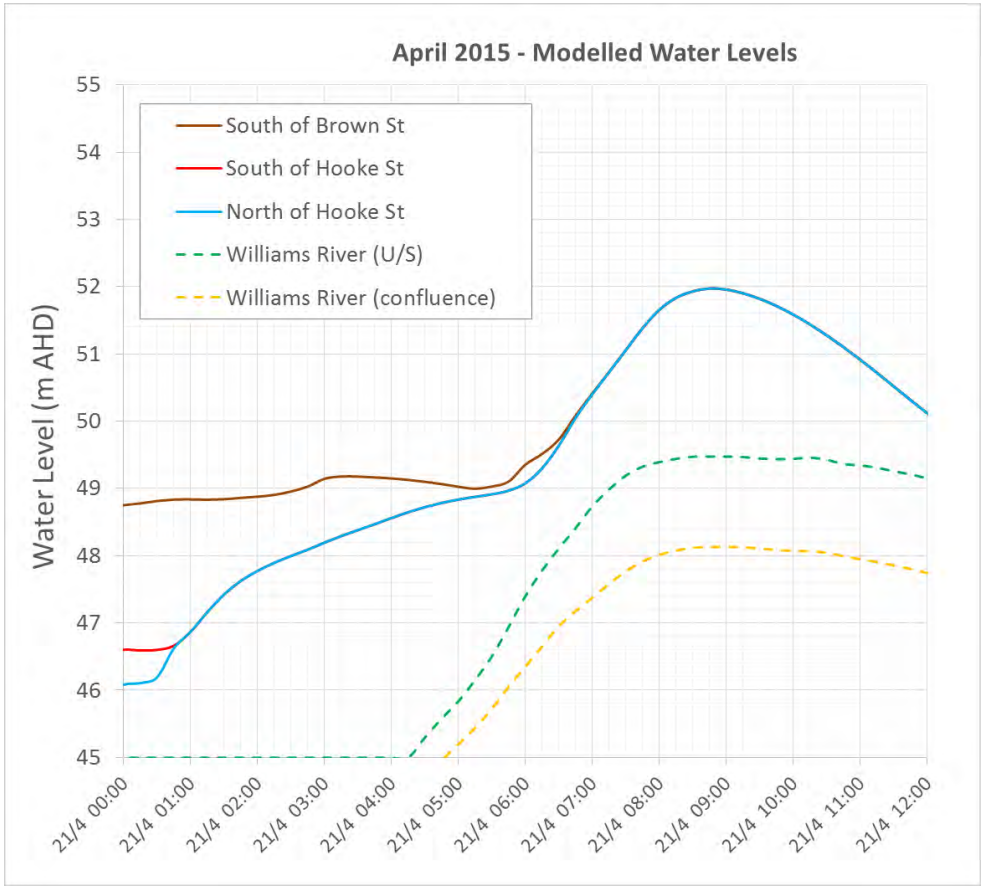

Figure 7-3: Modelled Water Levels – April 2015 Flood Events

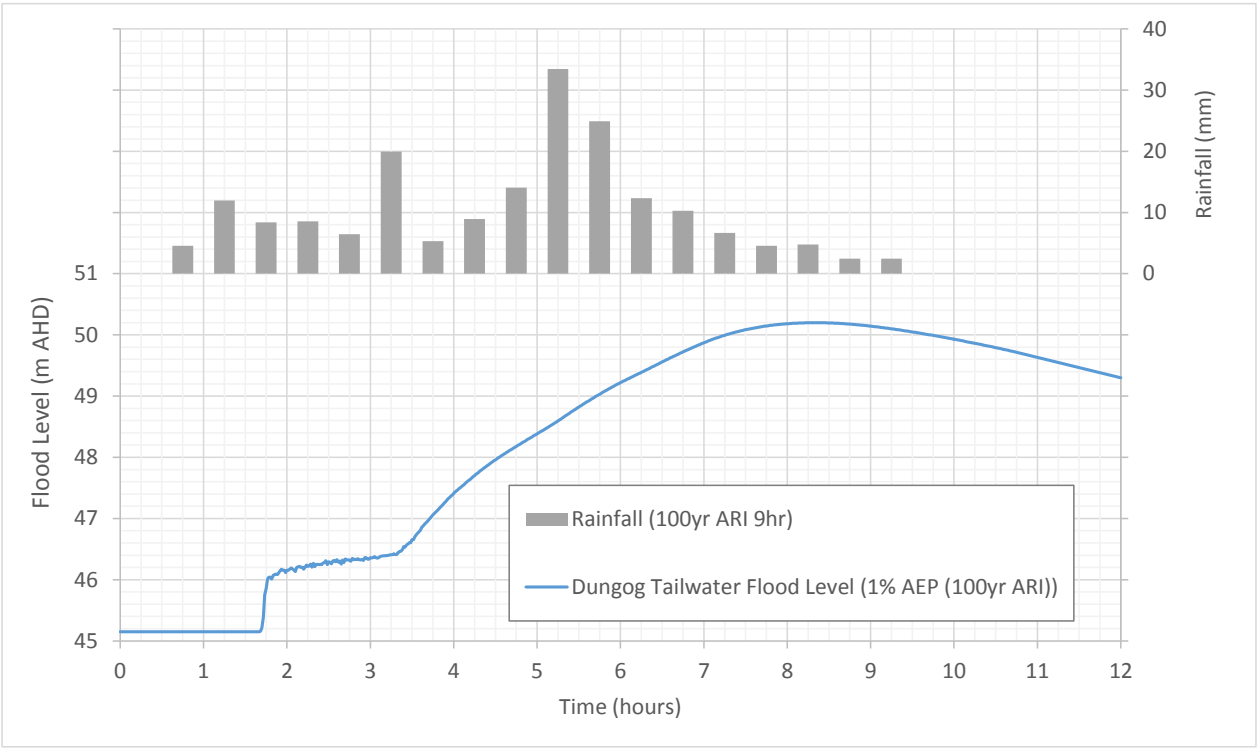

Figure 7-4: Design Rainfall and Modelled Water Levels – 1% AEP (100yr ARI)

Existing DipStick Gauge

It should be noted that a trial water level gauge was installed in early 2017 immediately upstream of the Hooke Street culvert. The “dipstick gauge” provides information on water depth (the level of the gauge does not appear to have been surveyed) and uses a camera system to verify the data. Images and water levels are uploaded to a website. It is understood that the “dipstick gauge” was provided as Dungog is one of 6 Councils to be included in a trial organised by NRMA insurance in partnership with the SES (https://www.nrma.com.au/dipstik-flood-trial).

The use of this gauge in a more formal flood warning system should be further investigated. However, it is important to note that the manufacturers state that the gauge is designed more for the provision of flood information, and that the accuracy of the water level sensor was not designed for data collection purposes (pers.comm. Peter Stone (CEO Tuftec Solutions), 21/3/2017). Unless the accuracy of the gauge can be confirmed as appropriate, it is likely that an alternate water level monitoring system (as discussed below) will be required. However, while the “dipstick gauge” may not be appropriate as a primary gauge, if the feed can be integrated into the warning system, it would be appropriate to use as a backup or source of confirmation data. The second “dipstick gauge” located on the Williams River at Bendolba is unlikely to provide any useful information for a flood warning system for Dungog, though does provide useful information for the Fosterton Road causeway.

Options for Advanced Hybrid Data / Model based Flood Warning System

An advanced hybrid flood warning system that integrates rainfall and water level data, rainfall radar and forecast rain could further increase available warning times and increase the accuracy of peak water level predictions. Such a system would use observed and forecast rainfall data to run flood models to predict future water levels. This type of system not only provides increased warning time and accuracy it also reduces the likelihood of false warnings being delivered. However, these systems are significantly more expensive to develop and maintain.

Communication

Effective communication of flood warnings is required to reduce the negative impacts of floods. Warning systems should be accurate, timely, reliable and be delivered through appropriate mechanisms. The advantages of a broad range of delivery mechanisms are presented in **Figure 7-5.** It is likely that a mixture of text messages (SMS), automated telephone messages (required for older residents), sirens, flashing lights and door knocking would be required.

Prior community awareness of flood risk tends to make warning more effective. While the April 2015 extreme flood event means that there is currently a very high level of awareness of flood risk in Dungog, it will be important to implement ongoing education programs to ensure new residents are informed of flood risk and to ensure complacency doesn’t develop over time.

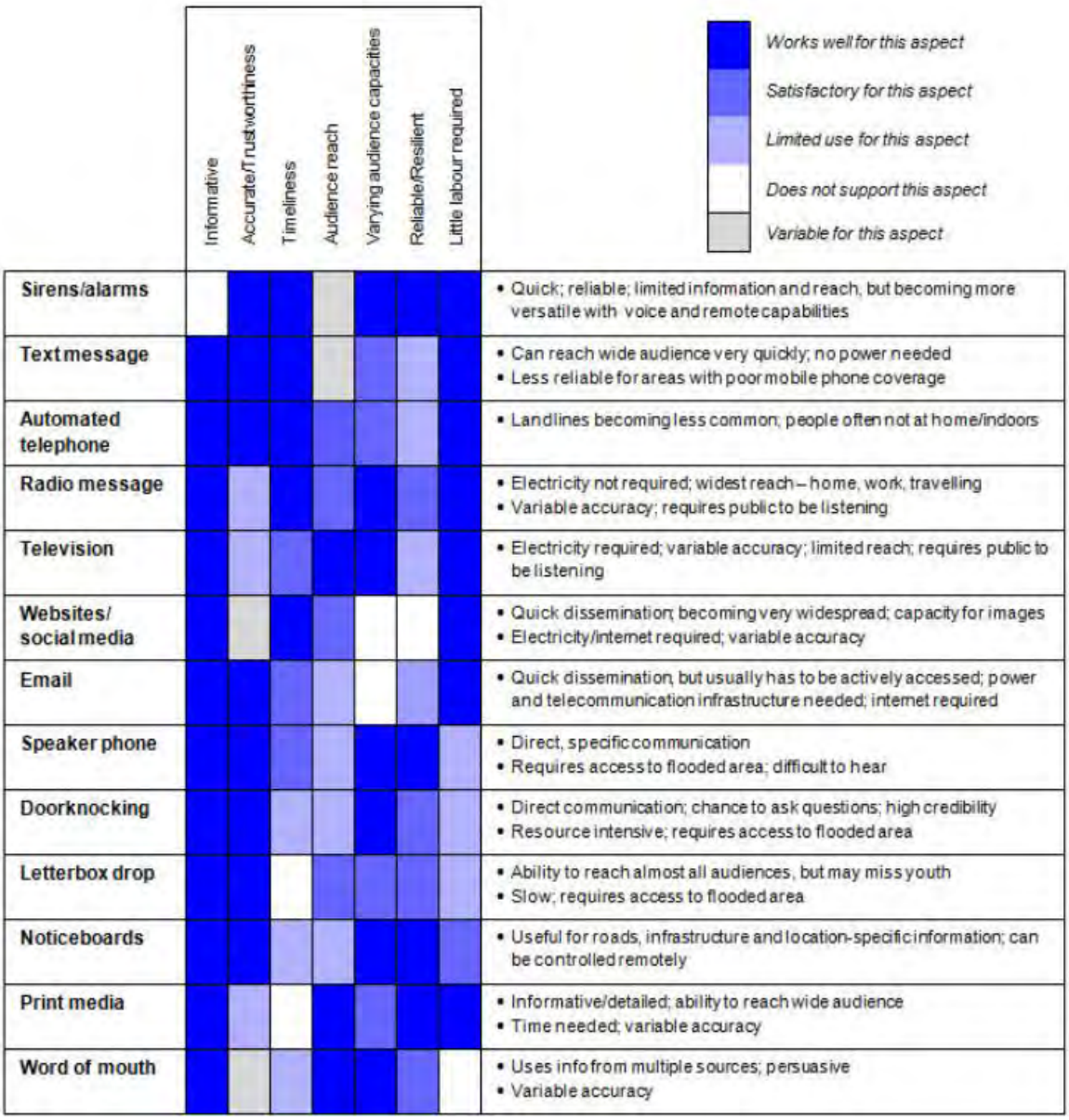

Figure 7-5: Pros and cons of different flood warning communication methods

From http://chiefscientist.qld.gov.au/publications/understanding-floods/flood-warnings (accessed 5th April 2017)

Outline of Costs for Flood Warning System Options

Approximate costs for various flood warning system configurations and options are outlined below.

A rainfall based option using the existing BoM rainfall gauges would be the cheapest option. The Australian Early Warning Network company (EWN) delivers a range of warning services to Councils and Commercial organisation throughout Australia. EWN provided the below pricing information for a rainfall based system in Dungog, that would send SMS or phone messages to registered users. EWN operate a 24hr/7day a week staffed operations room and manually check all alerts before generating warnings.

- setup costs (i.e. user registration and implementation of triggers): $2000-4000
- Monthly monitoring cost $50/gauge
- $50 / event + costs of SMS / calls

An allowance for consultancy costs to undertake a desktop or model based assessment of trigger warnings (i.e. refine **Table 7-1**) of $5,000 to $15,000 should also be included. Given that two rainfall gauges would be monitored, an allowance of $1200/yr for monitoring costs would be required. Assuming 4 warnings are generated each year, with warnings distributed to 100 residents or emergency workers (@50c / txt or call), an allowance for $1600/yr is required.

Installation of an automated water level gauge is likely to cost $7,000[1] to $30,000[2]. EWN is able to provide water level based monitoring in addition to rainfall based systems so pricing would be as per above. A siren and/or strobe warning is likely to add $5,000 to $10,000 to such a system. A high powered, fully featured and tested, mass alert flood warning system for a large area could cost approximately $70,000[3].

Given the harsh operating conditions that flood warning systems are subjected to, there is usually a typical 30% failure rate of gauges and it is important to include a degree of redundancy in flood warning systems. This means it is advisable to either have dual gauges in the tailwater area or to deploy a water level gauge further up the catchment. A water level gauge higher in the catchment would increase available warning times; however, due to the branched catchment shape, two additional gauges would be desirable. The cost for each additional water level gauges is $7,000[1] to $15,000[2]. The use of manually read flood gauges may be a valid alternative for Dungog and could be a suitable redundancy measure. It is recommended that two gauge boards are installed in Hooke Street and one installed in Lord St, Mackay St and Brown St as presented in **Figure 7-6**. These five gauge/information boards should provide historic and design flood level information and would be useful for ongoing flood education. An allowance of $7,500[5] for the five signs (including supply, survey and install) is appropriate.

An advanced hybrid flood warning system that integrates rainfall and water level data, rainfall radar and/or forecast rain to drive a fast solving flood model would cost $120,000 to $170,000[4] to setup and commission. Annual software and licence costs are likely to be $10,000 to $50,000[4].

A summary of costs for the three options is provided in **Table 7-3**.

It is recommended that after a number of years (say 5) of operation, the system is reviewed and refined. An allowance of $10,000 - $15,000 is likely to be sufficient for an external consultant to undertake a full review.

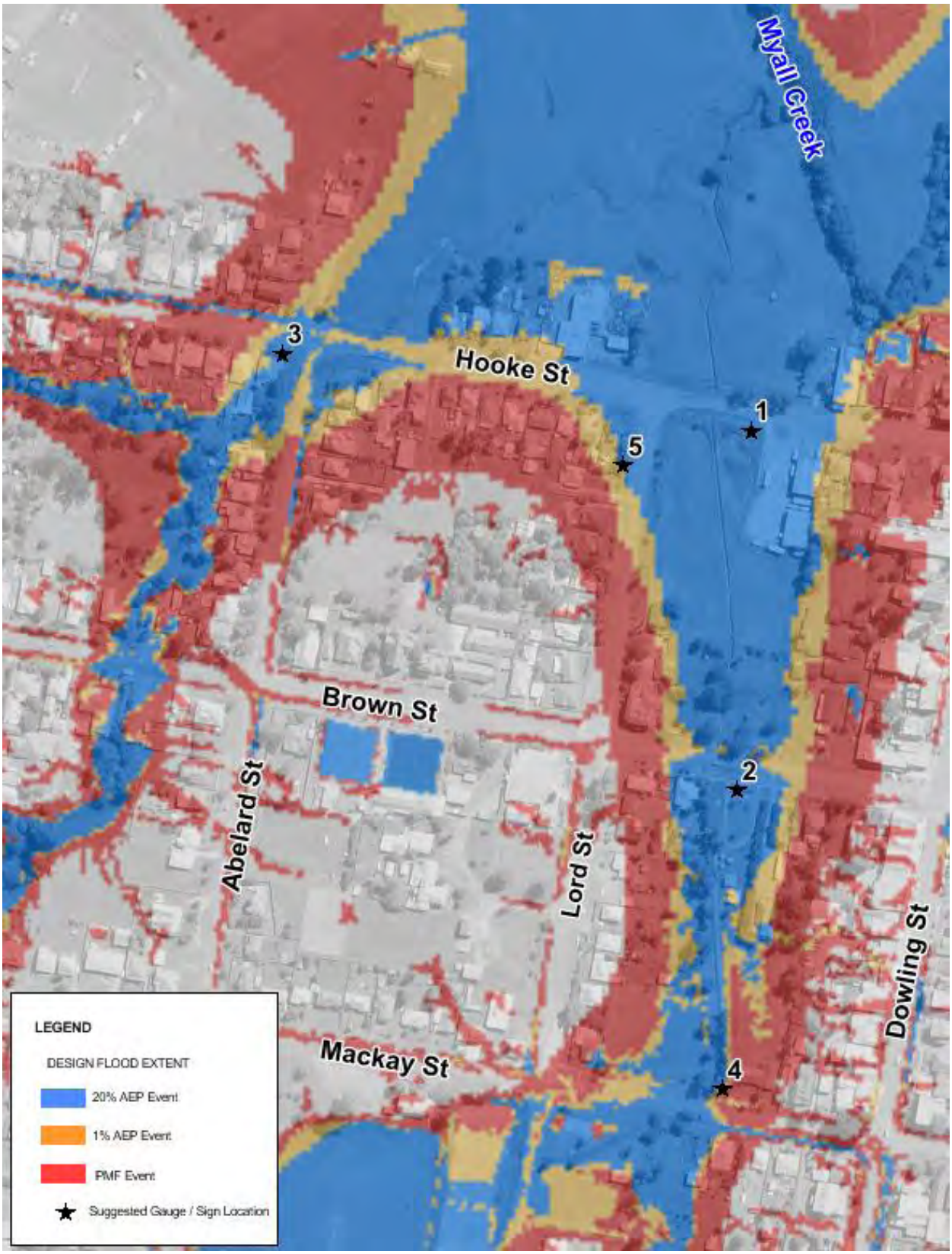

Figure 7-6: Suggested Location of Water Level Gauges and Gauge Boards / Flood Information Signs

Suggested location for water level gauge is location 1 (existing power pole on Hooke St, ground elevation is ~46.3mAHD)

Table 7-3: Summary of Approximate Costs for Flood Warning System Options

Item	Cost
Rainfall based system using existing BoM gauges	
Consultancy costs to refine trigger warnings and assist system development	$5,000-$15,000
System setup (user registration and implementation of triggers)	$2,000-$4,000[6]
Monthly monitoring cost ($50/gauge)	$1200/year[6]
Cost to check and disseminate warnings ($50/event + SMS and calls costs) Assume 100 warnings delivered at 50c per call or SMS and 4 warnings per year.	$200/year[6]
Water Level based system using existing BoM gauges	
Consultancy cost to refine trigger warnings and assist system development	$5,000-$15,000
Supply of water level gauge (most system include a camera feature)	$7,000[1]- $30,000[2]
Additional water level gauge (most system include a camera feature)	$7,000[1]- $15,000[2]
optional siren and/or flashing lights (estimated)	$5,000- $10,000
Integrated mass warning system (Whelen WPS2903)	$70,000[3]
optional supply and install of 5 gauge boards / signs (including survey)	$7,500[5]
EWN system setup (user registration and implementation of triggers) may be included in some WL warning systems, this option could allow the use of both water level and rain based triggers	$2,000-$4,000[6]
Monthly monitoring cost ($50/gauge) single water level gauge only	$600/year[6]
Monthly monitoring cost ($50/gauge) water level only and 2 rain gauges	$1800/year[6]
Cost to check and disseminate warnings ($50/event + SMS and calls costs) Assume 100 warnings delivered at 50c per call or SMS and 4 warnings per year.	$200/year[6]
Advanced hybrid flood warning system (including flood model based forecasts)	
Development and commissioning of system	$120,000 - $170,000[4]
Annual software and licence costs are likely to be $10,000 to $50,000	$10,000 - $50,000[4]

Notes:
1) cost for dipstik system (low accuracy system with basic image output, though SMS is also available)
2) cost for Digilant system (radar based WL gauge with high functioning interface including software and SMS alerts)
3) proposed cost for Wallsend Flood Warning System using a Whelen WPS2903 based system (Prospect Environmental)
4) based on proposed cost for Parramatta CBD Flood Warning System using Lizard Portal interface and a cloud based 3Di flood model.
5) based on proposed cost for Wallsend Flood Signage study (RHDHV, 2016)
6) based discussions with EWN (The Australian Early Warning Network company)

Costs Benefit Considerations for Flood Warning Systems

The benefit of such a system is difficult to quantify. While the limited warning time is likely to allow for residents to raise some items (and therefore reducing flood damages), this cannot be relied upon to reduce damages. The main benefit of such a system is in intangibles including reduced fear in the community and also reduced likelihood of flood related loss of life.

Summary & Recommendation

Based on the information presented above, the implementation of flood warning systems is recommended for the Dungog tailwater area. Community consultation undertaken during the FRMS indicates that many residents in low lying areas are still dealing with the psychological stress of the severe flooding that resulted in significant property destruction and caused three fatalities. These residents fear that a similar event could occur again and believe that a suitable flood warning system would reduce the potential for similar tragedy to occur again.

The higher degree of uncertainty associated with a solely rainfall based system is unlikely to fit in with community expectations of a flood warning system. A water level based flood warning system would provide a higher degree of certainty in the warning and can be more easily related to the degree of flood risk (i.e. number of properties inundated) that exists in the Dungog tailwater. While a hybrid (model based) flood warning system may be able to produce more accurate estimates of peak water level and would provide an increase in the available warning time, given the relative ease of evacuation for properties in Dungog it would be difficult to justify the higher cost of such a system.

Based on the above, it is recommended that a water level based flood warning system is implemented in Dungog to reduce fear in the community and potentially protect against further tragedy. The initial cost for such a system could cost up to $55,000 (for a single water level gauge (including camera feed)), including low powered sirens or flashing light and $15,000 for consultancy, design and installation) and an annual allowance of $1600 for ongoing costs is required. It is also recommended that flood gauge boards be installed at key locations (cost ~$7,500). These signs provide an alternate manual system should the water level gauge fail during an event. The signs would also be useful for ongoing community flood education and engagement.

The suitability of the existing “dipstick gauge” should be investigated for inclusion in the proposed flood warning system either as a primary or secondary water level gauge. If the gauge is considered appropriate as a primary gauge, the cost of implementing a flood warning system in Dungog could be considerably reduced.

In order to increase available warning times, the addition of rainfall based triggers is recommended. The addition of the two available BoM rainfall gauges to the flood warning system would cost $1200/yr and allowance of up to $15,000 may be required to refine alert triggers. The use of predicted (i.e. forecast) rainfall products should also be considered to provide even greater flood warning times. These increased flood warning times would assist emergency services such as the SES coordinate resources during severe flood events. When developing the flood warning service, it is recommended that input from the new national Flash Flood Advisory Resource (FLARE) is sought. FLARE is an authoritative resource created to assist responsible agencies to design, implement and manage fit-for-purpose flash flood warning systems. FLARE is coordinated by the BoM and aims to help agencies, and through them the community, to increase their resilience to flash floods through better preparation and more effective response.

PART B – FLOODPLAIN RISK MANAGEMENT PLAN

8 Draft Dungog Floodplain Risk Management Plan

8.1 Introduction

The following section forms the draft Dungog Floodplain Risk Management Plan (the FRM Plan) and provides a framework by which the plan will be implemented. The objective of this Plan is to recommend a range of property, response and flood modification measures to mitigate the existing and future flood affectation in the study area. This plan has been completed in accordance with the Floodplain Development Manual (NSW State Government, 2005).

8.2 Floodplain Risk Management Measures

The implementation program essentially forms the action list for this Plan and is shown in **Table 8-1**. The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these options. Further steps in the floodplain management process include:

- Draft Plan to be exhibited for public comment
- Plan to be finalised incorporating public comments
- Floodplain Management Committee to consider and adopt recommendations of this Plan;
- Council to consider the Floodplain Management Committee's recommendations;
- Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate; and
- As funds become available from Council's own resources, OEH and/or other state government agencies, implement the measures in accordance with the established priorities.

Table 6-10, provides a summary and brief analysis of the all the Floodplain Risk Management options including further details of what each option entails. Full details of the options are provided in the Dungog Floodplain Risk Management Study (i.e. Part A of this document (mostly in **Section 6.4**)).

The FRM Plan as detailed in **Table 8-1**, should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the FRM Plan.

Table 8-1: Mitigation Measures Recommended for Implementation

Measure*	Description	Estimated Capital Costs and (Ongoing Costs)	Responsibility and Funding	Priority / Time frame
O11	Flood Warning System	$50,000 to $100,000 ($5,000 / yr)	Council and OEH	**Very High** 1-2 years[1]
P1	Adopt non-standard FPL for Dungog tailwater	Council staff time of ~$5,000	Council	**Very High** <1 years
EM1	Emergency Management Planning (develop a Local Flood Plan)	SES and Council staff time of ~$10,000	SES.	**High** <1 years
P2	Update LEP for purchased properties near Bennett Bridge	Council staff time of $5,000	Council	**High** <1 years
O9	VP for 3 properties, VHR for 4 properties demolition of 6 Alison Court properties.	VP = $900,000 VHR = $200,000 Demolition = $120,000	VP – Council and OEH VHR - Property owner and OEH Demolition – Council[2]	**High** 1-5 years[2]
O10	Bennett Park Tennis Court Surface Protection	Synpave - $100,000 Bonded grass - $180,000.	Club and/or Council and/or Insurance Agency.	**Medium** After flood damage
EM2	Community Flood Education	Council / SES staff time ~$10,000	Council / SES.	**Medium** 2-5 years
O2	Minor Bridge Upgrade	$4.4 Million	Council and/or NSW RMS and OEH	**Low** 5-50 years[3]

Notes: * details of the mitigation measures are provided in **Table 6-10**, and **Section 6.4**

VP = Voluntary Purchase, VHR = Voluntary House Raising

1) a NSW Floodplain Management Application for the Flood Warning System was submitted in April 2017.

2) the demolition of 6 Alison Court properties was approved by Council in April 2017. VP and VHR options are subject to the availability of Council and OEH funding and negotiations with property owners. Funding for the demolition of the 6 properties through Federal Government Disaster Recovery Funds has been approved in principle but has not been forthcoming at this time.

3) This option should be considered if bridge upgrades are being considered due to maintenance or capacity requirements or if increases in storm intensity produce more regular flooding in Dungog.

8.3 Funding, Implementation and Actions

8.3.1 Funding and Implementation

The timing of the implementation of recommended measures will depend on the available resources, overall budgetary commitments of Council and the availability of funds and support from other sources. It is envisaged that the FRM Plan would be implemented progressively over a 5 year time frame.

There are a variety of sources of potential funding that could be considered to implement the FRM Plan. These include:

- Council funds and staff resources;
- Section 94 contributions;
- State funding for flood risk management measures through the Office of Environment and Heritage; and
- State Emergency Service, either through volunteered time or funding assistance for emergency management measures.

State funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State:Council) basis. Although much of the FRM Plan may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the floodplain management plan.

8.3.2 Flood Risk Management Plan Actions

In September 2016, Dungog Shire Council (with 2:1 funding from NSW OEH) purchased the five properties on Dowling Street adjacent to Bennett Bridge that were washed away during the April 2015 super storm. The removal of these high risk lands from private ownership ensures that the overall level of flood risk in Dungog has been reduced. Council will need to update the LEP to ensure that future development in this location considers the high flood risk at these locations.

The demolition of 6 Council owned Alison Court properties was supported by Dungog Council in April 2017, as it was deemed that independent senior living units should not be allowed in the newly designated FPA (flood planning area). The demolition of these units is likely to occur in 2018, however this is dependent on funding. Funding was originally promised from a Federal Government disaster recovery source, however, the actual funds are yet to be paid. The demolition of these 6 properties will reduce the risk to life and also future flood damages and was included in both the VHR and VP options assessed in mitigation options O8 and O9.

In April 2017, Dungog Council submitted a floodplain management grant application to obtain 2/3 funding from the NSW Government Office of Environment and Heritage (OEH) for the design, installation and operation of a flood warning system for Dungog. If the grant application is successful the flood warning system should be operational by 2019. A flood warning system that improves the time available for evacuation of all properties that are potentially flood affected (including those deemed suitable for VHR) should reduce risk to life in Dungog.

The voluntary purchase (VP) of 3 properties is recommended in the plan and is subject to Council's resolution to acquire the property and the property owners concurrence to participate.

This measure can be the subject of an OEH grant application (due for lodgement in March each year) at Councils discretion and if successful Council would be required to fund 1/3 of the costs of purchase while OEH would fund 2/3 costs. Similarly, the Voluntary House Raising (VHR) of 4 properties is recommended in the plan and is subject to Council's resolution and the property owners concurrence to participate. Whilst Council may lodge a grant application for VHR at its discretion, if successful property owners would likely be required to pay 1/3 of the costs while OEH would fund 2/3 of the costs.

Emergency management in Dungog is also being improved with SES updating currently in the process of updating their Flood Plan using information produced during this FRMS&P study. The updated Flood Plan was released in July 2017 and will assist the SES improve the efficiency and effectiveness of evacuating at risk properties in Dungog.

9 References

1. AEMI (2013), **Managing the floodplain: a guide to best practice in flood risk management in Australia,** Edited and published by the Australian Emergency Management Institute (AEMI), part of the Australian Government Attorney-General's Department.
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Appendix A – Mitigation Option Cost Calculations

Appendix A presents detailed cost estimations which been undertaken for the five mitigation options listed below:

O1) Major Myall Creek (Road and Rail) Bridge Modifications
O2) Minor Myall Creek (Road and Rail) Bridge Modifications
O3) Myall Creek Levee with Pumps
O4) Myall Creek Levee with Diversion Culverts
O5) Vegetation Removal with Scour Protection

These cost estimates are indicative and are based on our experience from a number of projects at a range of sites and conditions. This estimates are provided for broad guidance only and are NOT guaranteed by Royal HaskoningDHV as we have no control over contractor's prices, market forces and competitive bids from tenderers. Any construction cost estimates provided may exclude items which should be considered in a cost plan. Examples of such items are design fees, project management fees, authority approval fees, contractors risk, preliminaries and project contingencies (e.g. to account for construction and site conditions, weather conditions, ground conditions and unknown services). If a reliable cost estimate is required, an appropriately qualified Quantity Surveyor should be engaged and market feedback sought.

It should be noted that the cost estimates are suitable for the comparison and assessment of the mitigation options for the Dungog Floodplain Risk Management Study.

Budget Cost Estimate

Haskoning Australia Pty Ltd

Date: 5-Dec-16

Client: Dungog Shire Council

RHDHV Job No. PA1316

Project Name: Dungog Floodplain Risk Management Study & Plan

OPTION O1 - Major Modifications of the Myall Creek Road and Rail Bridg

Item #	Description	Rate	Unit	Qty	Total
1	**General**				
1.1	Site establishment	$ 20,000	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 2,500	Weeks	12	$ 30,000
1.3	Survey, Service Location and setout of works by surveyor	$ 5,000	Days	3	$ 15,000
1.4	Geotechnical testing and certification of pavements	$ 150	Tests	10	$ 1,500
1.5	Relocation and protection of Services	$ 80,000	item	1	$ 80,000
1.6	Traffic control	$ 20,000	item	1	$ 20,000
1.7	Preparation and implementation of Works EMP	$ 20,000	item	1	$ 20,000
				Subtotal	**$ 186,500**
2	**Clearing**				
2.1	Clear trees mulch and stockpile on site	$ 10.00	sqm	2,500	$ 25,000
				Subtotal	**$ 25,000**
3	**Topsoil & Mulch**				
3.1	Strip and Stockpile 150mm of topsoil from construction areas	$ 4.50	cum	5,625	$ 25,313
3.2	Replace 150mm topsoil on construction areas	$ 5.60	cum	5,625	$ 31,500
				Subtotal	**$ 56,813**
4	**Bulk Earthworks**				
4.1	Bulk Excavation to form lowered overbank areas	$ 4.50	cum	36,000	$ 162,000
4.2	Imported Fill for Abutments, Bedding and Surrounds	$ 25.00	cum	1,748	$ 43,700
				Subtotal	**$ 205,700**
5	**Roadworks**				
5.1	30mm AC Concrete	$ 16.50	sqm	1,300	$ 21,450
5.2	7mm Primer Seal	$ 5.70	sqm	1,300	$ 7,410
5.3	150mm Basecourse	$ 15.00	sqm	1,300	$ 19,500
5.4	380mm Sub-base	$ 60.00	sqm	1,300	$ 78,000
5.5	Allowance to make smooth connection with existing road	$ 200.00	lin.m	20	o1
				Subtotal	**$ 126,360**
6	**Concrete Works**				
6.1	Upright Kerb and Gutter (road bridge and approaches)	$ 240	lin.m	240	$ 57,600
6.2	Concrete Footpath (on one side of the bridge)	$ 35	sqm	300	$ 10,500
6.3	Road Box Culvert Headwall	$ 1,100	cum	52	$ 57,640
6.4	Road Box Culvert Base and Apron Slabs	$ 600	cum	540	$ 324,000
6.5	Road Box Culvert Wingwalls	$ 1,100	cum	26	$ 28,160
6.6	*Rail* Box Culvert Headwall	$ 1,100	cum	41	$ 45,320
6.7	*Rail* Box Culvert Base and Apron Slabs	$ 600	cum	312	$ 187,200
6.8	*Rail* Box Culvert Wingwalls	$ 1,100	cum	13	$ 14,080
				Subtotal	**$ 724,500**
7	**Culverts Units**				
7.1	Road Culvert - Standard 3.6 x 3.0 Box Culvert Crown Units delivered to site	$ 7,500	item	135	$ 1,012,500
7.2	Rail Culvert - Bespoke 3.6m wide x 3.0m high RC Culvert Units delivered to site	$ 10,000	item	60	$ 600,000
7.3	Road Culvert Construction	$ 400,000	item	1	$ 400,000
7.4	Rail Culvert Construction	$ 800,000	item	1	$ 800,000
				Subtotal	**$ 2,812,500**
8	**Allowance for Timber Piling under base slab units (say 20m length of base slab closest to creekline)**				
8.1	Road - 300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	1,111	$ 322,222
8.2	Road - Allowance to Cut Timber Piles to Length	$ 60	item	111	$ 6,660
8.3	Road - Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	111	$ 16,650
8.4	Rail - 300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	667	$ 193,333
8.5	Rail - Allowance to Cut Timber Piles to Length	$ 60	item	66	$ 3,960
8.6	Rail - Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	66	$ 9,900
				Subtotal	**$ 552,726**
9	**Scour Protection**				
9.1	Road - Geotextile Fabric	$ 7	sqm	600	$ 3,900
9.2	Road - Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	600	$ 90,000
9.3	Road - Allow for 400mm underlayer	$ 65	sqm	600	$ 39,000
9.4	Rail - Geotextile Fabric	$ 7	sqm	480	$ 3,120
9.5	Rail - Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	480	$ 72,000
9.6	Rail - Allow for 400mm underlayer	$ 65	sqm	480	$ 31,200
				Subtotal	**$ 239,220**
				SUBTOTAL (excl. GST)	**$ 4,929,318**
				Engineering Design (4%)	$ 197,172.72
				Environmental Assessment and Approvals	$ 50,000
				Tender Preparation (0.6%)	$ 29,576
				Supervision and Contract Administration (2%)	$ 98,586.36
				Contingency (30%)	$ 1,478,795
				TOTAL (excl. GST)	**$ 6,783,448**

Budget Cost Estimate

Haskoning Australia Pty Ltd

Date: 5-Dec-16

Client: Dungog Shire Council

RHDHV Job No. PA1316

Project Name: Dungog Floodplain Risk Management Study & Plan

OPTION O2 - Minor Modifications of the Myall Creek Road and Rail Bridg

Item #	Description	Rate	Unit	Qty	Total
1	**General**				
1.1	Site establishment	$ 20,000	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 2,500	Weeks	12	$ 30,000
1.3	Survey, Service Location and setout of works by surveyor	$ 5,000	Days	3	$ 15,000
1.4	Geotechnical testing and certification of pavements	$ 150	Tests	10	$ 1,500
1.5	Relocation and protection of Services	$ 80,000	item	1	$ 80,000
1.6	Traffic control	$ 20,000	item	1	$ 20,000
1.7	Preparation and implementation of Works EMP	$ 20,000	item	1	$ 20,000
				Subtotal	**$ 186,500**
2	**Clearing**				
2.1	Clear trees mulch and stockpile on site	$ 10.00	sqm	1,800	$ 18,000
				Subtotal	**$ 18,000**
3	**Topsoil & Mulch**				
3.1	Strip and Stockpile 150mm of topsoil from construction areas	$ 4.50	cum	4,200	$ 18,900
3.2	Replace 150mm topsoil on construction areas	$ 5.60	cum	4,200	$ 23,520
				Subtotal	**$ 42,420**
4	**Bulk Earthworks**				
4.1	Bulk Excavation to form lowered overbank areas	$ 4.50	cum	25,000	$ 112,500
4.2	Imported Fill for Abutments, Bedding and Surrounds	$ 25.00	cum	1,273	$ 31,825
				Subtotal	**$ 144,325**
5	**Roadworks**				
5.1	30mm AC Concrete	$ 16.50	sqm	650	$ 10,725
5.2	7mm Primer Seal	$ 5.70	sqm	650	$ 3,705
5.3	150mm Basecourse	$ 15.00	sqm	650	$ 9,750
5.4	380mm Sub-base	$ 60.00	sqm	650	$ 39,000
5.5	Allowance to make smooth connection with existing road	$ 200.00	lin.m	20	$ 4,000
				Subtotal	**$ 67,180**
6	**Concrete Works**				
6.1	Upright Kerb and Gutter (road bridge and approaches)	$ 240	lin.m	120	$ 28,800
6.2	Concrete Footpath (on one side of the bridge)	$ 35	sqm	150	$ 5,250
6.3	Road Box Culvert Headwall	$ 1,100	cum	27	$ 30,140
6.4	Road Box Culvert Base and Apron Slabs	$ 600	cum	270	$ 162,000
6.5	Road Box Culvert Wingwalls	$ 1,100	cum	26	$ 28,160
6.6	*Rail* Box Culvert Headwall	$ 1,100	cum	24	$ 26,070
6.7	*Rail* Box Culvert Base and Apron Slabs	$ 600	cum	176	$ 105,300
6.8	*Rail* Box Culvert Wingwalls	$ 1,100	cum	13	$ 14,080
				Subtotal	**$ 399,800**
7	**Culverts Units**				
7.1	Road Culvert - Standard 3.6m wide x 3.0m high Box Culvert Crown Units delivered to site	$ 7,500	item	70	$ 525,000
7.2	Rail Culvert - Bespoke 3.6m wide x 3.0m high RC Culvert Units delivered to site	$ 10,000	item	42	$ 420,000
7.3	Road Culvert Construction	$ 200,000	item	1	$ 200,000
7.4	Rail Culvert Construction	$ 500,000	item	1	$ 500,000
				Subtotal	**$ 1,645,000**
8	**Allowance for Timber Piling under base slab units (say 20m length of base slab closest to creekline)**				
8.1	Road - 300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	1,111	$ 322,222
8.2	Road - Allowance to Cut Timber Piles to Length	$ 60	item	111	$ 6,660
8.3	Road - Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	111	$ 16,650
8.4	Rail - 300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	667	$ 193,333
8.5	Rail - Allowance to Cut Timber Piles to Length	$ 60	item	66	$ 3,960
8.6	Rail - Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	66	$ 9,900
				Subtotal	**$ 552,726**
9	**Scour Protection**				
9.1	Road - Geotextile Fabric	$ 7	sqm	300	$ 1,950
9.2	Road - Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	300	$ 45,000
9.3	Road - Allow for 400mm underlayer	$ 65	sqm	300	$ 19,500
9.4	Rail - Geotextile Fabric	$ 7	sqm	270	$ 1,755
9.5	Rail - Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	270	$ 40,500
9.6	Rail - Allow for 400mm underlayer	$ 65	sqm	270	$ 17,550
				Subtotal	**$ 126,255**
				SUBTOTAL (excl. GST)	**$ 3,182,206**
				Engineering Design (4%)	$ 127,288.22
				Environmental Assessment and Approvals	$ 50,000
				Tender Preparation (0.6%)	$ 19,093
				Supervision and Contract Administration (2%)	$ 63,644.11
				Contingency (30%)	$ 954,662
				TOTAL (excl. GST)	**$ 4,396,893**

Budget Cost Estimate

Haskoning Australia Pty Ltd

Date: 5-Dec-16

Client: Dungog Shire Council

RHDHV Job No. PA1316

Project Name: Dungog Floodplain Risk Management Study & Plan

OPTION O3 - Levee with 5 cumec pump capacity

Item #	Description	Rate	Unit	Qty	Total
1	**General**				
1.1	Site establishment	$ 20,000	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 2,500	Weeks	12	$ 30,000
1.3	Survey, Service Location and setout of works by surveyor	$ 5,000	Days	3	$ 15,000
1.4	Geotechnical testing and certification of pavements	$ 150	Tests	10	$ 1,500
1.5	Relocation and protection of Services	$ 80,000	item	1	$ 80,000
1.6	Traffic control	$ 20,000	item	1	$ 20,000
1.7	Preparation and implementation of Works EMP	$ 20,000	item	1	$ 20,000
				Subtotal	**$ 186,500**
2	**Clearing**				
2.1	Clear trees mulch and stockpile on site	$ 10.00	sqm	300	$ 3,000
				Subtotal	**$ 3,000**
3	**Topsoil, Mulch and Turf**				
3.1	Strip and Stockpile 150mm of topsoil from construction areas	$ 4.50	cum	2,738	$ 12,319
3.2	Replace 150mm topsoil on construction areas	$ 5.60	cum	3,518	$ 19,698
3.3	Turf to Embankment	$ 5.60	cum	3,518	$ 19,698
				Subtotal	**$ 32,017**
4	**Bulk Earthworks for Levee**				
4.1	Bulk Excavation to form cut-off trench (1.5m deep)	$ 4.50	cum	4,050	$ 18,225
4.2	Bulk Excavation to Detention Storages	$ 4.50	cum	4,000	$ 18,000
4.3	Imported Fill for Embankment and cut off trench	$ 25.00	cum	47,250	$ 1,181,250
				Subtotal	**$ 1,217,475**
5	**Blockwork Levee Wall**				
5.1	Reinforced Concrete Footing Including Excavation	$ 564	cum	95	$ 53,298
5.2	Blockwork Wall	$ 233	sqm	768	$ 178,944
5.3	Sheetpile Wall Footing (assume 60m length adjacent to Creek, 12m width)	$ 650	sqm	720	$ 468,000
				Subtotal	**$ 700,242**
6	**Roadworks**				
6.1	30mm AC Concrete	$ 16.50	sqm		$ -
6.2	7mm Primer Seal	$ 5.70	sqm		$ -
6.3	150mm Basecourse	$ 15.00	sqm		$ -
6.4	380mm Sub-base	$ 60.00	sqm		$ -
6.5	Allowance to make smooth connection with existing road	$ 200.00	lin.m		$ -
				Subtotal	**$ -**
7	**Concrete Works**				
7.1	Upright Kerb and Gutter (road bridge and approaches)	$ 240	lin.m	20	$ 4,800
7.2	Concrete Lined Spillway	$ 600	cum	720	$ 432,000
7.3	Box Culvert Headwall	$ 1,100	cum	25	$ 27,500
7.4	Box Culvert Base and Apron Slabs	$ 600	cum	96	$ 57,600
7.5	Box Culvert Wingwalls	$ 1,100	cum	13	$ 14,080
				Subtotal	**$ 535,980**
8	**Culverts Units**				
8.1	Levee Culverts - Standard 3.6 x 3.6 Box Culvert Crown Units delivered to site	$ 8,500	item	33.00	$ 280,500
8.2	Levee Culvert Construction	$ 300,000	item	1	$ 300,000
				Subtotal	**$ 580,500**
9	**Stormwater Pump Stations**				
9.1	Excavation for Wet Well on each outlet	$ 10	item	500	$ 5,000
9.2	Pump Well and Intake Works	$ 430,000	item	1	$ 430,000
9.3	Outlet Pipes and Structures	$ 725,000	item	1	$ 725,000
9.4	Supply and Installation of 1000 l/s (55 KW) pumps and galvanised steel disharge column	$ 150,000	item	5	$ 750,000
9.5	Electrical Connection	$ 250,000	item	1	$ 250,000
9.6	Pump Control System	$ 250,000	item	1	$ 250,000
9.7	Make Good Surface Features	$ 60,000	item	1	$ 60,000
				Subtotal	**$ 2,470,000**
9	**Allowance for Timber Piling under base slab units (say 6 culvert lengths of base slab in low lying areas)**				
9.1	300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	240	$ 69,600
9.2	Allowance to Cut Timber Piles to Length	$ 60	item	24	$ 1,440
9.3	Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	24	$ 3,600
				Subtotal	**$ 74,640**
10	**Scour Protection**				
10.1	Geotextile Fabric	$ 7	sqm	100	$ 650
10.2	Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	100	$ 15,000
10.3	Allow for 400mm underlayer	$ 65	sqm	100	$ 6,500
				Subtotal	**$ 22,150**
				SUBTOTAL (excl. GST)	**$ 5,822,504**
				Engineering Design (4%)	$ 232,900.15
				Environmental Assessment and Approvals	$ 50,000
				Tender Preparation (0.6%)	$ 34,935
				Supervision and Contract Administration (2%)	$ 116,450.08
				Contingency (30%)	$ 1,746,751
				TOTAL (excl. GST)	**$ 8,003,540**

Budget Cost Estimate

Haskoning Australia Pty Ltd

Date: 5-Dec-16

Client: Dungog Shire Council

RHDHV Job No. PA1316

Project Name: Dungog Floodplain Risk Management Study & Plan

OPTION O4 - Levee with Diversion Culvert

Item #	Description	Rate	Unit	Qty	Total
1	**General**				
1.1	Site establishment	$ 20,000	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 2,500	Weeks	12	$ 30,000
1.3	Survey, Service Location and setout of works by surveyor	$ 5,000	Days	3	$ 15,000
1.4	Geotechnical testing and certification of pavements	$ 150	Tests	10	$ 1,500
1.5	Relocation and protection of Services	$ 80,000	item	1	$ 80,000
1.6	Traffic control	$ 20,000	item	1	$ 20,000
1.7	Preparation and implementation of Works EMP	$ 20,000	item	1	$ 20,000
				Subtotal	**$ 186,500**
2	**Clearing**				
2.1	Clear trees mulch and stockpile on site	$ 10.00	sqm	300	$ 3,000
				Subtotal	**$ 3,000**
3	**Topsoil, Mulch and Turf**				
3.1	Strip and Stockpile 150mm of topsoil from construction areas	$ 4.50	cum	2,738	$ 12,319
3.2	Replace 150mm topsoil on construction areas	$ 5.60	cum	3,518	$ 19,698
3.3	Turf to Embankment	$ 5.60	cum	3,518	$ 19,698
				Subtotal	**$ 32,017**
4	**Bulk Earthworks for Levee**				
4.1	Bulk Excavation to form cut- off trench (1.5m deep)	$ 4.50	cum	4,050	$ 18,225
4.2	Bulk Excavation to Detention Storages	$ 4.50	cum	4,000	$ 18,000
4.3	Imported Fill for Embankment and cut off trench	$ 25.00	cum	47,250	$ 1,181,250
				Subtotal	**$ 1,217,475**
5	**Blockwork Levee Wall**				
5.1	Reinforced Concrete Footing Including Excavation	$ 564	cum	95	$ 53,298
5.2	Blockwork Wall	$ 233	sqm	768	$ 178,944
5.3	Sheetpile Wall Footing (assume 60m length adjacent to Creek, 12m length)	$ 650	sqm	720	$ 468,000
				Subtotal	**$ 700,242**
6	**Roadworks**				
6.1	30mm AC Concrete	$ 16.50	sqm	200	$ 3,300
6.2	7mm Primer Seal	$ 5.70	sqm	200	$ 1,140
6.3	150mm Basecourse	$ 15.00	sqm	200	$ 3,000
6.4	380mm Sub- base	$ 60.00	sqm	200	$ 12,000
6.5	Allowance to make smooth connection with existing road	$ 200.00	lin.m	20	$ 4,000
				Subtotal	**$ 23,440**
7	**Concrete Works**				
7.1	Upright Kerb and Gutter (road bridge and approaches)	$ 240	lin.m	20	$ 4,800
7.2	Concrete Lined Spillway	$ 600	cum	720	$ 432,000
7.3	Box Culvert Headwall	$ 1,100	cum	25	$ 27,500
7.4	Box Culvert Base and Apron Slabs	$ 600	cum	96	$ 57,600
7.5	Box Culvert Wingwalls	$ 1,100	cum	13	$ 14,080
				Subtotal	**$ 535,980**
8	**Culverts Units (through levee)**				
8.1	Levee Culverts - Standard 3.6 x 3.6 Box Culvert Crown Units delivered to site	$ 8,500	item	33.00	$ 280,500
8.2	Levee Culvert Construction	$ 300,000	item	1	$ 300,000
				Subtotal	**$ 580,500**
9	**Culverts Units (to d/s Bennett Bridge)**				
9.1	250m Culverts - Standard 3.6 x 3.6 Box Culvert Crown Units delivered to site	$ 8,500	item	104	$ 884,000
9.2	Levee Culvert Construction	$ 300,000	item	3	$ 900,000
9.3	Inlet / Outlet Structures	$ 10,000	item	2	$ 20,000
9.7			item	-	$ -
				Subtotal	**$ 1,804,000**
9	**Allowance for Timber Piling under base slab units (say 6 culvert lengths of base slab in low lying areas)**				
9.1	300 Diameter F17 Grade hardwood timber piles to H5 treatment class driven to 500kN load capacity (assumed 10m pile lenths) - assumes 4No. Piles per Culvert Unit	$ 290	m	240	$ 69,600
9.2	Allowance to Cut Timber Piles to Length	$ 60	item	24	$ 1,440
9.3	Allowance for M24 Coach Screws galv embedded 250mm into timber piles	$ 150	item	24	$ 3,600
				Subtotal	**$ 74,640**
10	**Scour Protection**				
10.1	Geotextile Fabric	$ 7	sqm	100	$ 650
10.2	Allow for 800mm thick Rock Rip- Rap Armour	$ 150	sqm	100	$ 15,000
10.3	Allow for 400mm underlayer	$ 65	sqm	100	$ 6,500
				Subtotal	**$ 22,150**
				SUBTOTAL (excl. GST)	**$ 5,179,944**
				Engineering Design (4%)	$ 207,197.75
				Environmental Assessment and Approvals	$ 50,000
				Tender Preparation (0.6%)	$ 31,080
				Supervision and Contract Administration (2%)	$ 103,598.88
				Contingency (30%)	$ 1,553,983
				TOTAL (excl. GST)	**$ 7,125,803**

Budget Cost Estimate

Haskoning Australia Pty Ltd

Date: 5-Dec-16

Client: Dungog Shire Council

RHDHV Job No. PA1316

Project Name: Dungog Floodplain Risk Management Study & Plan

OPTION O5 - Channel Vegetation Removal with Scour Protection

Item #	Description	Rate	Unit	Qty	Total
1	**General**				
1.1	Site establishment	$ 20,000	item	1	$ 20,000
1.2	Supervision, management, amenities	$ 2,500	Weeks	12	$ 30,000
1.3	Survey, Service Location and setout of works by surveyor	$ 5,000	Days	2	$ 10,000
1.4	Geotechnical testing and certification of pavements	$ 150	Tests	1	$ 150
1.5	Relocation and protection of Services	$ 15,000	item	1	$ 15,000
1.6	Relocation and protection of Fauna	$ 200,000	item	1	$ 200,000
1.7	Traffic control	$ 20,000	item	1	$ 20,000
1.8	Preparation and implementation of Works EMP	$ 20,000	item	1	$ 20,000
				Subtotal	**$ 315,150**
2	**Clearing**				
2.1	Clear trees mulch and stockpile on site	$ 20.00	sqm	25,000	$ 500,000
2.2	Transport of Mulch Offsite for Re-use	$ 15.00	tonne	20,000	$ 300,000
				Subtotal	**$ 800,000**
3	**Scour Protection for Channel Invert**				
3.1	Geotextile Fabric	$ 7	sqm	5,000	$ 32,500
3.2	Allow for 800mm thick Rock Rip-Rap Armour	$ 150	sqm	5,000	$ 750,000
3.3	Allow for 400mm underlayer	$ 65	sqm	5,000	$ 325,000
				Subtotal	**$ 1,107,500**
4	**Bed Stabilisation with Less Dense Vegetation**				
4.1	150mm topsoil on bank areas	$ 5.60	cum	2,850	$ 15,960
4.2	Planting	$ 15.00	sqm	15,000	$ 225,000
				Subtotal	**$ 240,960**
				SUBTOTAL (excl. GST)	**$ 2,463,610**
				Design (4%)	$ 98,544.40
				Environmental Assessment and Approvals	$ 150,000
				Tender Preparation (0.6%)	$ 14,782
				Supervision and Contract Administration (2%)	$ 49,272.20
				Contingency (30%)	$ 739,083
				TOTAL (excl. GST)	**$ 3,515,291**

Appendix B

Council reports and resolutions concerning Dungog Flood Risk Management Study and Plan

Paul Minett

3. DRAFT DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN EF15/84

Precis:

The purpose of this report is to seek resolution to place the Draft Dungog Flood Risk Management Study and Plan on public exhibition.

****

BACKGROUND

Councillors are aware that work is continuing in relation to the preparation of the Dungog Flood Risk Management Study and Plan(FRMS&P). This work is being carried out by consultants Royal Haskoning DHV (RHDHV) under the supervision of Council's Flood Plain Management Committee and in accordance with the NSW Flood Plain Management Manual and conditions imposed by the NSW Office of Environment and Heritage (OEH) under its Floodplain Management Grants program.

The process set down in the NSW Flood Plain Management Manual for the preparation of Flood Risk Management Studies has been followed and it is expected that the project will be completed by the end of September 2017.

A Draft Flood Risk Management Study and Plan has now been prepared and is ready to be placed on Public Exhibition.

The Draft Study and Plan contains the following information –

- An explanation of the Study Objectives
- Description of the Dungog catchment flood mechanisms
- A summary of the Public Consultation process followed
- A description of existing flood behaviour, property inundation and damages
- A review of existing Planning provisions.
- An assessment of Floodplain Management measures
- A detailed assessment of Early Flood warning systems for Dungog
- The **Draft Plan** which provides recommended actions to address flood management in Dungog.

The Flood Risk Management Plan component provides a list of prioritised flood mitigation measures along with the costs associated with achieving them.

The priority areas under the plan include –

- The design and installation of an effective early flood warning system for Dungog
- The Voluntary Purchase of 3 affected properties.
- The Voluntary House raising of 4 affected properties.
- Review of Emergency management responses in association with the SES and the updating of the Dungog Flood plan.

Copies of the Draft Study and Plan can be made available to interested Councillors on request but due to the size of the document have not been attached to this report.

COMMUNITY CONSULTATION

A range of consultation and communication methods have been utilised to date in the preparation of the Dungog FRMS&P including:

- A media release in the Dungog Chronicle at the start of the project;
- Development of a project study website providing information on the study (www.dungogfloodstudy.org);
- Development of a project study facebook page providing information and an opportunity for feedback and engagement. (www.facebook.com/DungogFloodStudy);
- An information brochure and questionnaire was delivered to all residents and businesses in Dungog informing them of the study and requesting any information on previous flood events. The survey is available online at www.surveymonkey.com/r/DungogFloodStudy
- Discussion with individual home owners during site visits; and
- A community information evening held on 7 December 2016 at the Doug Walters Pavilion.
- A further community information session is intended to be held during the exhibition period on 5 July 2017 at the Doug Walters Pavilion.

IMPLICATIONS

Financial

The preparation of the Dungog Flood Study, which has been incorporated into the overall process of preparing the Dungog FRMS&P is part of a project funded under the NSW Flood Plain Management Grants Program. Grant funding of $140,000 has been allocated by the Office of Environment and Heritage on a $2:$1 basis with Council's $70,000 share of the project being funded through the floodplain management budget allocation.

Legislative

It is compulsory for the Draft Dungog Flood Study to be placed on public exhibition. The exhibition process seeks community feedback to assist the ongoing development and finalization of the Dungog Flood Risk Management Study and Plan.

OFFICERS RECOMMENDATION

The Draft Dungog Flood Risk Management Study be placed on Public exhibition for a period of 28 days.

Parks/Reserves/Cemeteries:-
The following Parks/Reserves/Cemeteries were mown *(the number of mowings is shown in brackets)*:- Jubilee Park (2), Lions Park (Clarence Town Road) (1), Lions Park (Scott Avenue) (1), Bryun Park (1), Apex Park (1), Frank Robison Memorial Park (2), Dave Sands Memorial (1), Paterson War Memorial (1), Kings Wharf Reserve (1), John Tucker Park (1), Allan Fairhall Reserve (1), Skipline Park (1), Vacy Park (1), Orana Park (1), Gresford Skate Park (1), Dungog Cemetery (1), Paterson Cemetery (1), Clarence Town Cemetery (1).

Major Works scheduled to be continued or commenced in the next 3 months:-

Attached as **Annexure 'C'** is a list of the major works scheduled for the forthcoming 3 months.

IMPLICATIONS

There are no financial, statutory, environmental, community or consultative implications of this report.

OFFICERS RECOMMENDATION

That the report be received and the information noted.

ENVIRONMENTAL SERVICES DEPARTMENT
MANAGERS REPORT

Paul Minett

1. PATERSON RIVER FLOOD STUDY
EF15/30

Précis:

This report seeks the adoption of the recently completed Paterson River Flood Study.

****

Minute No. 37455

RESOLVED on the motion of Cr Bowden and seconded by Cr Knudsen that the Paterson River Flood Study be adopted by Council.

Paul Minett

2. DUNGOG CATCHMENT FLOOD PLANNING
EF15/97

Precis:

The purpose of this report is to seek a Council resolution to set a Flood Planning Level for the Dungog township, having regard to the data collected in the Dungog Flood Study.

****

Minute No. 37456

RESOLVED on the motion of Cr Bowden and seconded by Cr Booth that:

1. Council adopt a Flood Planning Level for the Dungog Flood Risk Management Study area of the **500yr ARI (average recurrent interval) plus 0.5 m freeboard.**

2. A planning proposal be prepared and submitted to the Department of Planning and Environment to amend LEP 2014 to affect the new Flood Planning Level.

Paul Minett

3. DRAFT DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN
EF15/84

Precis:

The purpose of this report is to seek resolution to place the Draft Dungog Flood Risk Management Study and Plan on public exhibition.

****

Minute No. 37457

RESOLVED on the motion of Cr Booth and seconded by Cr Bowden that the Draft Dungog Flood Risk Management Study be placed on Public exhibition for a period of 28 days.

ENVIRONMENTAL SERVICES DEPARTMENT MANAGERS REPORT

Paul Minett

1. DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN EF15/84

Precis:

The purpose of this report is to seek resolution to adopt the Dungog Flood Risk Management Study and Plan.

BACKGROUND

The preparation of the Dungog Flood Risk Management Study and Plan(FRMS&P) has now reached its concluding stages.

The Study and Plan have been prepared following the process set down in the NSW Flood Plain Management Manual, commencing in April 2016. Consultants Royal Haskoning DHV (RHDHV) have now provided a finalised version of the Study and Plan and this was endorsed by Council's Flood Plain Management Committee at its meeting on 14 August 2017.

Council resolved at its June Meeting to place the draft Dungog Flood Risk Management Study and Plan on public exhibition and this occurred between 21/06/17 and 21/07/17. A community information session was held during the exhibition period attracting 30 participants and Regional media attention however only one public submission was received. That submission was considered by the Committee with no changes made to the draft document.

Summary of the Dungog Flood Risk Management Study and Plan

The Study and Plan contains the following information –

- An explanation of the Study Objectives
- Description of the Dungog catchment flood mechanisms
- A summary of the Public Consultation process followed
- A description of existing flood behaviour, property inundation and damages
- A review of existing Planning provisions.
- An assessment of Floodplain Management measures
- A detailed assessment of Early Flood Warning Systems for Dungog
- Recommended actions to address flood management in Dungog.

The Flood Risk Management Plan component provides a list of prioritised flood mitigation measures along with the costs associated with achieving them.

The priority areas under the plan include:

- The design and installation of an effective Early Flood Warning System for Dungog- It should be noted that this matter was the subject of some preliminary recommendations (final not handed down as yet) of the recent Coroners inquest into the 2015 storm event, and that some planning actions are already underway in relation to providing an Early Flood Warning System for Dungog.

- The Voluntary Purchase of 3 affected properties.
- The Voluntary House raising of 4 affected properties.
- Review of Emergency management responses in association with the SES and the updating of the Dungog Flood plan.

Copies of Dungog Flood Risk Management Study and Plan can be made available to interested Councillors on request but due to the size of the document have not been attached to this report. Alternatively, Councillors may still access a copy of the Draft document on line at www.dungogfloodstudy.com.au but should note that small editing modifications have occurred in the final document which wont be published online until after Council resolves to adopt it.

COMMUNITY CONSULTATION

A range of consultation and communication methods have been utilised in the preparation of the Dungog FRMS&P including:

- A media release in the Dungog Chronicle at the start of the project;
- Development of a project study website providing information on the study and Plan (www.dungogfloodstudy.com.au), all of the documents that have been adopted by Council to date are accessible at this location.
- Development of a project study facebook page providing information and an opportunity for feedback and engagement.

  (www.facebook.com/DungogFloodStudy);
- An information brochure and questionnaire was delivered to all residents and businesses in Dungog informing them of the study and requesting any information on previous flood events. The survey is available online at www.surveymonkey.com/r/DungogFloodStudy
- Discussion with individual home owners during site visits
- Community information sessions held on the 7th December 2016 and 5th July 2017 at the Doug Walters Pavilion.
- Letter box drops to all residential properties in the Dungog township advising of the information sessions and summarised content of the Study.
- Media news coverage of the information sessions and exhibition period.

IMPLICATIONS

Financial

The Dungog Flood Risk Management Study and Plan, is a $176,975 project funded under the NSW Flood Plain Management Grants Program. The project received grant funding of $117,983 from the Office of Environment and Heritage with Council's share of the project being $58,992.

Recently (5/10/17), a variation to the project was approved by the Office of Environment and Heritage providing an additional $20,000 of grant funding to the project to enable some preliminary planning and design works for an Early Flood Warning System for Dungog. This variation and additional funding was provided on the basis of the Coroners preliminary recommendations into the 2015 storm event which placed a focus, among other things, on the need for a properly designed, installed and maintained Early Flood warning system.

Council should be aware that some of the actions contained in the Flood Risk Management Plan may infer a future Council financial commitment. These actions include:

- the commissioning of an early flood warning system,
- the voluntary purchase of some properties, and
- the consideration of future civil works for some locations.

There is currently no forward budget allocation for these actions and they will be the subject of further reports to Council in the future which would provide funding options and project details prior to seeking resolution to complete the actions.

OFFICERS RECOMMENDATION

The Draft Dungog Flood Risk Management Study and Plan be adopted.

58. The developer being responsible for any costs relating to minor alterations and extensions of existing roads, drainage and Council services for the purposes of the development.

59. The making good to the satisfaction of Council, or payment of the costs incurred by Council in making good, any pavement damage or structural deterioration caused to Council's roads by the use of such roads as haulage routes for materials used in construction or the operation of the approved development.

The Mayor in accordance with Section 375A of the Local Government Act called for a Division. The Division resulted in 8 for 0 against as follows:

For: Crs Norman, Rayward, Wall, Connors, Booth, Lyon, Murphy, Riley.

ENVIRONMENTAL SERVICES DEPARTMENT MANAGERS REPORT

Paul Minett

1. DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN EF15/84

Precis:

The purpose of this report is to seek resolution to adopt the Dungog Flood Risk Management Study and Plan.

****

Minute No. 37552

A MOTION was moved by Cr Connors and seconded by Cr Booth that Council defer consideration of this matter to the November meeting with a briefing held on the subject to inform Councillors in the interim.

On being put the motion was carried.

INFRASTRUCTURE AND ASSETS DEPARTMENT EXECUTIVE MANAGERS REPORT

Steve Hitchens

1. MR101 ROAD FUNDING SPECIFIC PURPOSE GRANT EF16/19

Precis:

This report provides Council with updated information with regards to the Specific Purpose Grant of $10 Million provided by the NSW Government for road upgrades on Main Road 101 (MR101).

****

Minute No. 37553

RESOLVED on the motion of Cr Riley and seconded by Cr Murphy that Council:-

1. Approve modification of the sequence of the projects within the MR101 Specific Purpose Grant Programme to allow the Dungog Road - North of Hilldale Road Intersection to South of Sandy Creek Road Intersection to be undertaken in 2017/2018; and

2. Make application to the Roads & Maritime Service for approval of the above modification.

ENVIRONMENTAL SERVICES DEPARTMENT MANAGERS REPORT

Paul Minett

1. DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN EF15/84

Precis:

The purpose of this report is to seek resolution to adopt the Dungog Flood Risk Management Study and Plan.

****

BACKGROUND

Council deferred consideration of this matter at its October 2017 meeting pending the delivery of a briefing session. This briefing was provided by consultant Royal Haskoning on 13 October 2017.

The preparation of the Dungog Flood Risk Management Study and Plan (FRMS&P) has now reached its concluding stages.

The Study and Plan have been prepared following the process set down in the NSW Flood Plain Management Manual, commencing in April 2016. Consultants Royal Haskoning DHV (RHDHV) have now provided a finalised version of the Study and Plan and this was endorsed by Council's Flood Plain Management Committee at its meeting on 14 August 2017.

Council resolved at its June Meeting to place the draft Dungog Flood Risk Management Study and Plan on public exhibition and this occurred between 21/06/17 and 21/07/17. A community information session was held during the exhibition period attracting 30 participants and Regional media attention however only one public submission was received. That submission was considered by the Committee with no changes made to the draft document.

Summary of the Dungog Flood Risk Management Study and Plan

The Study and Plan contains the following information –

- An explanation of the Study Objectives
- Description of the Dungog catchment flood mechanisms
- A summary of the Public Consultation process followed
- A description of existing flood behaviour, property inundation and damages
- A review of existing Planning provisions.
- An assessment of Floodplain Management measures
- A detailed assessment of Early Flood Warning Systems for Dungog
- Recommended actions to address flood management in Dungog.

The Flood Risk Management Plan component provides a list of prioritised flood mitigation measures along with the costs associated with achieving them.

The priority areas under the plan include –

- The design and installation of an effective Early Flood Warning System for Dungog- It should be noted that this matter was the subject of some preliminary recommendations (final not handed down as yet) of the recent Coroners inquest into the 2015 storm event, and that some planning actions are already underway in relation to providing an Early Flood Warning System for Dungog.

- The Voluntary Purchase of 3 affected properties.

- The Voluntary House raising of 4 affected properties.

- Review of Emergency management responses in association with the SES and the updating of the Dungog Flood plan.

Copies of Dungog Flood Risk Management Study and Plan can be made available to interested Councillors on request but due to the size of the document have not been attached to this report. Alternatively, Councillors may still access a copy of the Draft document on line at www.dungogfloodstudy.com.au but should note that small editing modifications have occurred in the final document which won't be published online until after Council resolves to adopt it.

COMMUNITY CONSULTATION

A range of consultation and communication methods have been utilised in the preparation of the Dungog FRMS&P including:

- A media release in the Dungog Chronicle at the start of the project;
- Development of a project study website providing information on the Study and Plan (www.dungogfloodstudy.com.au), all of the documents that have been adopted by Council to date are accessible at this location.
- Development of a project study facebook page providing information and an opportunity for feedback and engagement.

  (www.facebook.com/DungogFloodStudy);
- An information brochure and questionnaire was delivered to all residents and businesses in Dungog informing them of the study and requesting any information on previous flood events. The survey is available online at www.surveymonkey.com/r/DungogFloodStudy
- Discussion with individual home owners during site visits
- Community information sessions held on the 7th December 2016 and 5th July 2017 at the Doug Walters Pavilion.
- Letter box drops to all residential properties in the Dungog township advising of the information sessions and summarised content of the Study.
- Media news coverage of the information sessions and exhibition period.

IMPLICATIONS

Financial

The Dungog Flood Risk Management Study and Plan, is a $176,975 project funded under the NSW Flood Plain Management Grants Program. The project received grant funding of $117,983 from the Office of Environment and Heritage with Council's share of the project being $58,992.

Recently (5/10/17), a variation to the project was approved by the Office of Environment and Heritage providing an additional $20,000 of grant funding to the project to enable some preliminary planning and design works for an Early Flood Warning System for Dungog. This

variation and additional funding was provided on the basis of the Coroners preliminary recommendations into the 2015 storm event which placed a focus, among other things, on the need for a properly designed, installed and maintained Early Flood warning system.

Council should be aware that some of the actions contained in the Flood Risk Management Plan may infer a future Council financial commitment. These actions include:

- the commissioning of an early flood warning system,
- the voluntary purchase of some properties, and
- the consideration of future civil works for some locations.

There is currently no forward budget allocation for these actions and they will be the subject of further reports to Council in the future which would provide funding options and project details prior to seeking resolution to complete the actions.

OFFICERS RECOMMENDATION

The Draft Dungog Flood Risk Management Study and Plan be adopted.

Paul Minett

2. CHICHESTER TRUNK GRAVITY MAIN – CHANGE TO HUNTER WATER'S CUSTOMER AGREEMENT AND COMMUNITY CONCERN.
EF08/331

Precis:

The purpose of this report is to provide Council with information relating to issues surrounding Hunter Water Corporation's negotiations with "Non Standard Customers" to resolve issues associated with the supply and use of untreated water from the Chichester Trunk Gravity Main between Chichester Dam and the Dungog Water Treatment Plant.

****

Minute No. 37579

A MOTION was moved by Cr Murphy and seconded by Cr Lyon that Council acknowledge the situation with the Chichester Trunk Gravity Main and accept that it is Hunter Water Corporations responsibility to resolve this issue with affected residents. However, Councillors wish to be kept informed of issues affecting residents and request a briefing to be arranged with HWC for interested Councillors to take place in the near future for this purpose.

On being put the motion was carried.

CORPORATE SERVICES DEPARTMENT
EXECUTIVE MANAGERS REPORT

Shaun Chandler

1. QUARTERLY FINANCE REPORT FOR THE PERIOD ENDING 30 SEPTEMBER 2017
EF 08/224

Précis:

Review of expenditure and revenues as per Section 203 of the Local Government (General) Regulation 2005 for the quarter ending 30 September 2017.

****

Minute No. 37580

RESOLVED on the motion of Cr Low and seconded by Cr Riley that the variations to budgeted expenditures and revenues for the September quarter be approved and form part of the Operational Plan 2017/18.

Shaun Chandler

2. GRESFORD DISTRICT AGRICULTURAL SOCIETY INC
EF08/3;

Precis:

Request for financial assistance under Sec 356 of the Local Government Act 1993.

****

Minute No. 37581

RESOLVED on the motion of Cr Murphy and seconded by Cr Lyon that Council donate $250 to the Gresford District Agricultural Society Inc. for the 2018 Gresford Show.

Appendix C

Council report and resolution to prepare a planning proposal

Paul Minett

2. DUNGOG CATCHMENT FLOOD PLANNING EF15/97

Precis:

The purpose of this report is to seek a Council resolution to set a Flood Planning Level for the Dungog township, having regard to the data collected in the Dungog Flood Study.

****

BACKGROUND

Council at its meeting in November 2015 resolved to adopt an interim Flood Planning Level (FPL) after considering information provided in a Post Event Behaviour Analysis of the April 2015 Flood event (BMT-WBM).

At the time, it was considered that an interim FPL was required to guide Council's planning policies until such time as a comprehensive Dungog Flood Risk Management Study was completed. The FPL prior to this was derived from the Williams River Flood Study (2009) however the April 2015 event demonstrated that this Study did not adequately consider the combined influences of Myall Creek, Williams River and local catchment flooding.

The "Flood Planning Level" is used to set the appropriate floor level for new development. It is defined in Clause 6.3(5) of Dungog Local Environment Plan 2014 as –

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

The Dungog Flood Risk Management Study is now well progressed and is due for completion in September 2017. A recommendation to place the Study on public exhibition is the subject of another report to Council in this Business Paper.

Notwithstanding this, Council's consultants have made recommendations, based on flood modelling, in relation to a new FPL. These recommendations will appear in the Draft Dungog Flood Risk Management Study (to be exhibited) however the setting of an appropriate FPL was considered by the Technical sub-committee of the Dungog Flood Committee at its meeting on 27 April 2017. The subcommittee resolved to report to Council to seek the adoption of the new FPL.

It is considered that the work carried out to date on the Dungog Flood Risk Management Study is sufficient for Council to establish the new FPL even though the Study is incomplete. Council will note that the recommended FPL is different to that adopted as an interim FPL in November 2015 and that its adoption will involve the submission of a planning proposal to the NSW Department of Planning as it is proposed to change the wording of LEP 2014 and to submit amended flood mapping for Dungog. This process will take some time so it is considered prudent to commence actions prior to the adoption of the Flood Risk Management Study.

<u>Recommended Flood Planning Level</u>

Based on the consultant's work, the Technical sub committee of the Dungog Flood Committee has resolved to recommend that the Flood Planning Level for the Dungog township be the level of the **500yr ARI (average recurrent interval) plus 0.5 m freeboard.**

Based on the flood mapping presented in the draft Dungog Flood Risk Study, this level is **51.1m AHD plus 0.5 m freeboard. (51.6m AHD).**

To put this level into perspective, the following Table provides a summary of historical Flood Planning Levels in Dungog.

Table1: Summary of Historic Flood Planning levels (FPL) in Dungog (source: Draft Dungog Flood Risk management Study- Royal Haskoning 2017)

Year	Hooke Street FPL (m AHD)	Comments
1979	49.8	Minimum floor level of Alison Court. Based on the observed "Top Floor Level" of 48.8mAHD (Yeo, 2015)
1989/2004	52	An FPL for Dungog of 52mAHD is presented in the "Managing our Floodplains" Chapter of the Dungog Shire Wide DCP No 1.
2009	50.10	Williams River Flood Study (BMT WBM,2009),1% AEP Williams River and Tributaries + 500mm
2015 **(Current Interim FPL**)	50.70	Dungog Post Event Flood Behaviour Analysis (BMT-WBM), 1% AEP Myall Creek with 20%AEP Williams River + 500mm
2017	50.70	Dungog Flood Study (Royal Haskoning 2017), 1% AEP Myall Creel with 10% AEP Williams River + 500mm
Observed April 2015 Flood Level	**52.0 (Flood Level not FPL)**	**This event was extreme and is estimated to be approximately a 0.1%AEP /1000yr ARI**
2017 Recommended	**51.6**	**Dungog Flood Study (Royal Haskoning 2017) 0.2% AEP/500 yr ARI + 500mm**

The Table shows that the recommended FPL is in effect 900mm higher than the interim level adopted by Council in November 2015. It is however 400mm lower than the observed flood level of April 2015.

The proposed FPL has consideration to the large flood on record (April 2015) and the survivability prospects of persons in the event of another similar sized flood or in the event of the Maximum Permissible Flood (PMF) occurring – modelled to be 53.65 m AHD.

Council should be aware that the Flood Planning Level would be applied to new development or additions as defined in the Flood Management chapter of Council's Development Control Plan within the Flood Study area.

It was also considered by the Technical Subcommittee that the proposed FPL should be reviewed once again after the installation and commissioning of a comprehensive Early Flood Warning System for Dungog- which has also been recommended in the Draft Dungog Flood Risk Management Study and Plan and is the subject of an application under the current round of funding under the NSW Governments Floodplain management Grants program. This is because provisions for early evacuation and the protection of life could mitigate the need for such a high Flood Planning Level in Dungog.

The following table shows the design peak water levels in Dungog as derived by modelling in the current Study.

Table 2: Design Peak Water Levels in Dungog Tailwater (Hooke Street) (Source: Draft Dungog Flood Risk Management Study and Plan – Royal Haskoning 2017)

Design Conditions AEP/ARI	Peak Flood Level (m AHD)
1% / 100yr	50.2 (FPL= 50.7 (ie with 500mm freeboard)
0.5% / 200yr	50.64
0.2% / 500yr	51.11
PMF	53.65
April 2015	51.98

Planning Considerations

The adoption of an FPL as recommended would also require the concurrence of the Department of Planning and Environment as an amendment to Local Environment Plan 2014 in relation to the definition of the FPL contained in Clause 6.3(5) would be required. A planning proposal will need to be prepared for the Departments consideration. The NSW Office of Environment and Heritage representative of Councils Flood Committee has indicated that OEH would likely support such a proposal.

IMPLICATIONS

Financial

There are no financial implications to Council outside of staff time in preparing a planning proposal and liaising with Government Departments and the Flood Committee.

Legislative

Council is responsible for setting an appropriate Flood Planning Level having regard to the information available. The work contained in the Draft Dungog Flood Risk Management Study (prepared in accordance with the NSW Flood Plain Management Manual and best practice) has provided an updated understanding of flood Behaviour in the Dungog township and new Flood design levels have been modelled.

Council has a duty of care to have regard to this new data and to adopt an appropriate and reasonable Flood Planning Level to assist in planning decisions relating to Flood prone land.

The consultant's recommendation, subsequently endorsed by the Technical subcommittee of the Dungog Flood Committee, represents a change in definition of the FPL under the LEP 2014 and therefore will require concurrence from the NSW Department of Planning and Environment.

Consultation

The adoption of an appropriate Flood Planning Level has been recommended in the draft Dungog Flood Risk management Study and endorsed by the Technical Sub committee of Council's Flood Committee.

The proposed FPL will be publicly exhibited as part of the overall Flood Risk Management Study exhibition period which will include a community information session. It is however prudent that Council adopts the new FPL prior to the completion of the Study so that it can be applied in the interim period and to enable the process of amending the LEP to proceed.

The setting of the FPL is Council's responsibility and should be based on consideration of professional advice and the most up to date available data.

OFFICERS RECOMMENDATION

1. That Council adopt a Flood Planning Level for the Dungog Flood Risk Management Study area of the **500yr ARI (average recurrent interval) plus 0.5 m freeboard.**

2. That a planning proposal be prepared and submitted to the Department of Planning and Environment to amend LEP 2014 to affect the new Flood Planning Level.

ENVIRONMENTAL SERVICES DEPARTMENT
MANAGERS REPORT

Paul Minett

1. PATERSON RIVER FLOOD STUDY
EF15/30

Précis:

This report seeks the adoption of the recently completed Paterson River Flood Study.

****

Minute No. 37455

RESOLVED on the motion of Cr Bowden and seconded by Cr Knudsen that the Paterson River Flood Study be adopted by Council.

Paul Minett

2. DUNGOG CATCHMENT FLOOD PLANNING
EF15/97

Precis:

The purpose of this report is to seek a Council resolution to set a Flood Planning Level for the Dungog township, having regard to the data collected in the Dungog Flood Study.

****

Minute No. 37456

RESOLVED on the motion of Cr Bowden and seconded by Cr Booth that:

1. Council adopt a Flood Planning Level for the Dungog Flood Risk Management Study area of the **500yr ARI (average recurrent interval) plus 0.5 m freeboard.**

2. A planning proposal be prepared and submitted to the Department of Planning and Environment to amend LEP 2014 to affect the new Flood Planning Level.

Paul Minett

3. DRAFT DUNGOG FLOOD RISK MANAGEMENT STUDY AND PLAN
EF15/84

Precis:

The purpose of this report is to seek resolution to place the Draft Dungog Flood Risk Management Study and Plan on public exhibition.

****

Minute No. 37457

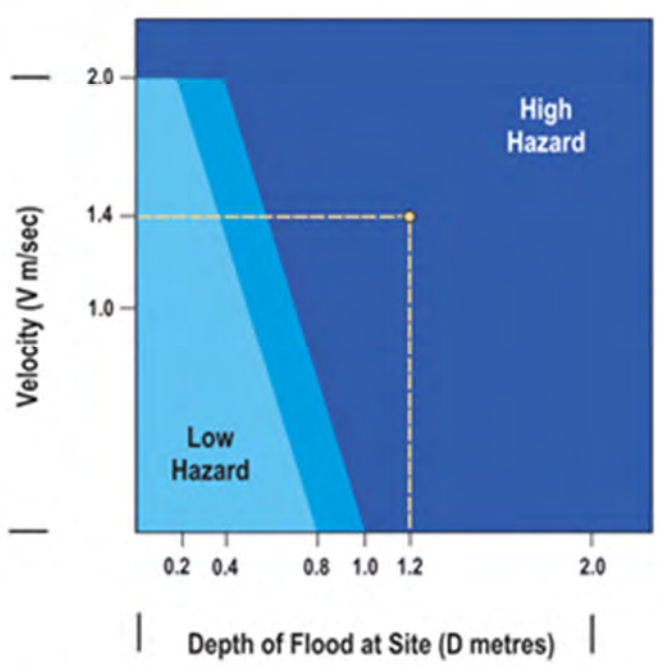
RESOLVED on the motion of Cr Booth and seconded by Cr Bowden that the Draft Dungog Flood Risk Management Study be placed on Public exhibition for a period of 28 days.

Appendix D

Flood Hazard Mapping - Dungog Flood Study 2017

LEGEND

FLOOD HAZARD CLASSIFICATION



Royal HaskoningDHV
Enhancing Society Together

FIGURE Haz 5%

PEAK FLOOD HAZARD (5% AEP EVENT)

NORTH

0 125 250m
Approx. Scale

SCALE 1:10,000

PAGE SIZE A3

FILEPATH I:\Projects\PA1316_Dungog FPRMS&P\GIS\Workspaces\ReportFigs\FloodStudy\MapCompendium

LEGEND

FLOOD HAZARD CLASSIFICATION

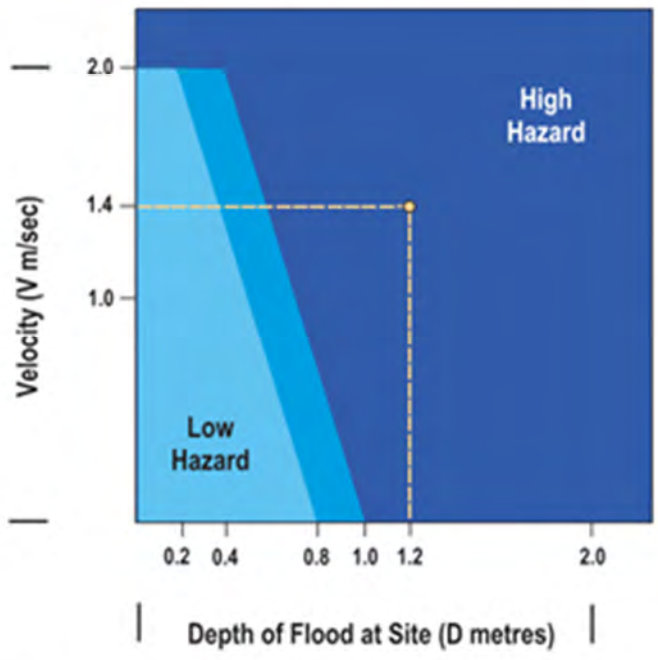


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FIGURE Haz 1%

PEAK FLOOD HAZARD (1% AEP EVENT)

NORTH

0 125 250m
Approx. Scale

SCALE 1:10,000

PAGE SIZE A3

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LEGEND

FLOOD HAZARD CLASSIFICATION

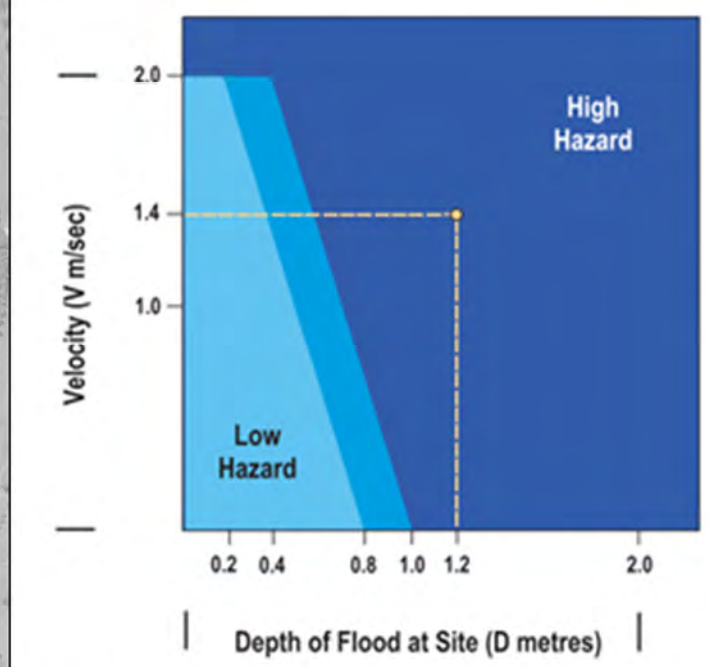

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FIGURE Haz PMF

PEAK FLOOD HAZARD (PMF EVENT)

NORTH

0 125 250m
Approx. Scale

SCALE 1:10,000

PAGE SIZE A3

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