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Clarence Town Floodplain Risk Management Study and Plan

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DUNGOG SHIRE COUNCIL 1958

Clarence Town Floodplain Risk Management Study and Plan

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

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Synopsis: **This report documents the Clarence Town Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for the catchment. The study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The end product is the Floodplain Management Plan, which describes how flood liable lands within Clarence Town are to be managed in the future.**

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Executive Summary

Introduction

Clarence Town is a small township within the Dungog Local Government Area (LGA), located on the Williams River 25km south of Dungog and 55km north of Newcastle. Flood studies have previously been completed for both the local Clarence Town catchment (BMT WBM, 2012) and the wider Williams River catchment (BMT WBM, 2009).

The primary objective of the flood studies was to define the flood behaviour of Clarence Town and the Williams River through the establishment of appropriate numerical models. The studies produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the Clarence Town Flood Study (BMT WBM, 2012) and the Williams River Flood Study (BMT WBM, 2009) establish the basis for subsequent floodplain management activities in Clarence Town, addressing both local and mainstream Williams River flooding issues. The Floodplain Risk Management Study (FRMS) aims to derive an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the Floodplain Development Manual. The findings of the study will be incorporated in a Plan of recommended works and measures and program for implementation.

The objectives of the Clarence Town Floodplain Risk Management Study and Plan are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Clarence Town locality.

This report documents the Floodplain Risk Management Study and presents a recommended Floodplain Risk Management Plan for Clarence Town.

The following provides an overview of the key findings and outcomes of the study, incorporating a review of design flood conditions within the catchment, assessment of potential floodplain management measures and a recommended Floodplain Management Plan.

This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

Flooding Behaviour

Flooding at the township is due to both mainstream flooding from the Williams River and local catchment runoff from Town Creek and a number of smaller watercourses which run through the urban areas discharging into the Williams River.

The local catchment of Clarence Town encompasses an area of approximately 2.5km^2. The local catchment is drained by Town Creek and a number of smaller watercourses running through the urban areas of Clarence Town. The majority of floodwater is conveyed through the local catchment via relatively low capacity channels along the main watercourse alignments, in roadside swales and other defined drainage channels and natural overland flow paths. In urban areas, roadside

drainage is typically employed to convey floodwater to controlled discharge points and limit inundation of private property. Town Creek is a tributary of the Williams River, the confluence approximately 80m east of the southern end of Rifle St in Clarence Town.

Given the size of the Clarence Town local catchment, and relatively steepness along the main flow path alignments, the catchment is highly responsive to rainfall such that the critical flood conditions within Clarence Town relate to high intensity short duration events of the order of 1 to 2 hours.

The Clarence Town Flood Study (BMT WBM, 2012) defined design flood levels at Clarence Town for a range of design event magnitudes, utilising a detailed hydraulic model (TUFLOW) calibrated to June 2007, February 2011 and February 2009 historical event data.

The Williams River is a significant system with a catchment area of the order of 1,100km^2. Elevations in the catchment range from above 1,400m AHD in the upper catchment in the Barrington Tops to sea level in the lower catchment. The Williams River is tidally influenced from the Hunter River confluence upstream to Seaham Weir (there no tidal impacts affecting Clarence Town).

Flooding in the Williams River in the vicinity of Clarence Town emanates from periods of prolonged rainfall across the wider Williams River catchment. The critical Williams River flood conditions within Clarence Town relate to longer duration events of the order of 24 to 36 hours.

The design water level conditions for the Williams River were established in the Williams River Flood Study (BMT WBM, 2009). The Williams River flooding in Clarence Town is a result of backwater from the river, with flows and velocities typically lower than those associated with local catchment flooding. The main areas of Clarence Town impacted by Williams River flooding are the lower floodplain areas between Grey Street and Marshall Street (encompassing King Street) extending up to Queen Street as well as the southern end of Durham Street. In larger design flood events flooding extends from Queen Street up to Prince Street.

A flood damages databases has been developed to identify potentially flood affected properties and to quantify the extent of damages in economic terms for existing flood conditions. In developing the damages database, a floor level survey of all existing properties identified with the Extreme Flood extent was undertaken. Key results from the flood damages database indicate:

- 5 residential homes and 3 commercial buildings would be flooded above floor level in the local catchment Extreme Flood event;
- 107 residential homes and 20 commercial buildings would be flooded above floor level in the Williams River Extreme Flood event;
- Zero residential homes and 1 commercial building would be flooded above floor level in the local catchment 100-year ARI flood;
- 6 residential homes and 1 commercial building would be flooded above floor level in the Williams River 100-year ARI flood;
- The predicted flood damage costs for the local catchment and Williams River 100-year ARI flood is of the order of $30,000 and $1M respectively.

Community Consultation

Community consultation was undertaken aimed at informing the community about the development of the Floodplain Risk Management Study and its likely outcome 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 concern 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;
- Distribution of questionnaires;
- Community information session; and
- Public exhibition of the Draft Floodplain Risk Management Study and Plan.

The key information provided in the responses includes:

- General appreciation that major flooding occurs in Clarence Town and the need to live with and respond appropriately;
- Experiences from a number of flood events including the June 2007 event;
- Concern over the ongoing maintenance of stormwater infrastructure and Town Creek channel;
- Suggestions for future works to be completed in the study area to reduce flood risk; and
- Differing opinions on what level of control Council should place on new development to minimise flood risk.

Floodplain Management Options Considered

The Clarence Town Floodplain Risk Management Study considered and assessed a number of floodplain management measures, summarised below.

- *Town Creek channel augmentation* – the augmentation works considered are downstream of the Prince Street culvert within the reach adjacent to the existing commercial centre. The works include upgrade of the existing culvert and widening of the channel to increase flow capacity. The channel works have considered providing close to 1% AEP flow capacity in order to limit out of bank flows and provide greater flood immunity to the existing commercial properties on Prince Street. The assessment determined the required channel profile to convey the 1% AEP discharge and reduce flood impacts on the commercial centre. The augmentation works have been considered in the Plan.
- *Local road re-profiling and drainage improvements* – the proposed works along Grey Street and Prince Street are to improve the management of overland flows, particularly the impacts on the commercial buildings on Prince Street. In high intensity storm events, the current road profiles and limited drainage provisions result in overland flows within the streetscapes to be directed towards the existing buildings. The works are recommended ion the Plan.
- *Flood detention basins* – The provision of a number of flood detention basins within the local catchment (two upstream of Marshall Street and one at Rifle/Prince Street) was assessed. The

temporary flood storage provide by the basin structures aim to reduce peak flows in the Town Creek channel downstream, thereby lowering flood levels. Whilst reducing flood levels in the Town Creek channel, the detention basins were found not provide for sufficient reductions to provide flood immunity to the commercial centre. The channel works and road/drainage improvements were found to have a greater cost benefit. Detentions Basins have not been recommended in the Plan.

- *Planning and development controls* – Council's existing 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 DCP is recommended in terms of recognition of the adopted FRM for Clarence Town and the associated flood risk mapping derived in the study. Some additional provisions for the management of overland flows are included.
- *Flood Warning* – There is no dedicated flood warning service for Clarence Town and surrounds. However, there is a formal flood warning service for the Williams River provided by the Bureau of Meteorology which benefits the majority of the lower Valley. Recommendations are included in the Plan in relation to improved dissemination of warnings provided for the Williams River and interpretation of the warnings and level predictions for Clarence Town.
- *Improved emergency management operations* – At present there is no specific details within the Local Flood Plan covering Clarence Town though additional flood information developed as part of the study can now be utilised. The additional detail on flood risk mapping, design flood conditions and the property database developed through the Clarence Town FRMS should be used to update and supplement existing databases and to refine the Local Flood Plan where relevant. The development of the flood database of property flood affectation will assist emergency management authorities to prioritise and target the highest risk properties.
- *Improved public awareness* – raising flood awareness in the community through the issue of flood certificates, community education programs, access to flood mapping. Improved access to flood information through Council (e.g. availability of reports, flood mapping, key flood emergency contacts an information on Council website).
- *Voluntary Purchase Schemes*: are generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. No property has been identified as suitable for voluntary purchase within the Clarence Town catchment and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan.
- *Voluntary house raising* - raising floor levels where practical to elevate habitable floor levels to required levels above the flood planning level. Not all houses are suitable for raising. Houses of brick construction or slab on ground construction are generally not suitable for house raising due to expense and construction difficulty. Generally this technique is limited to structures constructed on piers. No property has been identified as suitable for voluntary house raising within the Clarence Town catchment and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan.
- *Flood Proofing* – Flood proofing is proposed as part of the Plan for those properties that are below the 100 year ARI flood level. A detailed list of individual property levels relative to predicted flood levels has been established. For those properties identified within the 100-year

ARI flood envelope, advice may be provided to individual landowners on available opportunities to reduce on-site flood damages. Temporary flood gates in particular are identified as a feasible option for mitigating against local catchment flooding of the commercial centre and accordingly recommended in the Plan.

The Recommended Floodplain Management Plan and Implementation

A recommended floodplain management plan showing preferred floodplain management measures for Clarence Town is presented in Section 9 in the main body of the report. The key features of the plan are outlined below with indicative costs, priorities and responsibilities for implementation.

Recommended options that modify that modify flood behaviour include:

- Road re-profiling and drainage improvements in the vicinity of Grey Street and Prince Street

Estimated Cost **- $100K** Responsibility **– Council** Priority - **High**

- Augmentation of Town Creek channel downstream of Prince Street

Estimated Cost **- $100K** Responsibility **– Council** Priority - **Medium**

Recommended options that modify property include:

- Flood proofing of individual buildings (installation of flood gates at commercial centre); and

Estimated Cost **- $5K** Responsibility **– Landowner** Priority - **High**

Recommended options that modify flood response include:

- Improved flood awareness through issue of flood information (Council and SES);

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority - **Medium**

- Update of Local Flood Plans with current design flood information

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority - **High**

- Update emergency evacuation procedures in the Local Flood Plan based on revised flooding information.

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority - **High**

The steps in progressing the floodplain management process from this point forward are as follows:

1. Council allocates priorities to components of the Plan, based on available sources of funding and budgetary constraints;
2. Council negotiates other sources of funding as required such as through OEH and the “Natural Disaster Mitigation Package” (NDMP); and
3. as funds become available, implementation of the Plan proceeds in accordance with established priorities.

The Plan 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.

Contents

Contents

Contents

List of Figures

Contents

List of Tables

Glossary

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 m^3/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 m^3/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.
attenuation	Weakening in force or intensity
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 tems of vollume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres 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

Glossary

floodplain	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.
floodplain management	The co-ordinated management of activities that occur on the floodplain.
floodplain 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 determing 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.

Glossary

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 continously 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
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

The Clarence Town Flood Study was prepared for Dungog Shire Council (Council) by BMT WBM in 2012. The study defined the flood behaviour of the Town Creek catchment and other minor watercourses within Clarence Town. The Williams River Flood Study was prepared for Dungog Shire Council and Port Stephens Council by BMT WBM in 2009 to define the riverine flood behaviour in the Williams River from Raymond Terrace to 5km upstream of Dungog.

The primary objective of the flood studies was to define the flood behaviour of Clarence Town and the Williams River through the establishment of appropriate numerical models. The study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the Clarence Town Flood Study (BMT WBM, 2012) and the Williams River Flood Study (BMT WBM, 2009) establish the basis for subsequent floodplain management activities in Clarence Town, addressing both local and mainstream Williams River flooding issues. The Floodplain Risk Management Study (FRMS) aims to derive an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the Floodplain Development Manual. The findings of the study will be incorporated in a Plan of recommended works and measures and program for implementation.

The objectives of the Clarence Town Local Catchment and Williams River Flooding Floodplain Risk Management Study and Plan are to:

- Identify and assess measures for the mitigation of existing flood risk;
- Identify and assess planning and development controls to reduce future flood risks; and
- Present a recommended floodplain management plan that outlines the best possible measures to reduce flood damages in the Clarence Town locality.

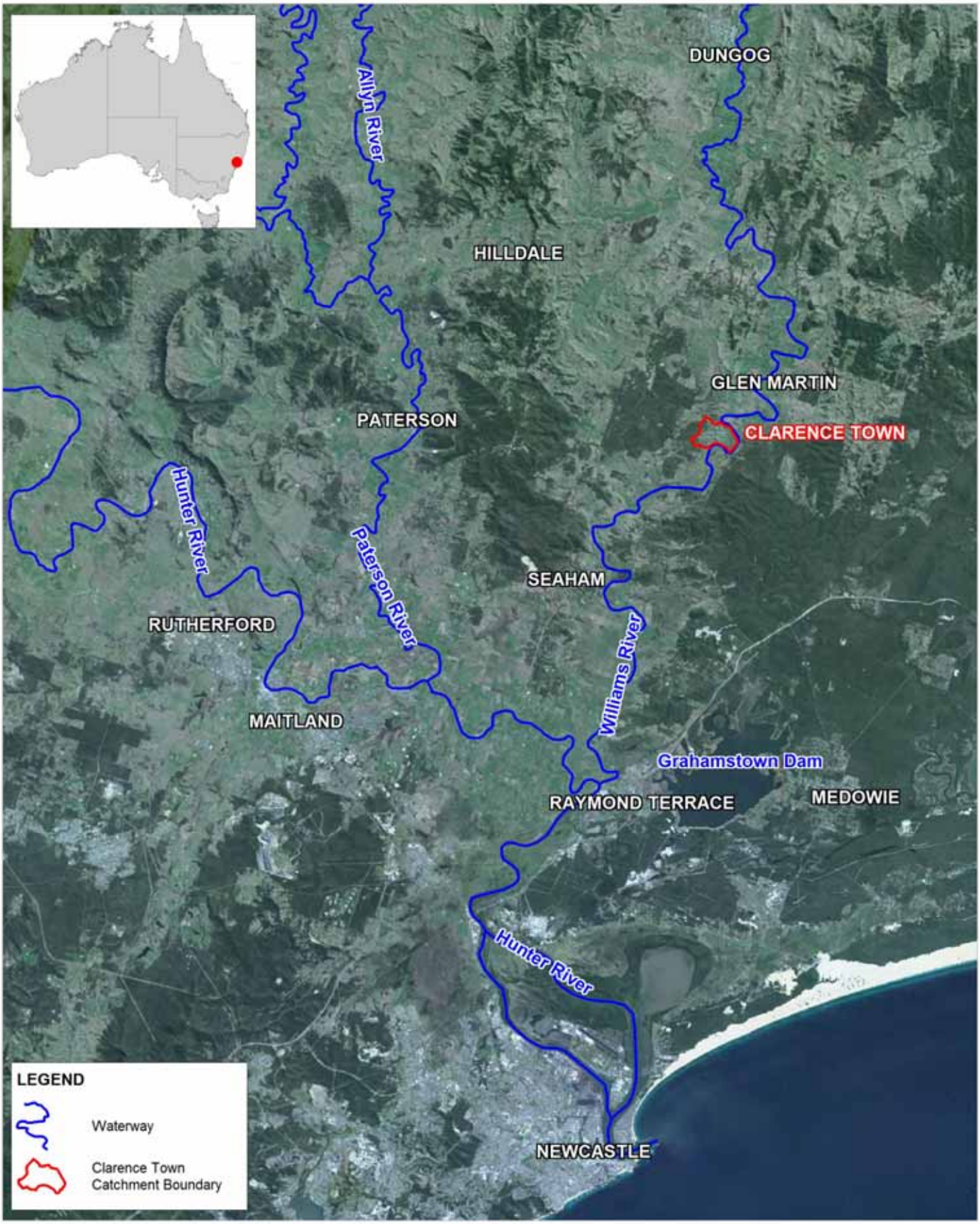
This report documents the Floodplain Risk Management Study and presents a recommended Floodplain Risk Management Plan for Clarence Town.

This project has been conducted under the State Assisted Floodplain Management Program and received State financial support.

1.1 Study Location

Clarence Town is a small township within the Dungog Local Government Area (LGA), located on the Williams River 25km south of Dungog and 55km north of Newcastle as shown in Figure 1-1. The township has a population of approximately 900.

A detail of the township, with largely represents the study area for the FRMS, is shown in Figure 1-2. The study area largely consists of low-density residential development, with a small commercial centre around the Prince Street/Grey Street intersection and other commercial and public infrastructure distributed around the town.



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Study Locality

Figure: 1-1

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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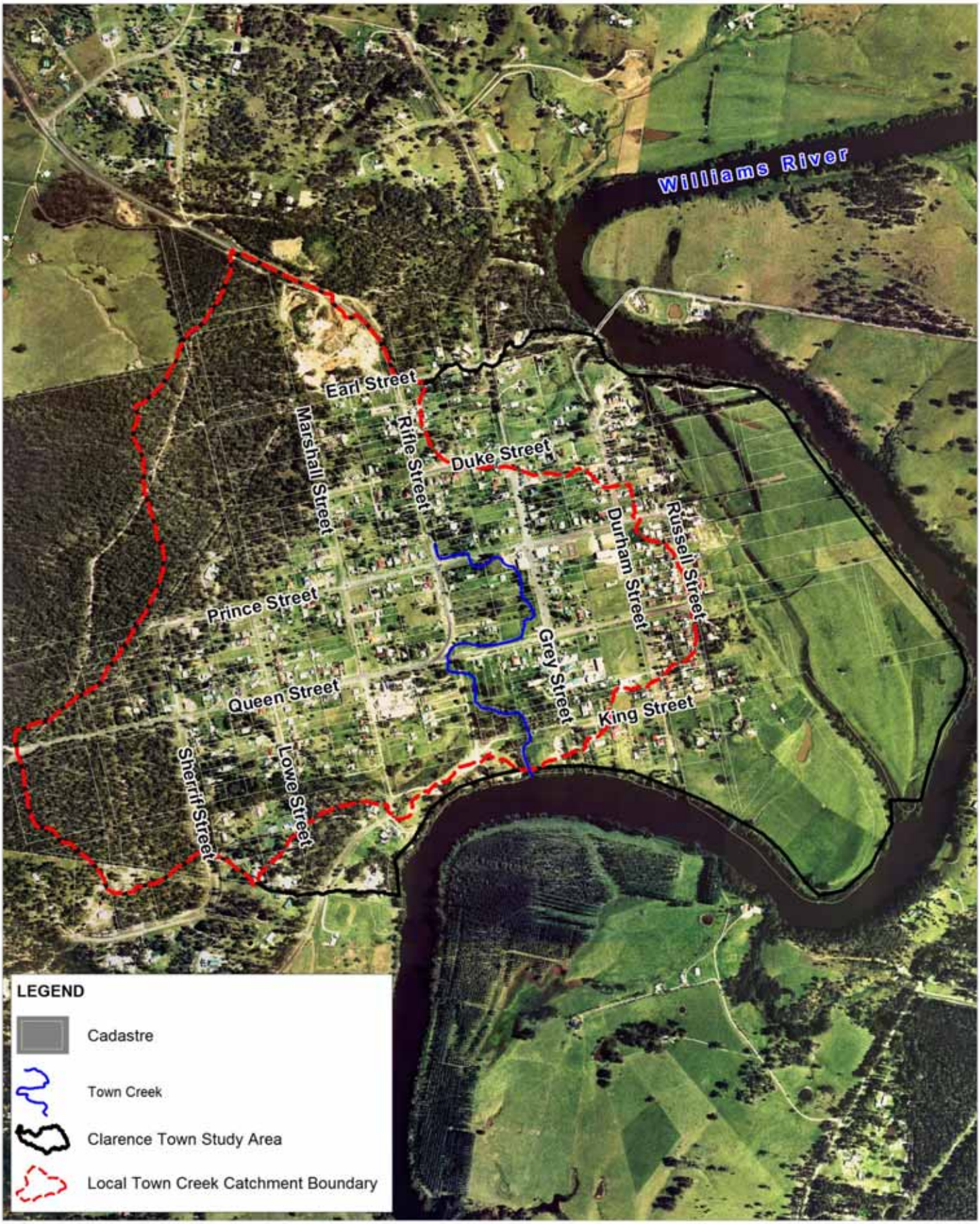

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Clarence Town Study Area

Figure: 1-2

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1.2 The Need for Floodplain Management at Clarence Town

Flooding at the township is due to both mainstream flooding from the Williams River and local catchment runoff from Town Creek and a number of smaller watercourses which run through the urban areas discharging into the Williams River.

The local catchment is approximately 2.5sq km with the majority of floodwater conveyed via relatively low capacity channels along the main watercourse alignments, in roadside swales and other defined drainage channels and natural overland flow paths

Past development within Clarence Town has often been in close proximity to the natural drainage paths, which has subsequently led to a number of properties within the township being subject to flood inundation, and in some instances at relatively frequent intervals. Some landholders have constructed on-ground works such as levees/embankments, drainage channels, and culverts for access roads to alleviate flood risk on their own property.

These structures can have a significant influence on the flooding behaviour in Clarence Town. Works located on major flowpaths can provide for significant impedance to out-of-bank floodplain flows in major flood events. In addition, the potential for blockage at hydraulic structures may exacerbate flood risk to upstream property. Given the proximity of some development to existing watercourses, the impact of backwater influence may be significant in terms of potential property inundation.

There is an expectation of increased future demand for infill development and an expansion of the urban area. If development is uncontrolled, this demand has the potential to cause further encroachment on the local waterways, exacerbate existing flooding conditions, and expose a greater number of people and property to flood risk.

Flooding considerations will be one of the major inputs/constraints on the location and nature of future development in the catchment. In determining the detailed flooding characteristics of the catchment 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.

The potential for climate change impacts is now a key consideration for floodplain management. The NSW Government has released a guideline for practical consideration of climate change in the floodplain management process that advocates consideration of increased design rainfall intensities of up to 30%. Accordingly, this increase in design rainfall will translate into increased design flood inundation in Clarence Town, such that future planning and floodplain management in the catchment will need to take due consideration of this potential increased flood risk.

Floodplain risk management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

Accordingly, Council desires to approach local floodplain management in a considered and systematic manner. This study comprises the initial 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 floodplain of Clarence Town.

1.3 The Floodplain Management Process

The State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the 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 in the discharge of their floodplain management responsibilities.

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

Table 1-1 Stages of Floodplain Management

	Stage	Description
1	Formation of a Committee	Established by Council and includes community group representatives and State agency specialists.
2	Data Collection	Past data such as flood levels, rainfall records, land use, soil types etc.
3	Flood Study	Determines the nature and extent of the flood problem.
4	**Floodplain Risk Management Study**	**Evaluates management options for the floodplain in respect of both existing and proposed developments.**
5	**Floodplain Risk Management Plan**	**Involves formal adoption by Council of a plan of management for the floodplain.**
6	Implementation of the Floodplain Risk Management Plan	Construction of flood mitigation works to protect existing development. Use of local environmental plans to ensure new development is compatible with the flood hazard.

The Clarence Town Flood Study (BMT WBM, 2012) defines the existing flood behaviour and establishes the basis for future floodplain management activities.

The Clarence Town Local Catchment and Williams River Flooding Floodplain Risk Management Study and Plan (this document) constitutes the fourth and fifth 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.

1.4 Structure of 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 catchment including climate change analysis.

Section 5 provides a summary of the flood damages assessment including identification of property potentially affected by flooding.

Section 6 provides a review of relevant existing planning measures and controls.

Section 7 provides an overview of potential floodplain risk management measures.

Section 8 presents the recommended measures and an implementation plan.

2 Background Information

2.1 Catchment Description

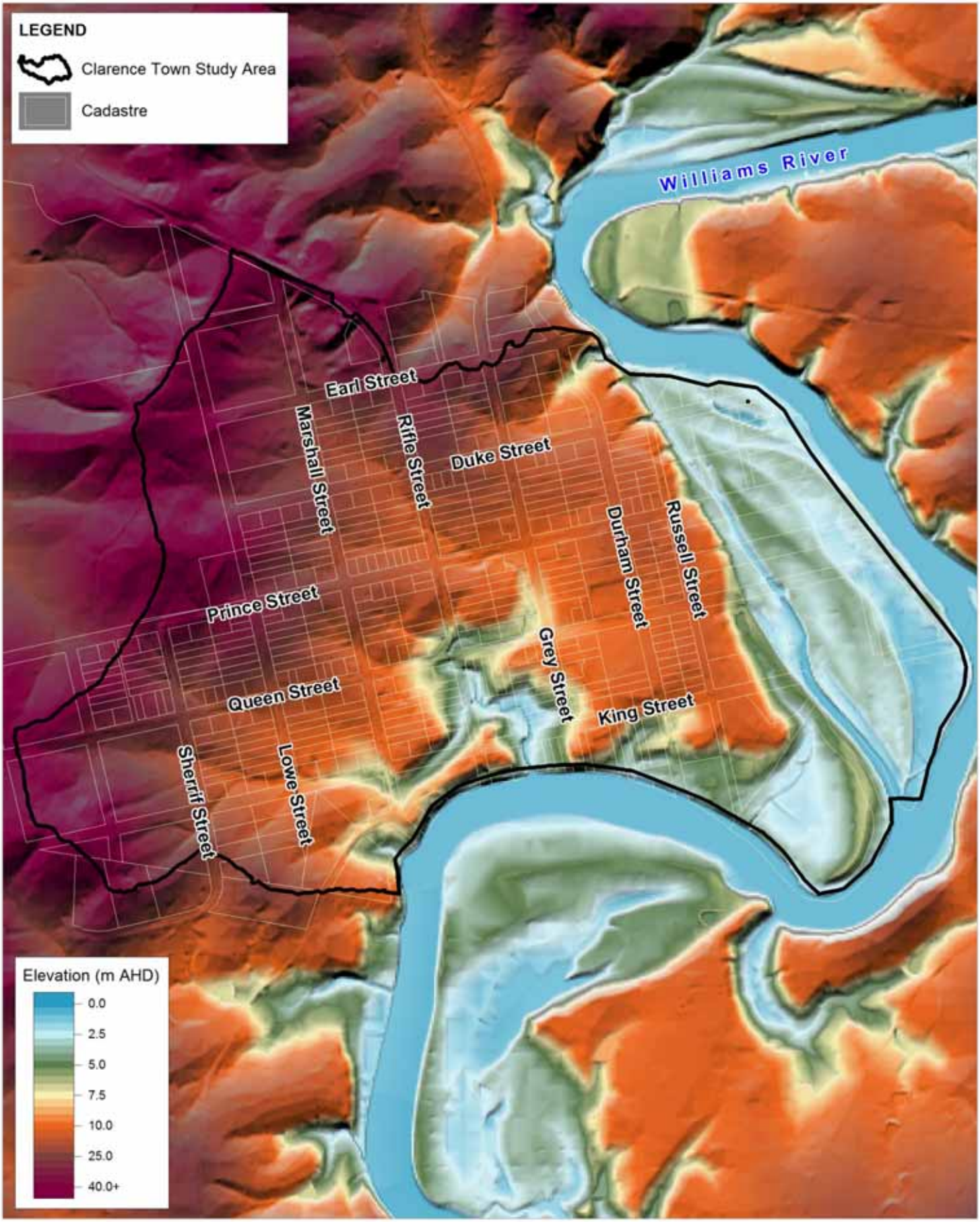
Clarence Town is situated some 54km north-north-west of the city of Newcastle, within the Dungog Shire Local Government Area (LGA). The study catchment encompasses an area of approximately 2.5km^2, extending from a naturally vegetated ridge line at the top of the catchment, and flowing generally south-east through Clarence Town before draining into the Williams River.

The topography of the catchment is shown in Figure 2-1. From an elevation of around 63m AHD at the top of the catchment, the topography grades relatively steeply from the naturally vegetated ridge line and vegetated hill slope to the floodplain around Clarence Town. Within Clarence Town the floodplain is undulating with a number of ephemeral watercourses.

The local catchment is drained by Town Creek and a number of smaller watercourses running through the urban areas of Clarence Town. The majority of floodwater is conveyed through the local catchment via relatively low capacity channels along the main watercourse alignments, in roadside swales and other defined drainage channels and natural overland flow paths. In urban areas, roadside drainage is typically employed to convey floodwater to controlled discharge points and limit inundation of private property.

Town Creek is a tributary of the Williams River, the confluence approximately 80m east of the southern end of Rifle St in Clarence Town. The Williams River is a significant system with a catchment area of the order of 1,100km^2. Flooding in the lower reaches of the Town Creek catchment is highly influenced by the conditions in the Williams River.

Land use within the study catchment primarily consists of low density urban development (73%), bushland (25%) and open space (22%). The majority of the open space relates to the Williams River floodplain area to the east of Clarence Town.



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Clarence Town Topography

Figure: 2-1

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2.2 History of Flooding

Whilst there is limited historical flood data recorded for Clarence Town in the absence of a local streamflow gauge and no previous documentation of anecdotal flooding data, there is however a long history of flooding within the township with historical newspaper reports providing firsthand account of flooding in Clarence Town dating back to the mid 1800's.

A review of historical newspaper articles highlighted a number of significant events that occurred in Clarence Town (predominantly emanating from Williams River flooding) during the mid to late 1800's. Newspaper articles reported major flooding events in 1857, 1875 and 1893. The daily rainfall total for the 1893 event (reported to be 301mm) is the highest recorded daily rainfall total for the Clarence Town area and resulted in widespread inundation and property loss. The 1893 flood event was reported to have resulted in a number of deaths and widespread property damage. Examples of historical newspaper articles cited are presented in Appendix D.

There is a long period of recorded (December 1927 – present) Williams River water levels at the Glen Martin (Mill Dam Falls) gauge, some 9km upstream of Clarence Town. Whilst the Glen Martin (Mill Dam Falls) gauge does not provide flood level information for Clarence Town directly, the hydraulic modelling undertaken as part of the Williams River Flood Study (BMT WBM, 2009) can be used to extrapolate the water levels at Clarence Town associated with water levels at Glen Martin (Mill Dam Falls) gauge. The maximum recorded flood levels for historical events at the Glen martin (Mill Dam Falls) gauge are presented in Table 2-1.

Table 2-1 Maximum Recorded Flood Level Data – Mill Dam Falls (Glen Martin) Gauge

Date	Flood Level (m AHD)
19-Mar-63	12.45
04-Feb-90	11.79
20-Mar-78	11.75
18-Apr-46	10.62
01-Mar-56	10.62
25-Jan-72	10.62
21-Feb-54	10.32
21-Oct-67	10.32
19-Feb-57	10.22
13-Oct-85	10.17
22-Jun-69	10.14
24-Mar-78	10.02
08-Jun-07	**10.02**
09-Feb-29	9.80
08-May-01	9.80

Daily read rainfall records for the BoM Clarence Town (Grey Street) gauge are available from September 1897 to present day. The maximum recorded one-day, two-day and three-day rainfall totals for the Clarence Town (Grey Street) gauge are presented in Table 2-2.

Table 2-2 Clarence Town (Grey Street) Gauge Records

Rank	Date	One-day Total Rainfall (mm)	Date	Two-day Total Rainfall (mm)	Date	Three-day Total Rainfall (mm)
1	Apr 1946	243.6	Feb 1990	307.8	Feb 1990	387.4
2	Apr 1927 (1)	228.1	Jan 1971	298.2	Jan 1971	363.2
3	Apr 1927 (2)	207.0	Jun 1930	290.9	Jun 1930	348.1
4	Nov 2013	200.0	Apr 1946	274.8	Apr 1946	327.1
5	Feb 2009	195.4	Jun 2007	273.8	May 2001	309.2
6	Jan 1971	176.8	May 2001	266.2	Apr 1927	300.5
7	Mar 1956	163.1	Nov 2013	260.0	Jun 2007	296.0
8	Dec 1926	162.8	Mar 1956	238.0	Mar 2009	269.0
9	Jul 1922	161.3	Mar 2009	236	Nov 2013	268.0
10	Jul 1928	161.3	Apr 1927	234.4	Feb 1908	259.1

As the Williams River flooding tends to emanate from catchment rainfall events in excess of 1-2 days duration, historical analysis of rainfall data can highlight the occurrence of major flood events. Major events in the Williams River catchment include 1893, 1956, 1990 and 2007 events.

In terms of Clarence Town local catchment flooding however, flooding tends to emanate from catchment rainfall events of 1-2 hours which effectively diminishes the effectiveness of daily rainfall analysis to highlight the occurrence of major flood events. For example the daily rainfall total for the February 2009 event is identified as the fifth highest recorded 1-day rainfall total (195mm) for Clarence Town. Despite the significant daily rainfall totals for February 2009 event, little evidence of major local catchment flooding in Clarence Town has emanated from the community consultation process. This can be attributed to the assumption that this volume of water was distributed evenly across the 24 hour period. In comparison, the rainfall event that occurred in February 2011 (72mm) resulted in a significant local catchment flooding event. In terms of a daily rainfall total, 72mm is not very significant from a Williams River flooding perspective in Clarence Town. However, the event occurred only over a couple of hours with high intensity rainfall resulting in a rapid catchment response and subsequent flash flooding within the local Town Creek catchment.

One significant pattern that is evident in Table 2-2 is the high prevalence of recent (2007 – present day) rainfall events in the recorded maximums. The June 2007, February 2009, and November 2013 events are all major rainfall events that have occurred in the last seven years that have

resulted in significant flood events in Clarence Town, particularly in relation to local Town Creek flooding.

To gain an appreciation of the relative intensity of the recent historical rainfall events, the recorded rainfall depths at Glen Martin (Mill Dam Falls) for various storm durations for the June 2007, February 2009 and November 2013 were compared with the design IFD data for the Clarence Town as shown in Figure 2-2. Note that the Glen Martin (Mill Dam Falls) gauge data was used for this comparison as sub-daily rainfall data was available for the above events.

It is evident that the June 2007 event generally tracks the design 1% AEP (100-year ARI) rainfall depth up to 18-hour duration; the November 2013 event generally tracks the design 2% AEP (50-year ARI) rainfall depth (duration > 6-hours); and the February 2009 event generally tracks the 5% AEP (20-year-ARI) rainfall depth (duration > 12-hours). Further discussion on IFD rainfall relationships is presented in Section 4.3.

As previously stated, given the relatively small size of the Clarence Town local catchment area, the high intensity short durations events (~2-hour duration) as experienced in June 2007 provide for the worst case flooding conditions for local catchment flooding. In terms of the mainstream Williams River flooding, the worst case flooding conditions are the result of longer duration events (24-48 hour duration).

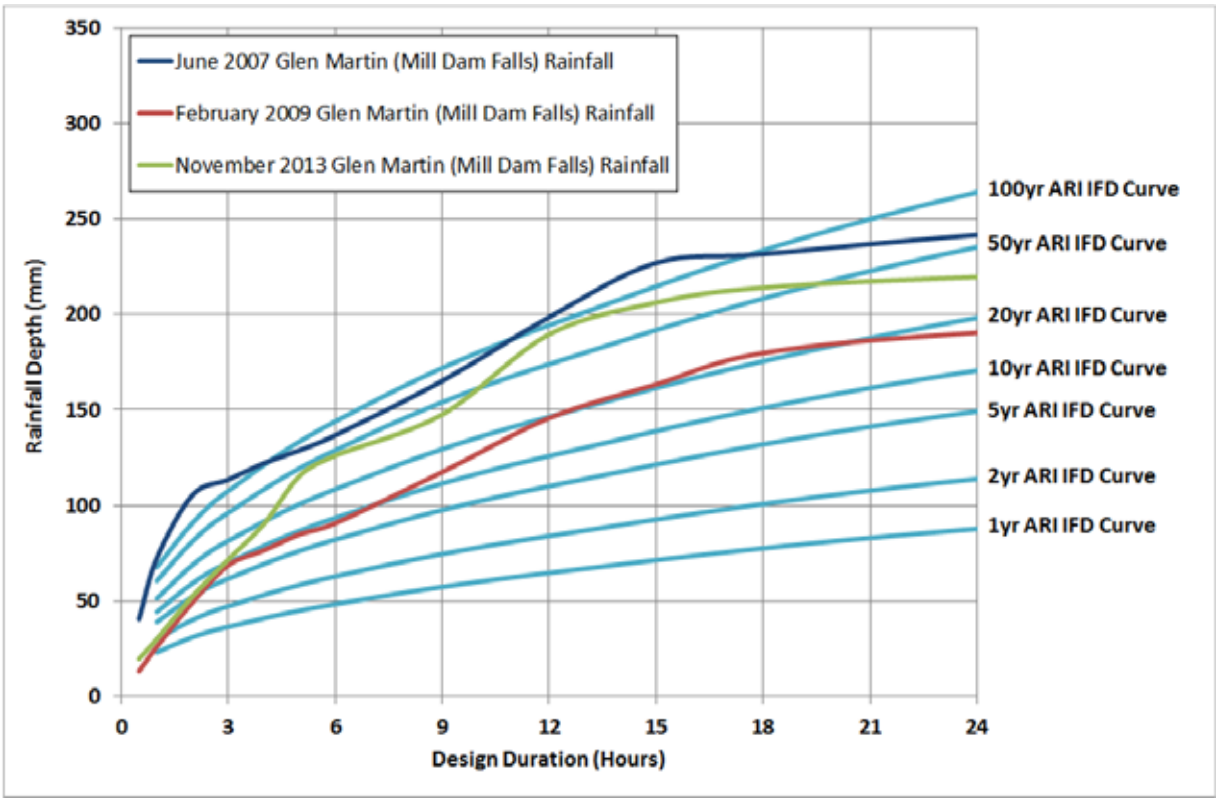


Figure 2-2 Comparison of Historical Rainfall Events with IFD Relationships

2.3 Previous Studies

2.3.1 Clarence Town Flood Study (BMT WBM, 2012)

Dungog Shire Council commissioned BMT WBM to define the flood behaviour of the Town Creek catchment and other minor watercourses within Clarence Town and establish the basis for subsequent floodplain management activities. The study encompassed the local catchment of Clarence Town and investigated the effect of combined flooding from both the local (Town Creek) catchment and the greater Williams River catchment. The study aimed to produce information on flood behaviour for a wide range of flood events under existing catchment and floodplain conditions.

The local Clarence Town catchment is drained by Town Creek and a number of smaller watercourses running through the urban areas of Clarence Town. Town Creek is a tributary of the Williams River, the confluence approximately 80m east of the southern end of Rifle St in Clarence Town. The Williams River is a significant system with a catchment area of the order of 1,100km^2. Flooding in the lower reaches of the Town Creek catchment is highly influenced by the conditions in the Williams River.

A 2D/1D hydraulic model (TUFLOW) was developed extending across the Clarence Town catchment in its entirety (total area of 2.3km^2). The main Town Creek Channel (extending from 40m north of the Prince St – Rifle St intersection down to its confluence with the Williams River) was modelled as a 1D open channel. The model was based on a 2m square grid. Rainfall data was input into the hydraulic model using a direct rainfall approach. The direct rainfall approach applies a rainfall depth to every active cell within the assigned rainfall region, and essentially replaces the need to use a hydrological model (e.g. RAFTS-XP, WBNM). Given the relatively small size of the Clarence Town catchment (<2.5km^2) and the lack of available data to justify any variation in the distribution of rainfall across the catchment (i.e. only one rainfall gauge is located within the catchment), only one rainfall region was assigned encompassing the Clarence Town catchment in its entirety (i.e. a single hydrograph was applied to the entire model area).

The TUFLOW model was calibrated based on the historical data available for the June 2007, February 2009 and February 2011 events.

The TUFLOW model was used to derive a detailed representation of the Clarence Town catchment for the 20%, 10%, 5%, 2%, 1%, 0.5% AEP design flood events as well as the probable maximum flood. The 0.5% AEP and 1% AEP flood extents are shown in Figure 2-3.

2.3.2 Williams River Flood Study (BMT WBM, 2009)

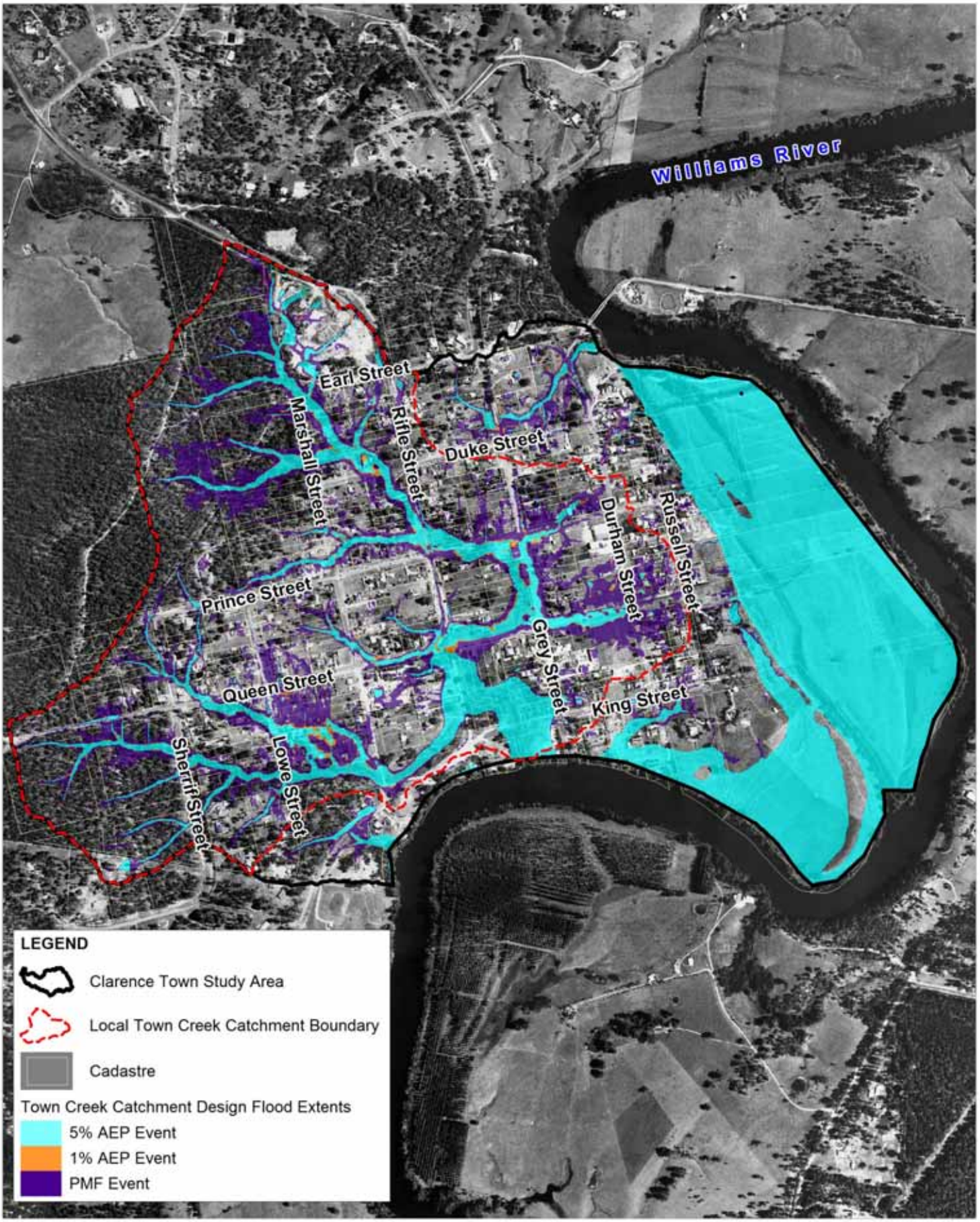
Dungog Shire and Port Stephens Councils commissioned BMT WBM to define the riverine flood behaviour in the Williams River from Raymond Terrace to 5km upstream of Dungog. The study encompassed the Lower Hunter River (from Green Rocks to Newcastle Harbour) and investigated the effect of combined flooding from both the Hunter and Williams Rivers. The study aimed to produce information on flood behaviour for a wide range of flood events under existing floodplain conditions.

The Williams River catchment extends from Raymond Terrace, approximately 20km north-west of Newcastle, to the Barrington Tops with a total catchment area of approximately 1,100 km^2 in area.

A hydrological model (RAFTS-XP) was developed of the Williams River catchment using topographical data. The catchment was divided into 59 sub-areas. The hydrological model was calibrated to the February 1990, March 1978 and May 2001 flood events. The hydrologic model was also used to produce local inflow hydrographs at various locations along the 2D / 1D hydraulic model.

A 2D/1D hydraulic model (TUFLOW) was developed for the Williams River covering a total area of 146 km^2 from approximately 5 km upstream of Dungog down to Raymond Terrace (at the junction with the Hunter River). The model was based on a 40m square grid, resulting in approximately 90,000 2D cells, with 163 1D sections representing the Williams River and tributaries. The hydraulic model was calibrated to the February 1990, March 1978 and May 2001 flood events.

The TUFLOW model was used to derive a detailed representation of the river and floodplain for the 20%, 10%, 5, 2%, 1%, 0.5% AEP design flood events as well as the probable maximum flood. The 0.5% AEP and 1% AEP flood extents are shown in Figure 2-4.



Title:

Design Flood Extents - Local Catchment Flooding

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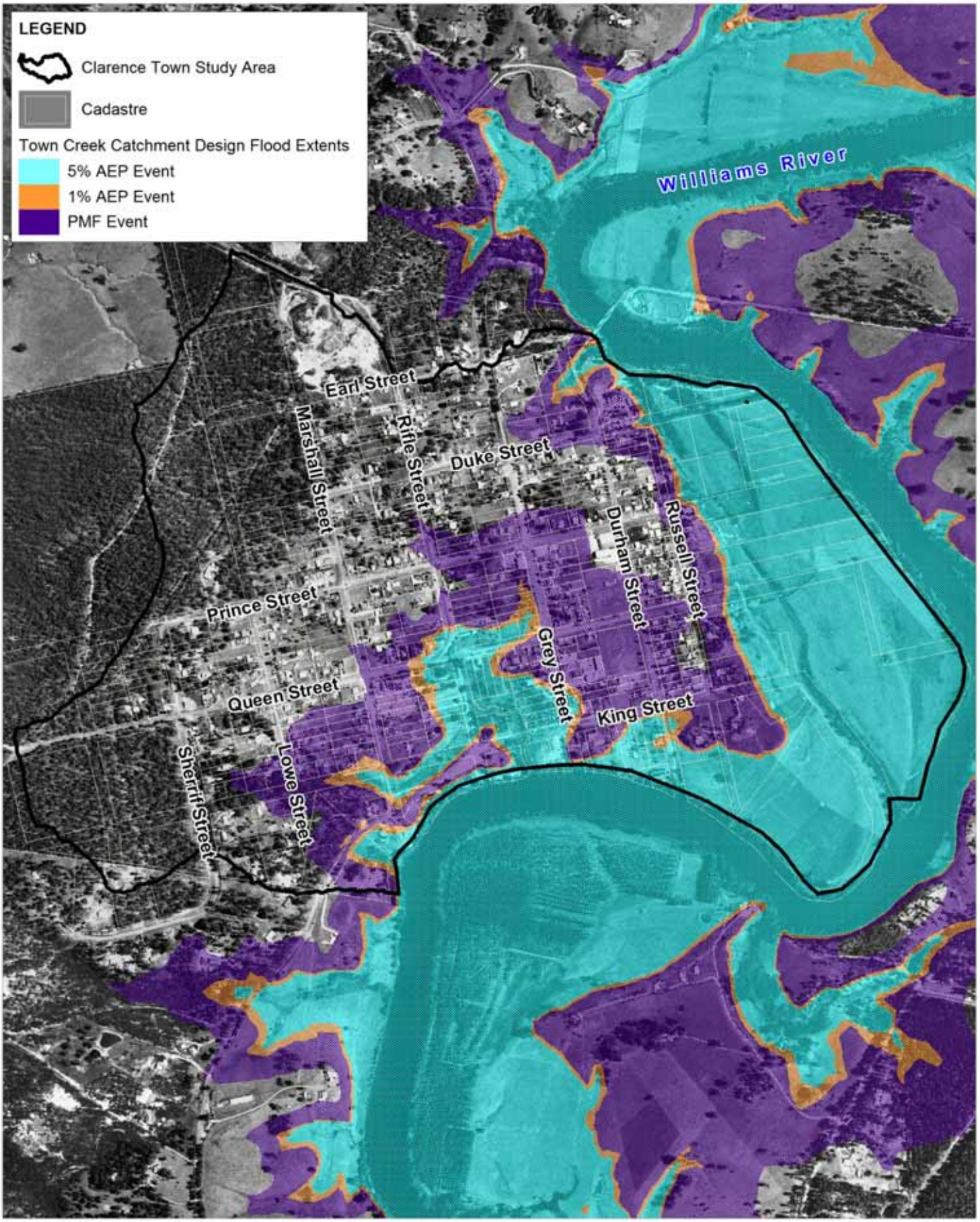

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Design Flood Extents - Williams River Flooding

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3 Community Consultation

3.1 The Community Consultation Process

Community consultation has been an important component of the current study. The consultation has aimed to inform the community about the development of the floodplain risk management study and its likely outcome as a precursor to the development of the floodplain risk management plan. It has provided an opportunity to collect information on their flood experience, their concern on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues.

The key elements of the consultation process have been as follows:

- Consultation with the Floodplain Management Committee through meetings, presentations and workshops;
- Distribution of information brochure and community questionnaire; and
- Public exhibition of the Draft Floodplain Risk Management Study and Plan **(to be undertaken)**.

These elements are discussed in detail below.

3.2 The Floodplain Management Committee

The study has been overseen by the Williams River Clarence Town Catchment Floodplain Management Committee (Committee). The Committee has assisted and advised Council in the development of the Clarence Town Local Catchment and Williams River Flooding Floodplain Risk Management Study and Plan.

The Committee is responsible for recommending the outcomes of the study for formal consideration by Council.

3.3 Community Questionnaires

In May 2013 a community questionnaire was distributed to landowners, residents and businesses located within the study area in which respondents were asked to provide information on previous flood history, and concerns or issues in regard to ongoing floodplain risk management in the catchment. Council received a total of ten responses to the community questionnaire (refer Figure 3-1).

Title:

Distribution of Responses to the Community Questionnaire

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The key information provided in the responses includes:

- General appreciation that major flooding occurs in Clarence Town and the need to live with and respond appropriately;
- Experiences from a number of flood events including the June 2007 event;
- Concern over the ongoing maintenance of stormwater infrastructure and Town Creek channel;
- Suggestions for future works to be completed in the study area to reduce flood risk; and
- Differing opinions on what level of control Council should place on new development to minimise flood risk.

3.4 Public Exhibition

Section to be completed following public exhibition.

4 Existing Flood Behaviour

4.1 Flood Behaviour

4.1.1 Local Catchment Flood Behaviour

As previously discussed, the local catchment of Clarence Town encompasses an area of approximately 2.5km^2. The local catchment is drained by Town Creek and a number of smaller watercourses running through the urban areas of Clarence Town. The majority of floodwater is conveyed through the local catchment via relatively low capacity channels along the main watercourse alignments, in roadside swales and other defined drainage channels and natural overland flow paths. In urban areas, roadside drainage is typically employed to convey floodwater to controlled discharge points and limit inundation of private property.

Town Creek is a tributary of the Williams River, the confluence approximately 80m east of the southern end of Rifle St in Clarence Town. The Williams River is a significant system with a catchment area of the order of 1,100km^2. Flooding in the lower reaches of the Town Creek catchment is highly influenced by the conditions in the Williams River.

Given the size of the Clarence Town local catchment, and relatively steepness along the main flow path alignments, the catchment is highly responsive to rainfall such that the critical flood conditions within Clarence Town relate to high intensity short duration events of the order of 1 to 2 hours.

The Clarence Town Flood Study (BMT WBM, 2012) defined design flood levels at Clarence Town for a range of design event magnitudes, utilising a detailed hydraulic model (TUFLOW) calibrated to June 2007, February 2011 and February 2009 historical event data.

Simulated peak flood levels and peak flows at selected locations shown in Figure 4-1 are summarised in Table 4-1 and Table 4-2 respectively. Peak flood extents from the Clarence Town Flood Study and Williams River Flood Study are shown in Figure 2-3 and Figure 2-4 respectively. The flood inundation patterns for simulated design events were found to be consistent with the historical events investigated as part of the Clarence Town Flood Study (BMT WBM, 2012) with floodwater generally confined to a series of natural gully lines that link with Town Creek at various locations throughout the catchment. The pattern of flooding is consistent through the design event magnitudes, with no additional major flow paths activated in the highest order events.

Table 4-1 Estimated Peak Flood Levels for Local Town Creek Design Events

Location	Peak Design Flood Level (m AHD)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	PMF
U/S Upper Rifle St Culvert	13.6	13.6	13.7	13.8	13.8	14.4
U/S Prince St Culvert	11.5	11.6	11.6	11.6	11.7	12.3
U/S IGA Culvert	9.4	9.4	9.5	9.6	9.6	10.4
U/S Queen St Culvert	5.0	5.3	5.4	5.5	5.5	6.3
U/S Marshall St Culvert	6.3	6.4	6.4	6.4	6.5	7.2
U/S Lowe St Culvert	10.4	10.4	10.4	10.5	10.5	11.0

Table 4-2 Design Peak Flows for Local Town Creek Design Events

Location	Design Peak Flows (m^3/s)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	PMF
Duke St (D/S House Embankment)	4.3	5.2	7.4	8.8	9.9	11.1	56.9
Prince St Culvert	5.5	7.3	9.4	11.7	14.4	16.5	75.5
Queen St Culvert	8.1	10.0	12.2	14.8	19.0	22.0	97.1
Marshall St Culvert	5.8	7.7	9.8	12.6	14.8	16.7	74.2
Town Creek/Williams R.	14.5	15.8	23.3	27.1	32.7	42.2	224.3

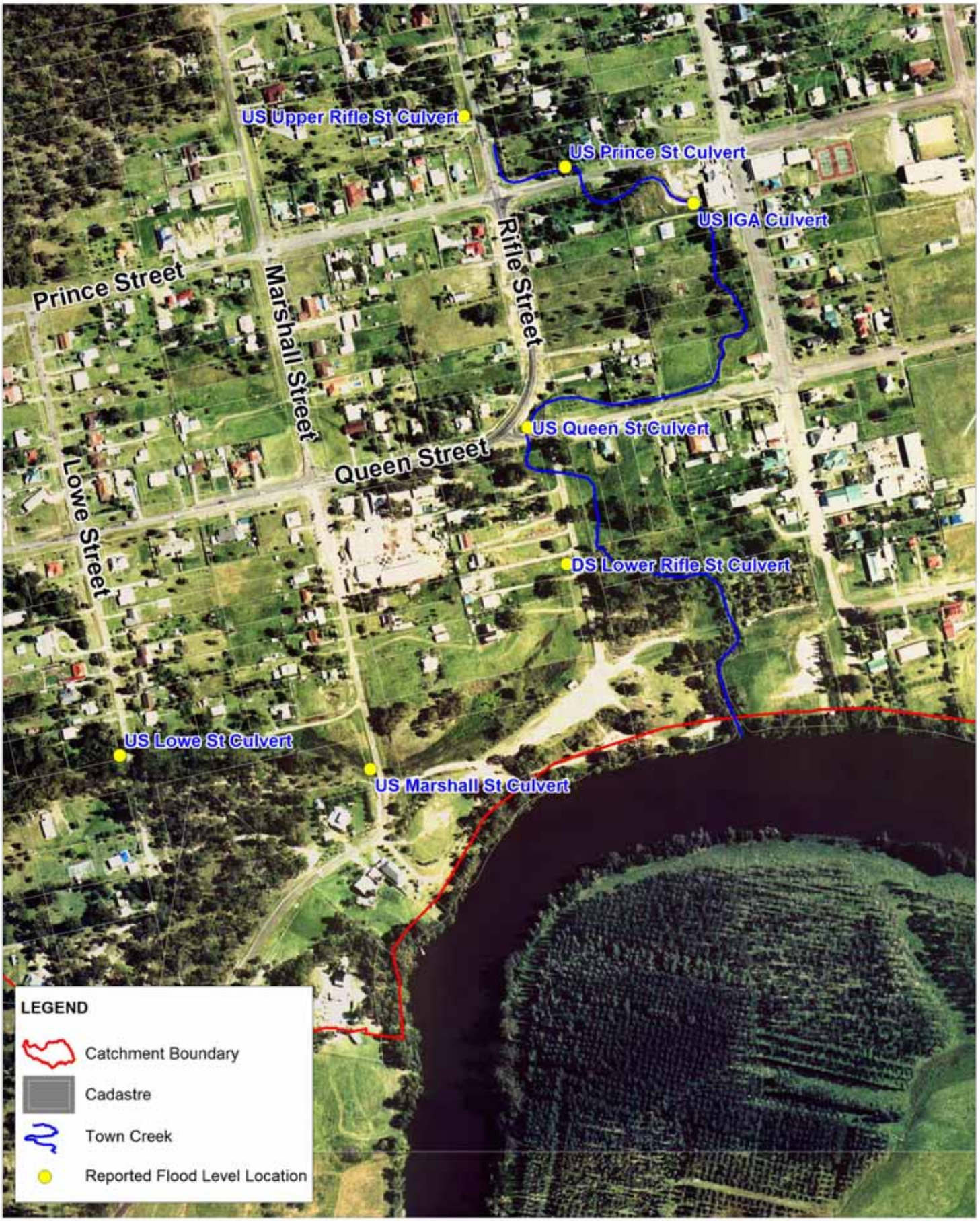
It is evident in Figure 2-3 that the floodwaters in the mid to upper catchment are generally confined to a series of natural gully lines that link with Town Creek at various locations throughout the catchment. Widespread inundation is largely limited to the floodplain in the east of the catchment (associated with the Williams River) and the lower catchment south of Queen Street with the majority of out of bank flow restricted to land between Rifle Street and Grey Street along the main Town Creek alignment. There is however numerous local overland flow paths (albeit relatively shallow depth) which pass through existing private property and are not aligned with the road network.

Longitudinal profiles showing predicted flood levels within the Town Creek channel for the 5% AEP, 1% AEP and PMF design events are shown in Figure 4-2. The June 2007 flood profile is also shown on Figure 4-2 for reference. The June 2007 flood event approximates to a 100-yr ARI water level profile. PMF levels are typically of the order of 1m higher than the 100-yr ARI flood levels at most locations.

There are a number of cross drainage structures within the catchment that provide for significant control of floodwater levels, as evidenced by the local flattening of the simulated flood water level profile upstream of the structures (i.e. backing up of floodwaters behind the structures).

The most significant of these structures in terms of terms culvert size, embankment height, and influence on flood water levels, is the box culvert (1.8m x 2.0m) on the corner of Queen Street and Rifle Street. This structure (and associated road embankment) provides a major flow constriction resulting in elevated water levels upstream of Queen Street. The capacity of this structure was exceeded during the June 2007 rainfall event resulting in overtopping of Queen Street above the structure.

Similar flow constrictions and resulting impacts on the peak water level profile also occur at the culvert structure behind the IGA store adjacent to Grey Street; the culvert structure on Rifle Street approximately 50m west of the Prince Street intersection; the culvert structure at the bottom end of Marshall Street and several smaller structures throughout the catchment. There are also a number of private access culverts constructed across the main Town Creek alignment that have an influence on the hydraulic behaviour of the creek.



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Reported Flood Level Locations

Figure: 4-1

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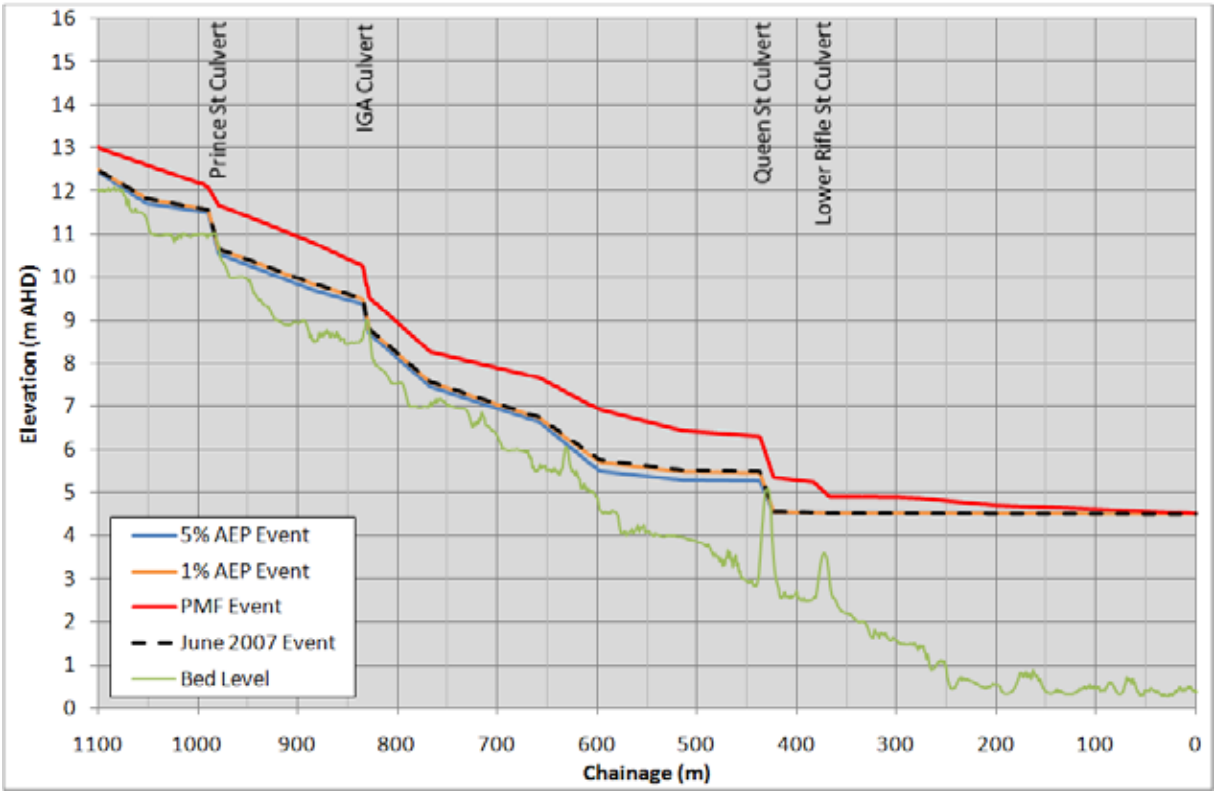


Figure 4-2 Design Flood Profiles for Town Creek Local Catchment Flooding

4.1.2 Williams River Flood Behaviour

As previously stated, the Williams River is a significant system with a catchment area of the order of 1,100km^2. Elevations in the catchment range from above 1,400m AHD in the upper catchment in the Barrington Tops to sea level in the lower catchment. The Williams River is tidally influenced from the Hunter River confluence upstream to Seaham Weir (there no tidal impacts affecting Clarence Town).

Flooding in the Williams River in the vicinity of Clarence Town emanates from periods of prolonged rainfall across the wider Williams River catchment. The critical Williams River flood conditions within Clarence Town relate to longer duration events of the order of 24 to 36 hours.

The design water level conditions for the Williams River were established in the Williams River Flood Study (BMT WBM, 2009). The Williams River flooding in Clarence Town is a result of backwater from the river, with flows and velocities typically lower than those associated with local catchment flooding. The main areas of Clarence Town impacted by Williams River flooding are the land between Grey Street and Marshall Street (encompassing King Street) extending up to Queen Street as well as the southern end of Durham Street. In larger design flood events flooding extends from Queen Street up to Prince Street.

The design water levels for the Williams River at the confluence of Town Creek and the Williams River and upstream of Limeburners Creek Road bridge are presented in Table 4-3. At these levels of in inundation, the Town Creek channel up to Prince Street is dominated by the Williams River. The extent of Williams River flood inundation is shown in Figure 2-4. The levels also show a water

level gradient of approximately one metre as floodwaters are conveyed from Limeburners Creek Road bridge (adjacent to the northern extent of the local Town Creek catchment) and the confluence with Town Creek some three kilometres downstream.

Table 4-3 Estimated Peak Flood Levels for Williams River Design Events

Location	Peak Design Flood Level (m AHD)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	PMF
Town Creek Confluence	5.4	6.0	6.8	7.5	8.1	8.7	14.1
Limeburners Creek Road Bridge	6.3	7.0	7.9	8.7	9.4	10.1	15.5

Longitudinal profiles showing predicted flood levels along the Williams River (extending from 1.5km upstream of the Glen Martin (Mill Dam Falls) gauge downstream to the Seaham Weir) for the 20% AEP, 5% AEP, 1% AEP and PMF design events are shown in Figure 4-3. The longitudinal profile shows that the difference in peak flood levels for the 1% AEP deign event at Glen Martin (Mill Dam Falls) gauge and Clarence Town is approximately 6.3 metres.

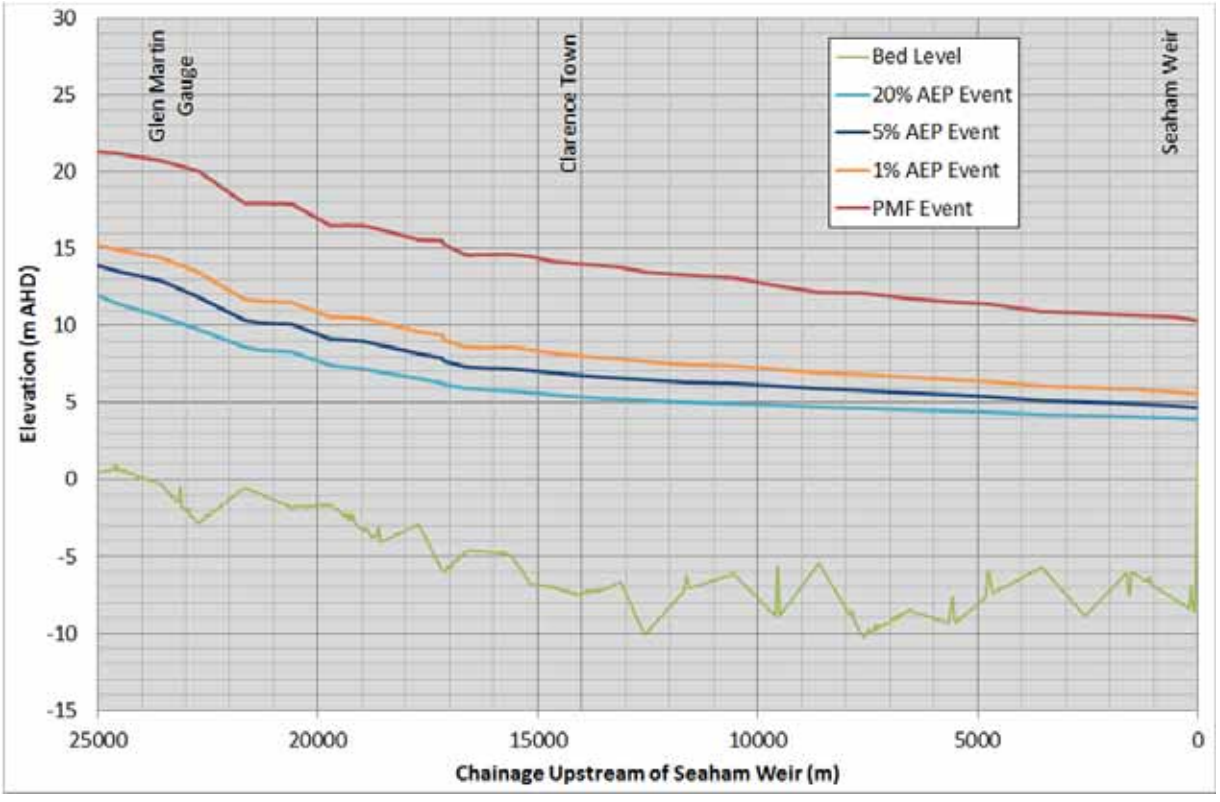


Figure 4-3 Design Flood Profiles for Williams River Flooding

4.1.3 Coincident Flooding

The coincident Town Creek and Williams River flooding condition is an important consideration in defining design flood event conditions for the Town Creek catchment. Some of the significant flood

events in Clarence Town have been primarily driven by Williams River flooding (e.g.1956, 1963, 1978, 1990 and 2001).

Of the historical events above, the relative contribution of flows from the Town Creek catchment is unknown. However, given the events generally correspond to long duration rainfall events of the order of 1-3 days, it is unlikely that the Town Creek flooding condition was as severe in terms of equivalent design magnitude as the Williams River catchment. It has been noted previously that much shorter duration rainfall events represent the critical duration for major flooding in Town Creek.

Given the differences in scale of the catchments, and the subsequent differences in critical rainfall duration, it is unlikely that a 1% AEP event would occur simultaneously. Nevertheless, there remains the opportunity for coincident major flooding in both the Town Creek and Williams River catchments. Under such conditions it would be expected that flooding in the lower catchment up to Prince Street would be dominated by Williams River flooding and flooding in the upper catchment upstream of Prince Street would be dominated by local catchment flooding.

4.2 Existing Flooding "Hot Spots"

As part of the Clarence Town Flood Study (BMT WBM, 2012) a number of areas within the floodplain where identified as flooding "hot spots" in need of further investigation and possible future flood management. A "hot spot" was defined to be an area within the catchment where flooding would have a significant impact on existing development and the community. Whilst the lower floodplain (land between Grey Street and Marshall Street extending up to Queen Street as well as King Street; the southern end of Durham Street; and land to the east of Russell Street) is significantly affected by both Williams River and local catchment flooding, it is predominantly development free and as such is not identified as a flooding "hot spot".

The first flooding "hot spot" is the area around the commercial buildings on the intersection of Prince Street and Grey Street. This area is immediately adjacent to the Town Creek channel and is subject to widespread inundation. This inundation is due to a number of factors including:

- Capacity of the Town Creek channel being exceeded resulting in out of bank / mainstream flooding from Town Creek;
- The constriction formed by the culvert on the access road behind the IGA building which results in a backwater flooding effect that further exacerbates the mainstream flooding from Town Creek; and
- Overland flooding as floodwaters flow down Grey Street and instead of continuing down Grey Street and into Town Creek, the floodwaters flow across the Grey Street / Prince Street intersection and into the front of the commercial buildings on Prince Street.

This area was subject to inundation during the June 2007 event as shown in Figure 4-4. A flood debris line at the front of the building indicated flooding above floor level of the order of 0.4m. A number of potential floodplain management options have been investigated for this area and are presented in Section 7.

Figure 4-4 June 2007 Flooding – Rural Transaction Centre

The second flooding "hot spot" is the area around the culvert structure on the corner of Queen Street and Rifle Street. As previously discussed, there are a number of cross drainage structures within the catchment that provide for significant control of floodwater levels. The culvert structure (1.8m x 2.0m box culvert) on the corner of Queen Street and Rifle Street is the most significant structure in terms of influence on flood water levels. This structure (and associated road embankment) provides a major flow constriction resulting in elevated water levels upstream of Queen Street. When the capacity of this structure is exceeded floodwaters can overtop Queen Street above the structure. The capacity of this structure is exceeded during flood events greater than the 2% AEP event. The capacity of this structure was exceeded during the June 2007 rainfall event resulting in overtopping of Queen Street above the structure as shown in Figure 4-5.

Although the culvert structure (and associated road embankment) does provide a major flow constriction resulting in elevated water levels it does not result in any above floor flooding of any existing developments during the 1% AEP event and as such was considered to be sufficient in its current state and therefore no floodplain management options have been investigated for this area.

Figure 4-5 June 2007 Flooding – Queen Street Culvert

4.3 Revision of AR&R Guidelines

The Clarence Town Flood Study (BMT WBM, 2012) utilised design rainfall parameters derived from standard procedures defined in AR&R (2001) The Bureau of Meteorology (BoM) is currently undertaking a revision of Engineers Australia's design handbook *Australian Rainfall and Runoff: A Guide to Flood Estimation*. The outputs of the revision will include new IFD design rainfall estimates, revised temporal patters and revised rainfall loss values.

The outputs of the revision project will be released progressively over the next two years, with the first release to be the new IFD design rainfall estimates (released in July 2013). The additional outputs including the revised temporal patterns have not yet been released.

The new IFD design rainfall estimates are based on a more extensive rainfall database then the 1987 IFD design rainfall estimates with statistical analysis of an additional 30 years of rainfall data as well as data from an additional 2300 rainfall stations included in the new rainfall database.

Whilst the new IFD design rainfall estimates are derived from a more extensive rainfall database, the BoM recommends careful consideration be used when using the new values with the existing temporal patterns and other design parameters based on AR&R 1987. The BoM states that *you cannot assume that using the 2013 IFD design rainfalls with AR&R87 techniques and design parameters will deliver a more reliable estimate of the design flood* (BoM, 2013).

Until such time as the revised temporal patterns are rainfall loss parameter values are released, the BoM recommends using the AR&R 1987 IFD data system and design parameters and using the

new IFD design rainfall estimates to conduct sensitivity testing. This will allow an assessment of the impact of the updates rainfall information to be incorporated into the decision making process.

Based on these recommendations a sensitivity test has been undertaken to assess the impact of the new IFD design rainfall estimates on the design flood levels in Clarence Town. The IFD data presented in Table 4-4 and Table 4-5 provides for the average intensity (or total depth) that occurs over a given storm duration based on the 1987 and 2013 IFD design rainfall estimates respectively.

Table 4-4 Design Rainfall Estimates Based on 1987 IFD Data (mm)

Duration (hours)	Design Event Frequency					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	30.4	39.4	44.7	51.8	61.1	68.2
2	40.6	52.6	59.8	69.2	81.6	91.2
3	47.7	61.8	70.5	81.6	96.3	107.7
6	63.0	82.2	93.6	108.0	127.8	143.4
12	84.2	109.8	124.8	145.2	171.6	193.2
24	113.8	148.8	169.7	197.3	233.8	261.6

Table 4-5 Design Rainfall Estimates Based on 2013 IFD Data (mm)

Duration (hours)	Design Event Frequency					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	28.9	41.4	50.6	60.3	74.0	85.2
2	36.7	52.7	64.4	76.5	93.8	107.9
3	42.3	60.6	74.0	87.9	107.7	123.8
6	54.5	77.8	94.9	112.8	138.2	159.0
12	71.5	101.9	124.4	147.9	181.6	209.4
24	94.6	134.8	164.8	196.4	242.0	280.0

A comparison of the 1987 and 2013 IFD design rainfall estimates, in the form of change in design rainfall estimate for the 2013 IFD data (i.e. 2013 value minus 1987 value), is shown in Table 4-6 and Figure 4-6. For the more frequent events (i.e. 50%, 20% and 10% AEP events) there is generally a slight decrease in the design rainfall estimate for Clarence Town. However for the rare events (>5% AEP) there is a general increase in design rainfall estimates. For the 1% AEP 2-hour design event (previously identified to be the critical 1% AEP flood event) there is a 12.2mm increase in design rainfall which equates to an approximate percentage increase of 18%. This increase in design rainfall is likely to result in an increase in the design 1% AEP flood levels for the local catchment flooding in Clarence Town.

Table 4-6 Comparison of 1987 and 2013 IFD Design Rainfall Estimates

Duration (hours)	Change in Design Rainfall Estimate for 2013 IFD Data (mm)					
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	+1.5	-1.5	+2.0	+5.9	+8.5	+12.9
2	+0.6	-3.9	+0.1	+4.6	+7.3	+12.2
3	-0.1	-5.4	-1.2	+3.5	+6.3	+11.4
6	-1.2	-8.5	-4.4	+1.3	+4.8	+10.4
12	-2.4	-12.7	-7.9	-0.4	+2.7	+10.0
24	-4.8	-19.2	-14.0	-4.9	-0.9	+8.2

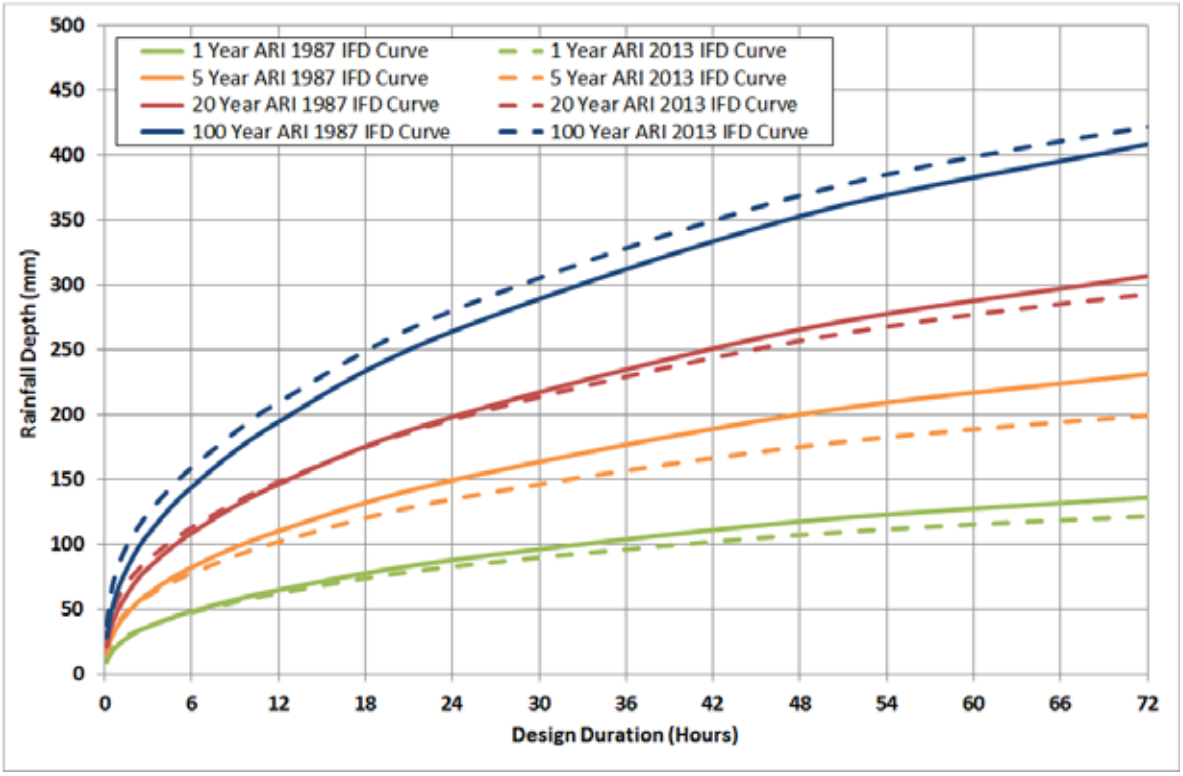


Figure 4-6 Comparison of 1987 and 2013 IFD Relationships

General increase in design rainfall estimates associated with the 2013 IFD relationships will decrease the statistical return periods of historical rainfall events. For example, using the 1987 IFD estimates, the June 2007 rainfall event approximates a 1% AEP 2-hour event. However, using the 2013 IFD estimates, the June 2007 rainfall event approximates a 2% AEP 2-hour event. This effectively decreases the return period of this event from 100 years to 50 years (i.e. two rainfall events of this magnitude would be expected to occur within a 100 year period instead of only one). A similar decrease in return period occurs when analysing the February 2011 rainfall event which drops from a 2% AEP 1-hour event (1987 IFD data) to a 5% AEP 1-hour event (2013 IFD data). This corresponds to a decrease in expected return period from 50 years to 20 years. The comparison between the historical rainfall events and the 1987 and 2013 IFD relationships are shown in Figure 4-6 and Figure 4-8 respectively.

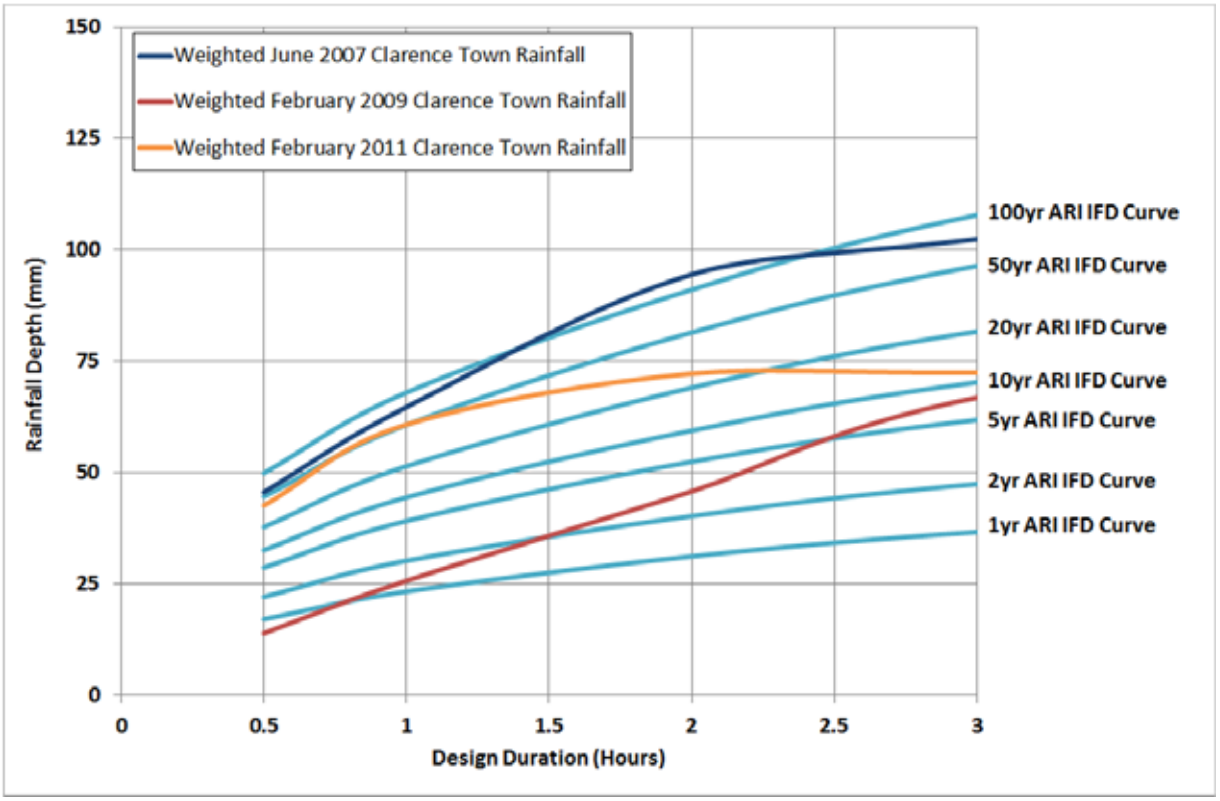


Figure 4-7 Comparison of Historical Rainfall Events with 1987 IFD Relationships

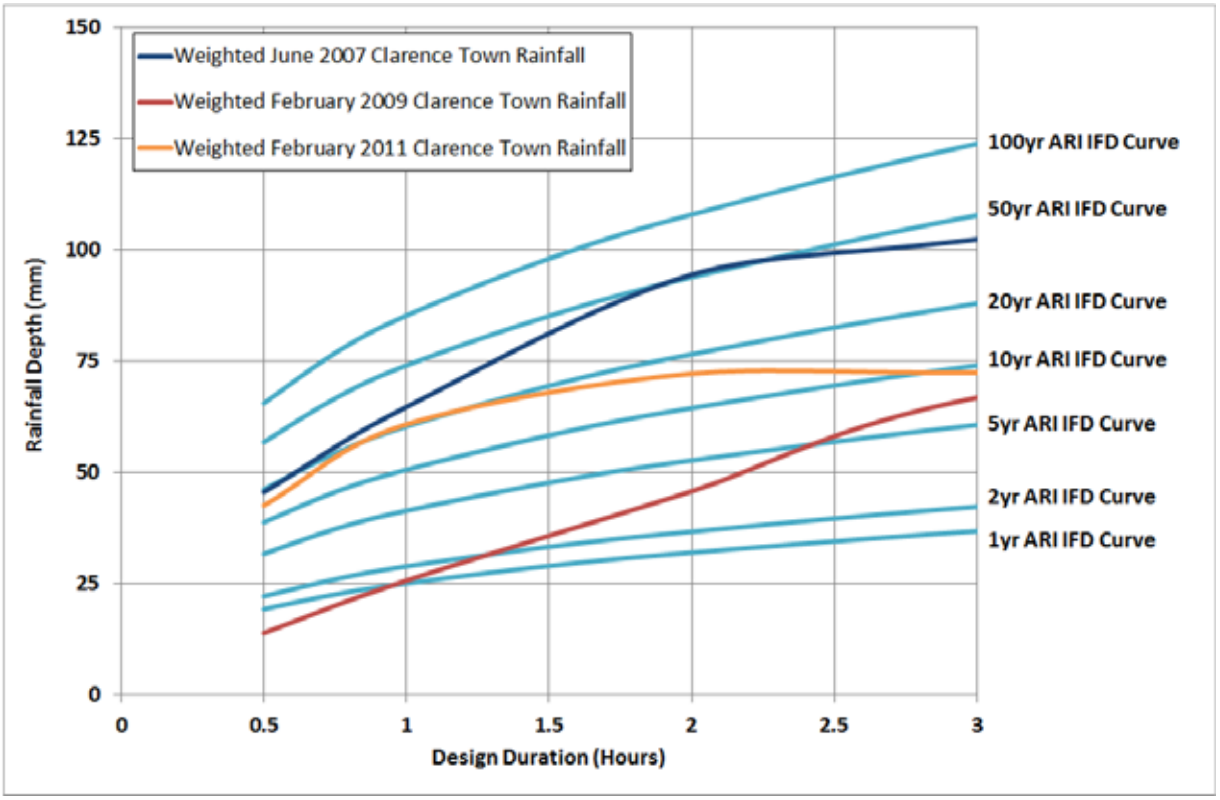


Figure 4-8 Comparison of Historical Rainfall Events with 2013 IFD Relationships

4.3.1 Results of Sensitivity Test on 2013 IFD Data

As previously stated, the BoM recommends sensitivity tests to be undertaken to assess the impact of the new IFD design rainfall estimates on the design flood levels. The sensitivity test has been undertaken for 1% AEP 2-hour local catchment design event.

The modelled peak flood levels for the 1% AEP design flood condition using the 2013 IFD design rainfall estimates are presented in Table 4-7 with reference to the predicted peak flood level for the baseline conditions using the 1987 IFD design rainfall estimates at selected locations.

Table 4-7 Change in Peak 1% AEP Flood Levels with 2013 IFD Design Rainfall Estimates

Location	Peak Flood Level (m AHD)	
	1987 IFD Data	2013 IFD Data
US Upper Rifle St Culvert	13.76	13.82 (+0.06)
US Prince St Culvert	11.67	11.72 (+0.05)
US IGA Culvert	9.57	9.66 (+0.09)
US Queen St Culvert	5.47	5.56 (+0.09)
DS Lower Rifle St Culvert	4.52	4.53 (+0.01)
US Marshall St Culvert	6.45	6.51 (+0.06)
US Lowe St Culvert	10.55	10.60 (+0.05)

Note: Bracketed value is change in peak flood level from standard design conditions

As shown in Table 4-7, the 2013 IFD design rainfall estimates only has minor (<0.1m) impact on 1% AEP local catchment flood conditions in Clarence Town.

4.4 Flood Risk Mapping

The flood results from the Clarence Town Flood Study were presented in a flood mapping series for each design event magnitude simulated, incorporating a map of peak flood depth, velocity and hydraulic hazard within study catchment. Additional mapping has been undertaken in the floodplain risk management study to further define the hydraulic category and flood hazard distributions.

4.4.1 Hydraulic Categorisation

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual (NSW Government, 2005) are essentially qualitative in nature. Of particular difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment.

The hydraulic categories as defined in the Floodplain Development Manual are:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.

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

The approaches used to define the hydraulic categorisation for local catchment and Williams River flooding are presented in the following sections.

4.4.1.1 Local Catchment Flooding – Hydraulic Categorisation

A number of approaches were considered when attempting to define flood impact categories across the Clarence Town catchment. Approaches to define hydraulic categories that were considered for this assessment included partitioning the floodplain based on:

- Peak flood velocity;
- Peak flood depth;
- Peak velocity * depth (sometimes referred to as unit discharge);
- Cumulative volume conveyed during the flood event; and
- Combinations of the above.

The definition of flood impact categories that was considered to best fit the application within the Clarence Town catchment, was based on a combination of velocity*depth and depth parameters. The adopted hydraulic categorisation for the 1% AEP event is defined in Table 4-8.

Table 4-8 Hydraulic Categories

Floodway	Velocity * Depth > 0.3	Areas and flowpaths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Velocity * Depth < 0.3 and Depth > 0.5 metres	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Velocity * Depth < 0.3 and Depth < 0.5 metres	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

Hydraulic category mapping for the 1% AEP local catchment design event is shown in Figure 4-9.

4.4.1.2 Williams River Flooding – Hydraulic Categorisation

The hydraulic categorisation for Williams River flooding was undertaken as part of the Williams River Flood Study (BMT WBM, 2009). The methodology used to define the hydraulic categories is detailed below.

For the purpose of studying the flow distribution, the total flow can be divided in unit flows (flow per meter width) across the floodplain. The integration of the peak unit flows along lines perpendicular to the main flow provides similar total flow values. Lines perpendicular to the main flow were digitised at close spacing down the catchment. The average unit flow of this line was determined. Unit flow at points spaced regularly along each of these lines was compared to the average unit flow, points of greater than average were defined as being within the floodway.

Sections with high but uniform flow across floodplain were originally defined as non-floodway in this process (with the exception of the main channel). To overcome this, floodway extents from the average unit flow process were combined with areas of high velocity-depth product (greater than $1.0m^2/s$).

Once the floodways were determined, the remainder of the floodplain is a combination of flood storage and flood fringe areas. The floodplain areas outside of the floodways are essentially characterised as flood storage. The flood fringe areas are those areas within the flood storage that contains a volume of water of small significance for the flood behaviour. Filling of these areas would have a minimal impact on flood behaviour.

The flood fringe was calculated using the following process.

(1) The floodplain was divided into smaller regions. 21 regions were used over the floodplain.

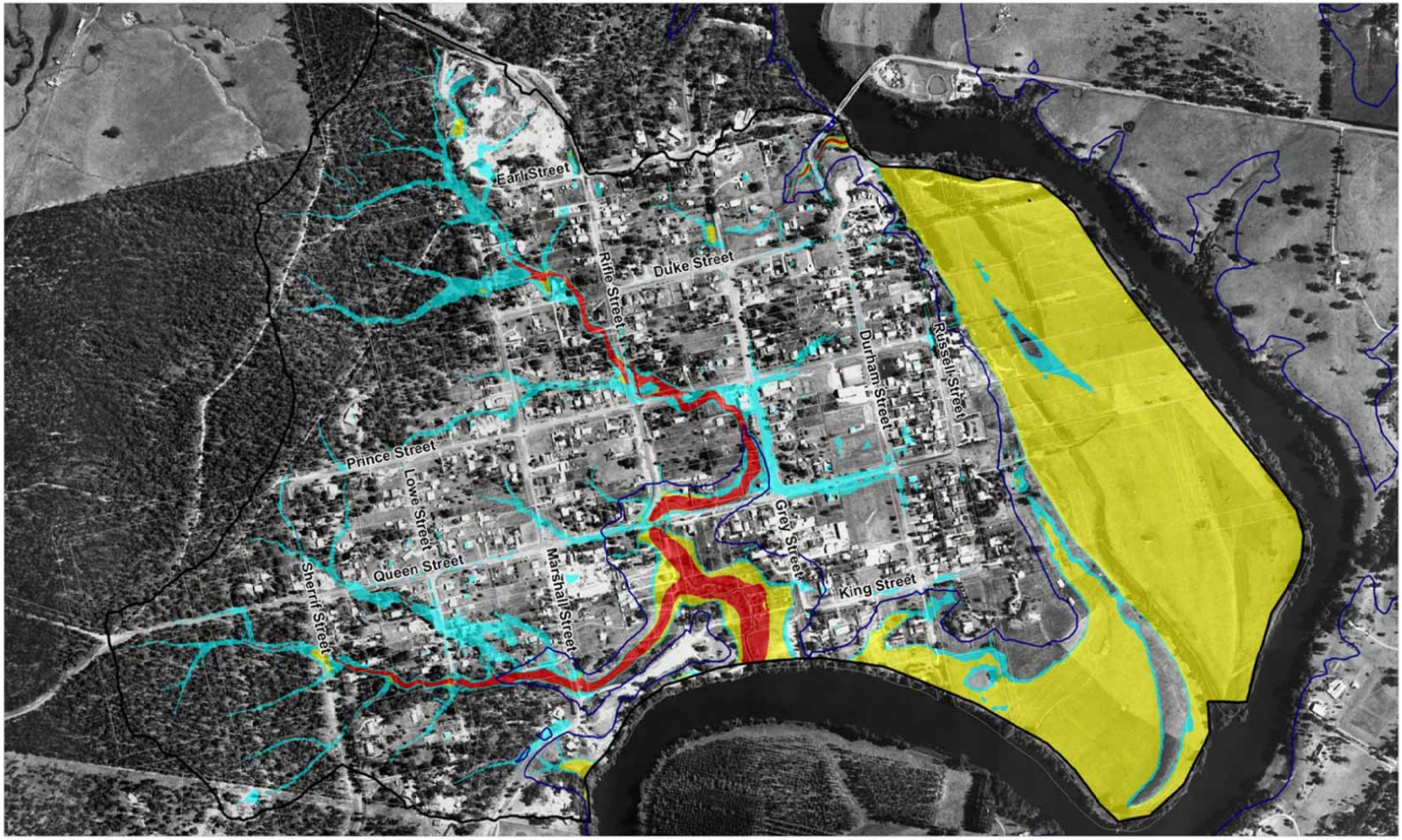
(2) In each region the volume of water required to raise the floodway area by a depth of 0.1m was determined.

(3) The flood fringe areas were those of lowest depth required with equivalent volume to that calculated in step 2.

(4) The resulting areas were then smoothed to remove small islands and irregular areas.

Hydraulic category mapping for the 1% AEP local catchment design event is shown in Figure 4-10.

The floodway area is generally limited to the floodplain areas to the east and south east of the Clarence Town catchment area. The flood storage and flood fringe areas extend up Town Creek as far as the IGA culvert. There is no existing developed located within the floodway area and only a limited number of development located within the flood storage or flood fringe areas. The affected properties are limited to developments on Durham Street and King Street (on south side of King Street) and developments on Rifle Street and Grey Street (south of Queen Street).



LEGEND

Maximum Flood Hazard

- Flood Fringe
- Flood Storage
- Floodway

- Cadastre
- Clarence Town Catchment Boundary
- Williams River 1% AEP Flood Extent

Title:

Hydraulic Categories: 1% AEP Local Catchment Event

Figure: **4-9**

Rev: **A**

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0 125 250m

Approx. Scale

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www.bmtwbm.com.au

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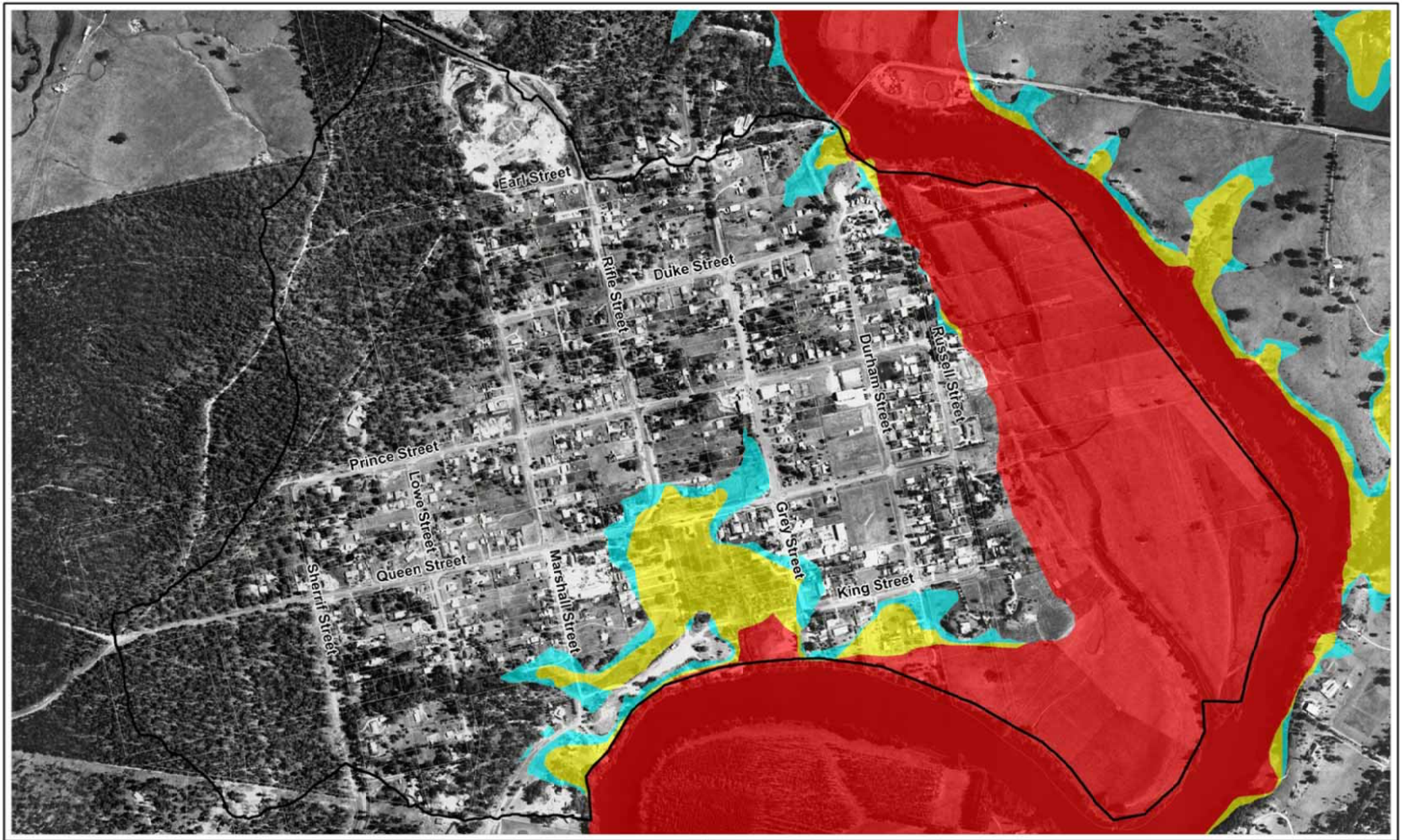

LEGEND

Maximum Flood Hazard

- Flood Fringe
- Flood Storage
- Floodway

- Cadastre
- Clarence Town Catchment Boundary
- Williams River 1% AEP Flood Extent

Title:

Hydraulic Categories: 1% AEP Williams River Event

Figure: 4-10

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4.4.2 Flood Hazard

Hazard categorisation is carried out to establish how hazardous (i.e. dangerous) various parts of the floodplain are. Primarily the hazard is a function of the depth and velocity of floodwater, however, the hazard categorisation considers a wider range of flood risks, particularly those relating to personal safety and evacuation. These hazard factors are derived from both hydraulic risk factors (such as depths and velocities) and human / behavioural issues (such as flood readiness). These considerations are summarised below in the context of the Clarence Town flood environment.

4.4.2.1 Size of Flood

The size of flood will have an obvious and significant influence on the degree of flood risk. Relatively frequent or minor floods would typically be associated with a low flood hazard, whilst the major or rare flood events are likely to provide for high hazard flood conditions.

The design flood extents for a range of flood magnitudes for both local catchment and Williams River flooding are shown in Figure 2-3 and Figure 2-4.

4.4.2.2 Depth and Velocity

Depth and velocity hazards have been identified according to the provisional hydraulic hazard categories provided in the Floodplain Development Manual. This has been further sub-categorised to show the predominant 'type' of hydraulic hazard (i.e. high velocity, depth, or combination) as shown in Figure 4-11 below.

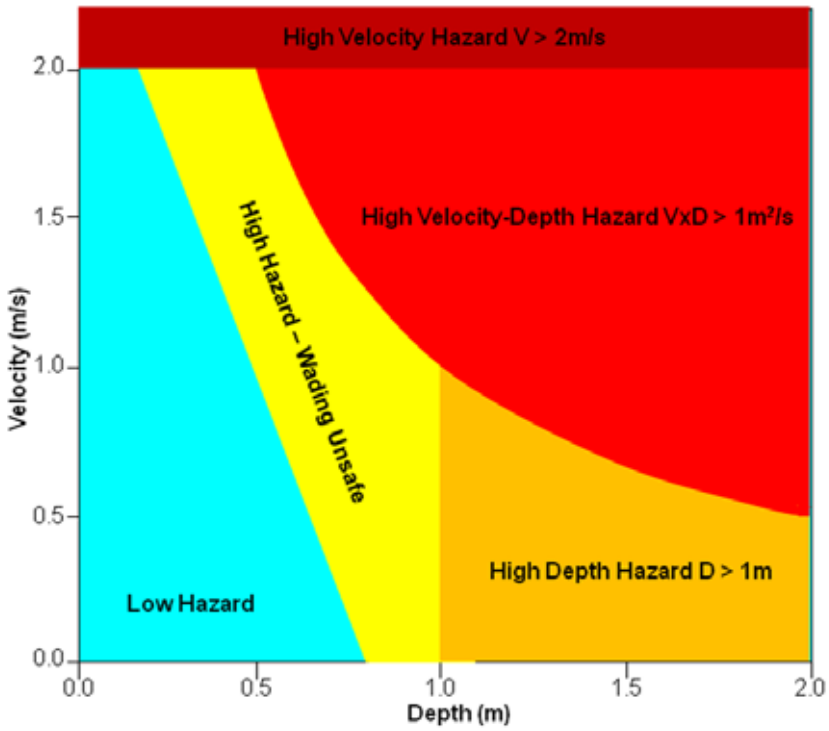


Figure 4-11 Hydraulic Hazard as a function of depth and velocity

4.4.2.3 Flood Readiness

The term 'flood readiness' encompasses a broad range of factors, including familiarity with flooding in the catchment, awareness of evacuation procedures and preparation for a flood (e.g. development of flood plans). Flood readiness can refer to individuals, organisations, communities and businesses.

The relatively recent June 2007 event flood, the largest since 1990 on the Williams River, provided for first-hand experience of major flooding and indication to the community of the potential flood risk. A flood of 1% AEP magnitude has not been experienced in living memory such that appreciation of the implications of an event of this magnitude is also limited.

General questions on flood awareness were targeted through the community questionnaire issued during the course of the study. Potentially there is a significant proportion of the community that are unaware if their property is at risk flooding at all, unaware of any flood warning procedures or available flood information, and generally indicated a low-level of flood preparedness in terms of personal flood emergency response.

With a number of local Town Creek catchment flood events in recent years, landowners affected by these event, in particular the commercial properties in the town centre, have high level of flood awareness.

4.4.2.4 Rate of Rise

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate.

Given the small size and relative steepness of the local catchment, the flood response of the local catchment can be relatively fast with peak flood water levels occurring in under an hour. In contrast, given the size of the Williams River catchment the flood response of the wider Williams River catchment is much slower with a gradual rate of rise of floodwaters occurring over a 12-24 hours.

Figure 4-12 shows the simulated water level rise for 1% AEP local catchment flood event in response to the adopted design rainfall pattern. The critical storm duration resulting in the highest peak flood level conditions was found to be the 2-hour storm event. It is evident that the local catchment is highly responsive to the design rainfall pattern with the peak flood level reached in less than an hour.

Figure 4-13 shows the simulated water level rise for 1% AEP Williams River flood event in response to the adopted design rainfall pattern. The critical storm duration resulting in the highest peak flood level conditions was found to be the 36-hour storm event. It is evident that the flood response of the Williams River catchment is much slower than the local catchment response, with the peak flood level reached approximately 28-hours after the onset of flood producing rainfall.

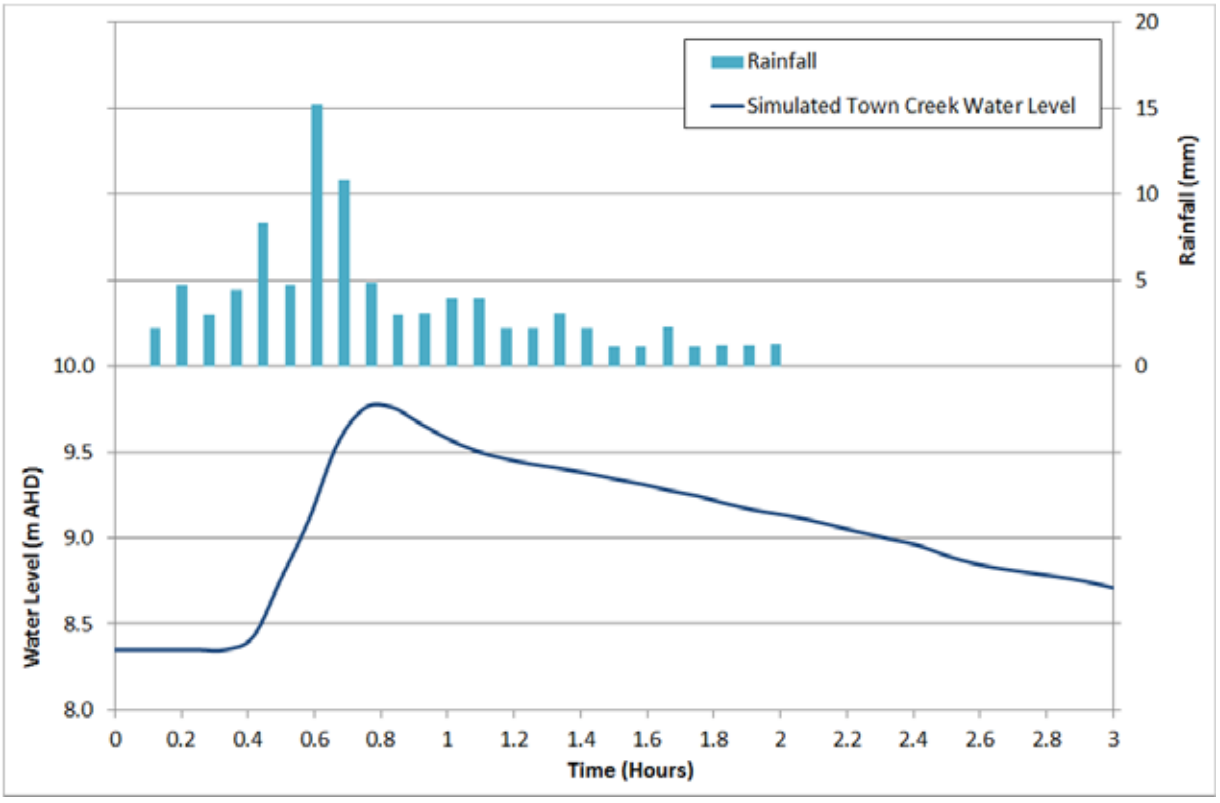


Figure 4-12 Rate of Rise of Floodwater (Design 1% AEP Local Catchment Flooding)

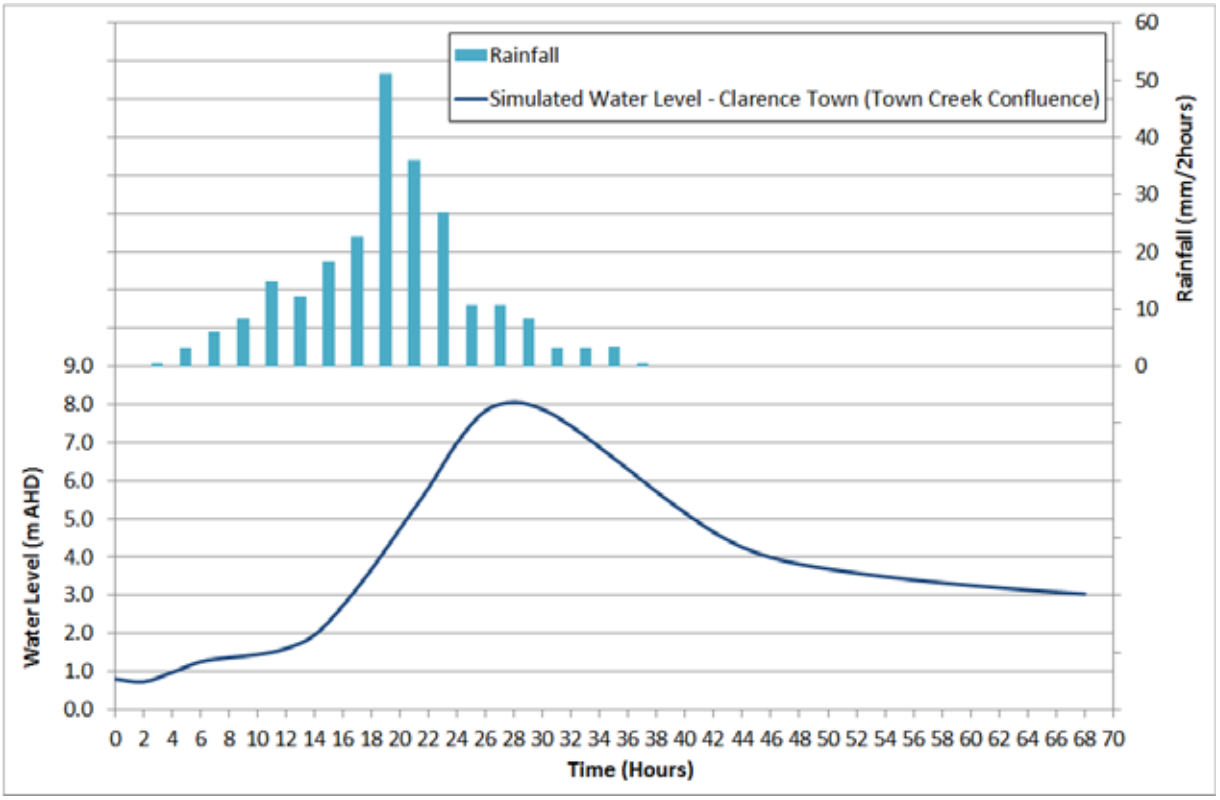


Figure 4-13 Rate of Rise of Floodwater (Design 1% AEP Williams River Flooding)

4.4.2.5 Duration of Flooding

The greater the duration of flood inundation the greater the potential impacts on damages and disruption to the community.

The duration of flooding is largely related to the size and duration of the rainfall event over the catchment. As noted in Section 4.4.2.4, the critical duration for peak flood levels in the local catchment was estimated as the 2-hour design flood event and for the Williams River it was estimated as the 36-hour design flood event. The overall volume of runoff will be more for longer storm durations (i.e. Williams River flooding), and whilst perhaps not providing for highest peak flood level condition in some parts of the catchment, the duration of overbank inundation may be extended. Given the highly responsive nature of local catchment flooding the period of inundation in expected to be less than one hour. However for the larger volume Williams River flood events, the period of inundation, particularly for low lying floodplain areas, could potentially be 20 hours. The period of inundation for Williams River flooding reduces significantly as the flood waters progress to higher ground within the Clarence Town catchment.

4.4.2.6 Flood Warning Times

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to respond appropriately and implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

To assess flood warning opportunity for Clarence Town, consideration has been given to the levels of warning times as defined in Table 4-9.

Table 4-9 Flood Warning Time Categories

no effective warning	<1 hr	No time for pro-active and systematic organisation of flood mitigation, evacuation, emergency response etc. Individuals would be self-directed in regards to emergency response.
minimal warning	1-6 hrs	Limited assistance and direction likely from emergency services. Measures requiring minimal time for implementation may be appropriate for flood management.
moderate warning	6-12 hrs	Potential assistance and direction from emergency services, depending on time of day. Measures requiring moderate time, or less, for implementation may be appropriate for flood management.
good warning	12+ hrs	Significant assistance and direction from emergency services may be available, including assistance with evacuation. Most measures requiring some form of on-demand implementation would be appropriate for flood management.

As discussed in Section 4.4.2.4, the local catchment is highly responsive to the design rainfall pattern with the peak flood level reached in less than an hour after the onset of flood producing rainfall. Clarence Town would therefore have no effective warning for local catchment flooding.

In the case of Williams River flooding, Clarence Town receives a moderate warning of between 6 and 12 hours. The NSW State Flood Plan states that 9 hours warning time is generally provided for flood levels in excess of 7.0m AHD and above at the Glen Martin (Mill Dam Falls) gauge.

4.4.2.7 Effective Flood Access

Access and evacuation difficulties arise from:

- high depths and velocities of floodwaters over access routes;
- difficulties associated with wading (uneven ground, obstruction such as fences);
- the distance to higher, flood free ground;
- the number of people and capacity of evacuation routes;
- the inability to communicate with evacuation and emergency services;
- the availability of suitable equipment (e.g. heavy vehicles, boats);
- a low level of community awareness of evacuation procedures or requirements; and
- a willingness of residents to remain at their property.

There are some areas of Clarence Town, particularly the low lying areas bordering on the Williams River, that could potentially require evacuation in a major flood event. The topography of Clarence Town (as shown in Figure 2-1) is such that in the event of a major flood event there should always be an uphill escape route available. There also no major road inundation points that could not be avoided by following alternate routes.

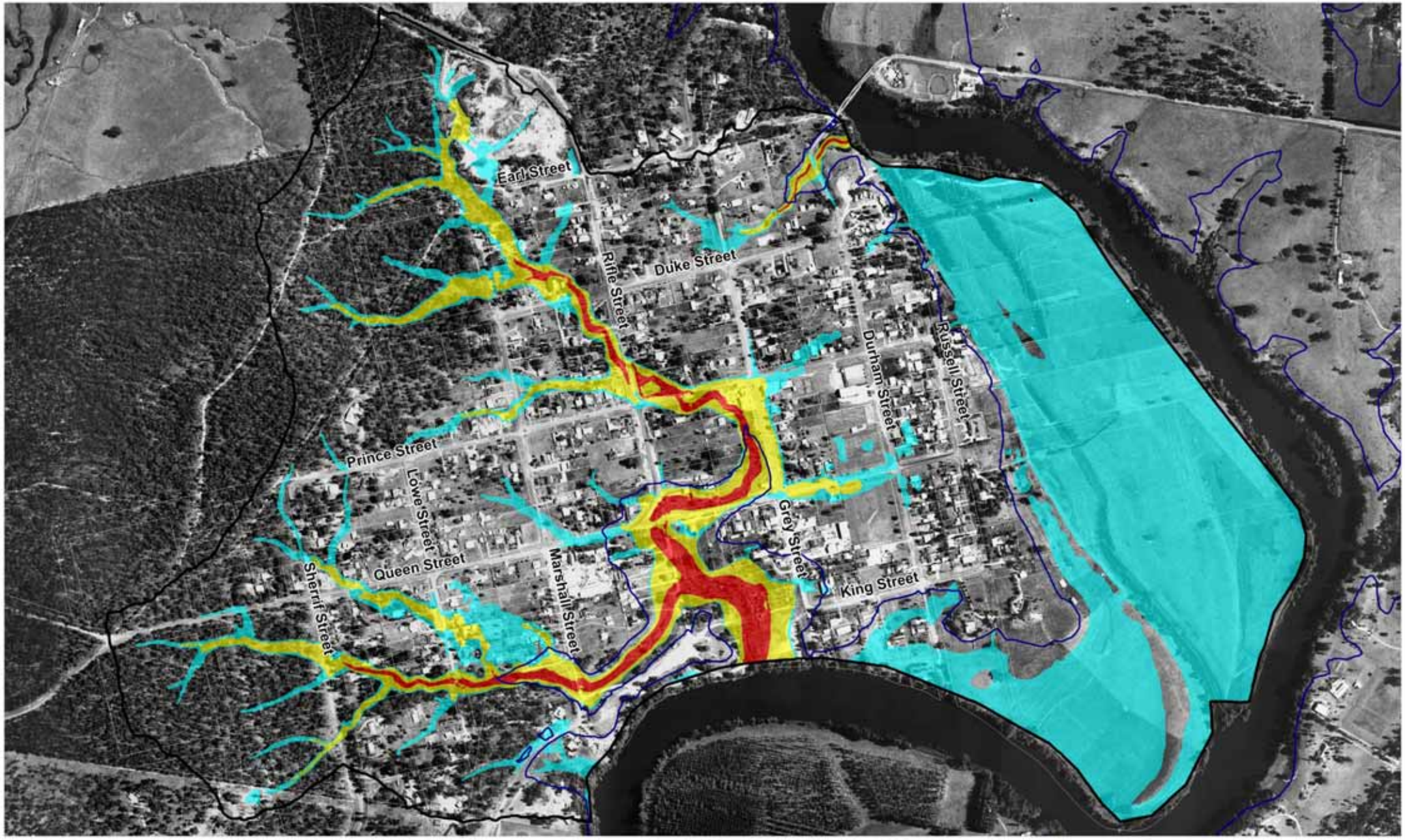
4.4.3 Adopted Flood Hazard Categories

The flood hazard categories adopted for Clarence Town were taken from Councils DCP (Dungog Development Control Plan No.1 – Managing our Floodplains) and are presented in Table 4-10. The flood hazard categories for local catchment flooding and Williams River flooding are presented in Figure 4-14 and Figure 4-15 respectively.

Table 4-10 Adopted Flood Hazard Categories

Flood Hazard Category*	Criteria
Floodway	Area defined as Floodway or High Hazard for the 1% AEP Flood
Flood Fringe	Area between Floodway area and the 1% AEP Flood (plus 0.5m freeboard)
Outer Floodplain	Area between the 1% AEP Flood (plus 0.5m freeboard) and the Extreme Flood

1 Flood Hazard categories are referred to as Floodplain Management Zones in "Dungog Development Control Plan No.1 – Managing our Floodplains"



LEGEND

Flood Hazard Category
- Outer Floodplain
- Flood Fringe
- Floodway

Cadastre

Clarence Town Catchment Boundary

Williams River 1% AEP Flood Extent

Title:
Flood Hazard Categories: Local Catchment Flooding

Figure: **4-14**

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Approx. Scale

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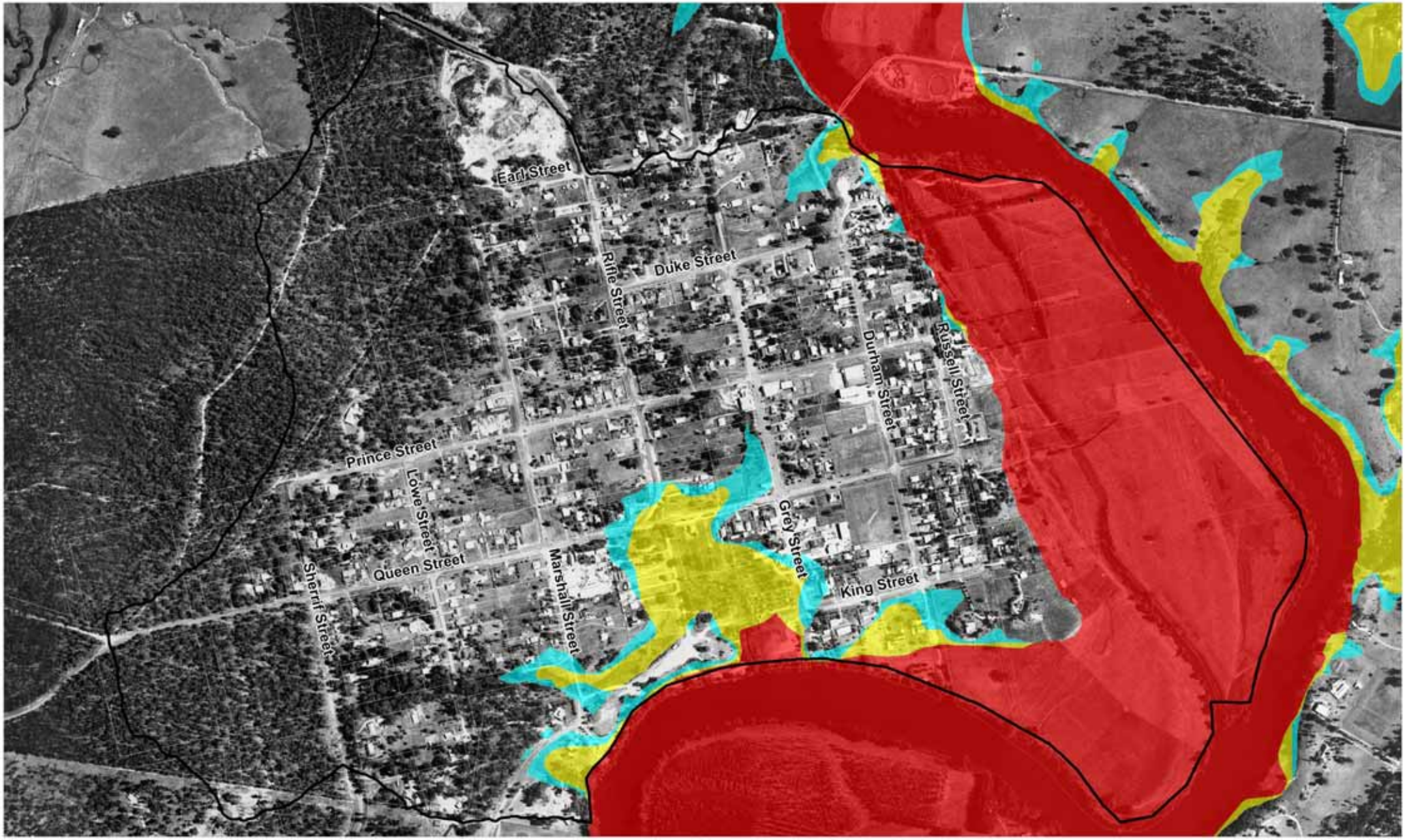

LEGEND

Maximum Flood Hazard

- Flood Fringe
- Flood Storage
- Floodway

Cadastre

Clarence Town Catchment Boundary

Title:

Hydraulic Categories: 1% AEP Williams River Event

Figure: 4-15

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4.5 Climate Change

Current practice in floodplain management generally requires consideration of the impact of potential climate change scenarios on design flood conditions. For Clarence Town this requires investigation of increases in design rainfall intensities. Accordingly, this increase in design rainfall will translate into increased design flood inundation in Clarence Town, such that future planning and floodplain management in the catchment will need to take due consideration of this increased flood risk. The climate change sensitivity tests considered increases in design rainfall intensity of 10%, 20% and 30% in accordance with DECCW Practical Consideration of Climate Change Guideline for Floodplain Risk Management (2007).

The potential impacts of future climate change were considered for the 1% AEP design flood condition for both the local Town Creek catchment and the wider Williams River catchment. The impact of potential climate change scenarios on the 1% AEP design flood condition is presented in Appendix A as a series of maps showing increase in peak flood inundation extents from the baseline (existing) conditions. Further discussion on relative increases from existing peak flood levels is provided hereunder.

The modelled peak flood levels for the 1% AEP design flood condition with increases in design rainfall for local catchment and Williams River flooding are presented in Table 4-11 and Table 4-12 respectively, with reference to the predicted peak flood level for the baseline conditions at selected locations.

Table 4-11 Change in Peak 1% AEP Flood Levels with Increased Design Rainfall – Local Catchment

Location	Peak Flood Level (m AHD)			
	Baseline	10% Increase	20% Increase	30% Increase
US Upper Rifle St Culvert	13.8	13.8 (0.0)	13.8 (0.0)	13.9 (+0.1)
US Prince St Culvert	11.7	11.7 (0.0)	11.7 (0.0)	11.8 (+0.1)
US IGA Culvert	9.6	9.6 (0.0)	9.7 (+0.1)	9.7 (+0.1)
US Queen St Culvert	5.5	5.5 (0.0)	5.6 (+0.1)	5.6 (+0.1)
DS Lower Rifle St Culvert	4.5	4.5 (0.0)	4.5 (0.0)	4.5 (0.0)
US Marshall St Culvert	6.5	6.5 (0.0)	6.5 (0.0)	6.5 (0.0)
US Lowe St Culvert	10.6	10.6 (0.0)	10.6 (0.0)	10.6 (0.0)

Note: Bracketed value is change in peak flood level from standard design conditions

Table 4-12 Change in Peak 1% AEP Flood Levels with Increased Design Rainfall – Williams River

Location	Ground Level (m AHD)	Peak Flood Level (m AHD)			
		Baseline	10% Increase	20% Increase	30% Increase
US Upper Rifle St Culvert	12.7	-	- (0.0)	- (0.0)	- (0.0)
US Prince St Culvert	11.0	-	- (0.0)	- (0.0)	- (0.0)
US IGA Culver	8.5	-	- (0.0)	9.1 (+0.6)	9.6 (+1.1)
US Queen St Culvert	2.8	8.1	8.6 (+0.5)	9.1 (+1.0)	9.6 (+1.5)
DS Lower Rifle St Culvert	1.9	8.1	8.6 (+0.5)	9.1 (+1.0)	9.6 (+1.5)
US Marshall St Culvert	5.3	8.1	8.6 (+0.5)	9.1 (+1.0)	9.6 (+1.5)
US Lowe St Culvert	9.6	-	- (0.0)	- (0.0)	- (0.0)

Note: Bracketed value is change in peak flood level from standard design conditions

The peak flood levels upstream of Prince Street are dominated by the local Town Creek flooding. The increases in peak flood water levels for the increased rainfall scenarios upstream of Prince Street are relatively modest (typically ≤0.1m) for up to the 30% increase scenario. A longitudinal profile showing the simulated local catchment flooding under baseline and climate change conditions is shown in Figure 4-17. The longitudinal profile confirms that the peak flood water levels for the increased rainfall scenarios for local catchment flooding are relatively modest (typically ≤0.1m). Figure 4-16 also confirms that the peak flood levels downstream of Prince Street are dominated by Williams River flooding.

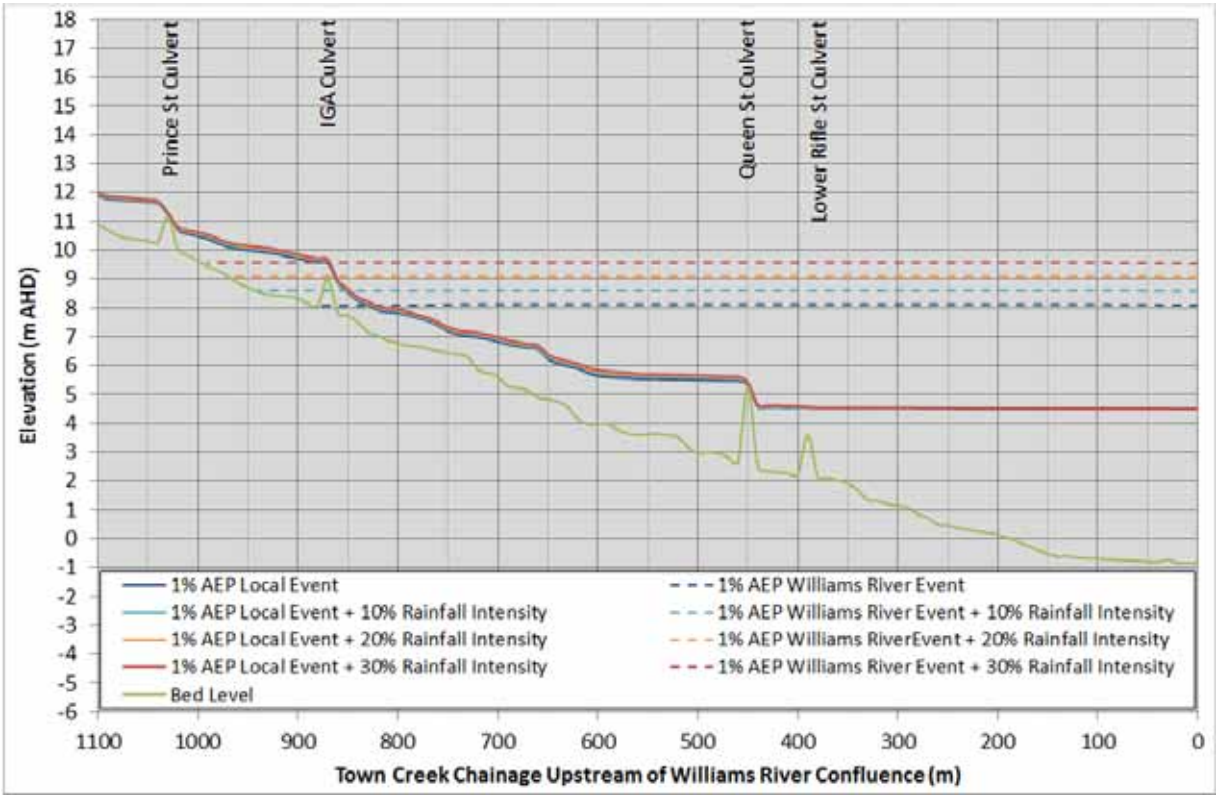


Figure 4-16 Design Flood Profiles for Climate Change Scenarios – Town Creek

The peak flood levels downstream of Prince Street are dominated by the Williams River flooding. The increases in peak flood water levels for the increased rainfall scenarios downstream of Prince Street are relatively high (typically 0.5m increase per 10% increase in rainfall) when compared to the increases in flood levels upstream of Prince Street. The higher increase in flood levels associated with the Williams River flooding can be attributed to the size of the Williams River catchment producing a much higher additional volume of rainfall in the Williams River for the increased rainfall scenarios. This same relationship is evident in the water level increases between increasing design event magnitudes in the Williams River. For instance, the peak flood water levels for the Williams River for a range of design flood events are presented in Table 4-3, it is evident that the increase in peak water level at the confluence of Town Creek and the Williams River between the 1% AEP and 0.5% AEP design event is 0.6m.

A longitudinal profile showing the simulated Williams River flooding under baseline and climate change conditions is shown in Figure 4-17. The longitudinal profile confirms that the peak flood water levels for the increased rainfall scenarios rise by approximately 0.5m per 10% increase in rainfall and also shows that this increase occurs consistently along the 25 kilometre reach of Williams River presented in Figure 4-17.

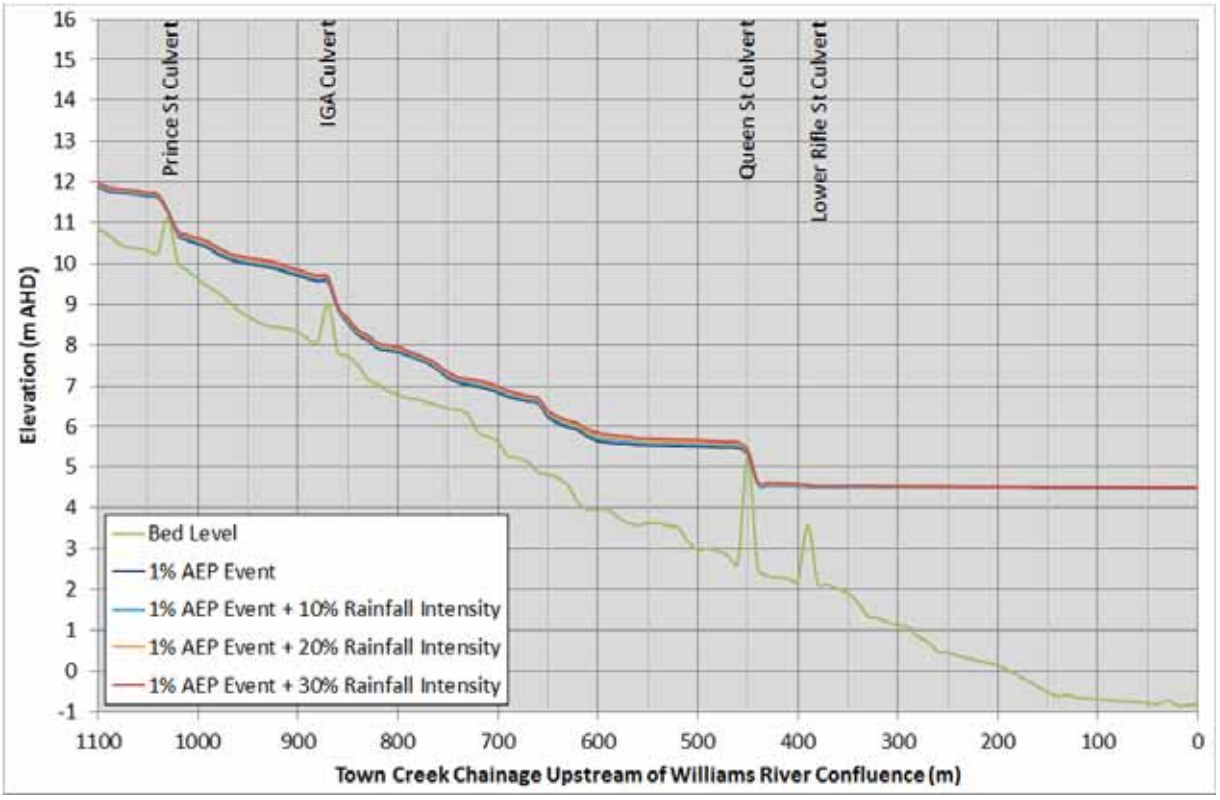
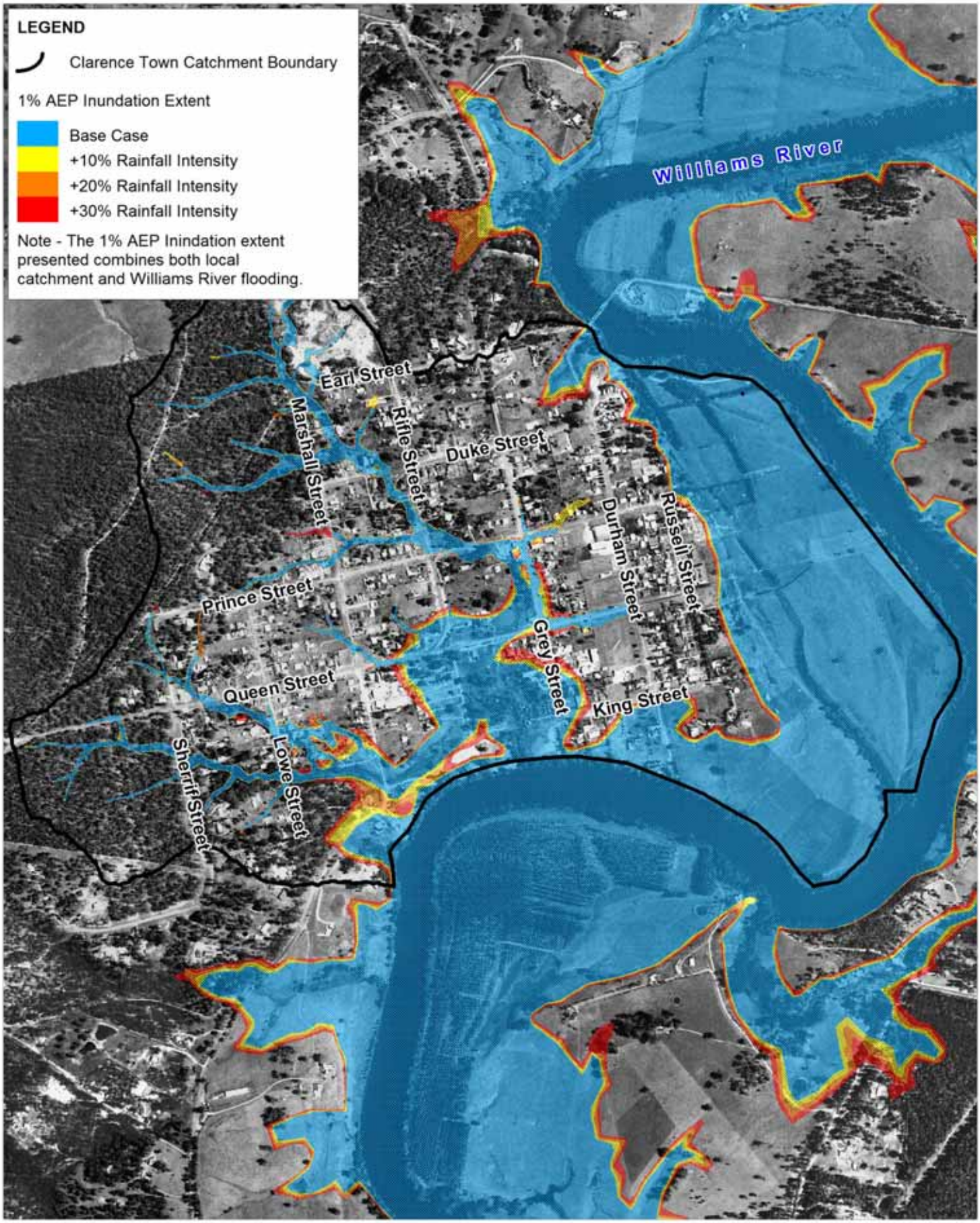


Figure 4-17 Design Flood Profiles for Climate Change Scenarios – Williams River

Figure 4-18 presents the combined local catchment and Williams River flood extents for the baseline and climate change scenarios. It is evident that the increases in peak flood levels translate into only minor increases in the flood extents throughout Clarence Town with the most significant increases in flood extents occurring in the lower catchment downstream of Queen Street.



Title:

Design Flood Extents for Rainfall Intensity Increase Scenarios

Figure: 4-18

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4.6 Road Inundation

The Dungog Local Flood Plan (SES, 2011) details are a number of roads within the Dungog LGA that can potentially be closed due to inundation by floodwaters. There are no road closures with the Clarence Town catchment identified in the Dungog Local Flood Plan.

However, as evidenced during the June 2007 flood event, a number of roads in Clarence Town are expected to be inundated in major flood events. Road inundation can potentially result in the isolation of flood affected property and have serious implications for emergency response.

The lengths of road inundated at the peak of the 1% AEP local catchment and Williams River flood events are shown in Figure 4-19 and Figure 4-20 respectively. The affected road locations are listed in Table 4-13.

Table 4-13 Road Inundation at 1% AEP Flood Level

ID	Location	Flooding Mechanism
1	Southern end of Rifle Street	Williams River
		Local Catchment
2	Queen Street / Rifle Street Intersection	Williams River
		Local Catchment
3	Prince Street	Local Catchment
4	Rifle Street (north of Prince Street intersection)	Local Catchment
5	Southern end of Marshall Street (near Fotheringay Road intersection)	Williams River
		Local Catchment
6	Southern end of Lowe Street	Local Catchment
7	Southern end of Grey Street	Williams River
8	Southern end of Durham Street	Williams River
9	Fotheringay Road	Williams River
10	Northern end of Durham Street / / Limeburners Creek Road	Williams River

The main access road through Clarence Town (Clarence Town Road – Queen St / Rifle Street) is inundated at two locations, the Queen Street / Rifle Street intersection can be detoured around and the section of Rifle Street north of the Prince Street intersection is expected to only be short lived (<1 hour) and have a shallow inundation depth. Two additional access roads (namely Fotheringay Road and Limeburners Creek Road) are also inundated. There are also a number of affected roads within Clarence Town along Grey Street, lower Rifle Street and Lowe Street.

The period of inundation will vary depending on whether the inundation occurs as a result of flooding in the local Town Creek catchment or backwater flooding from Williams River.

Title:

Road Inundation at 1% AEP Local Catchment Flood Level

Figure: **4-19**

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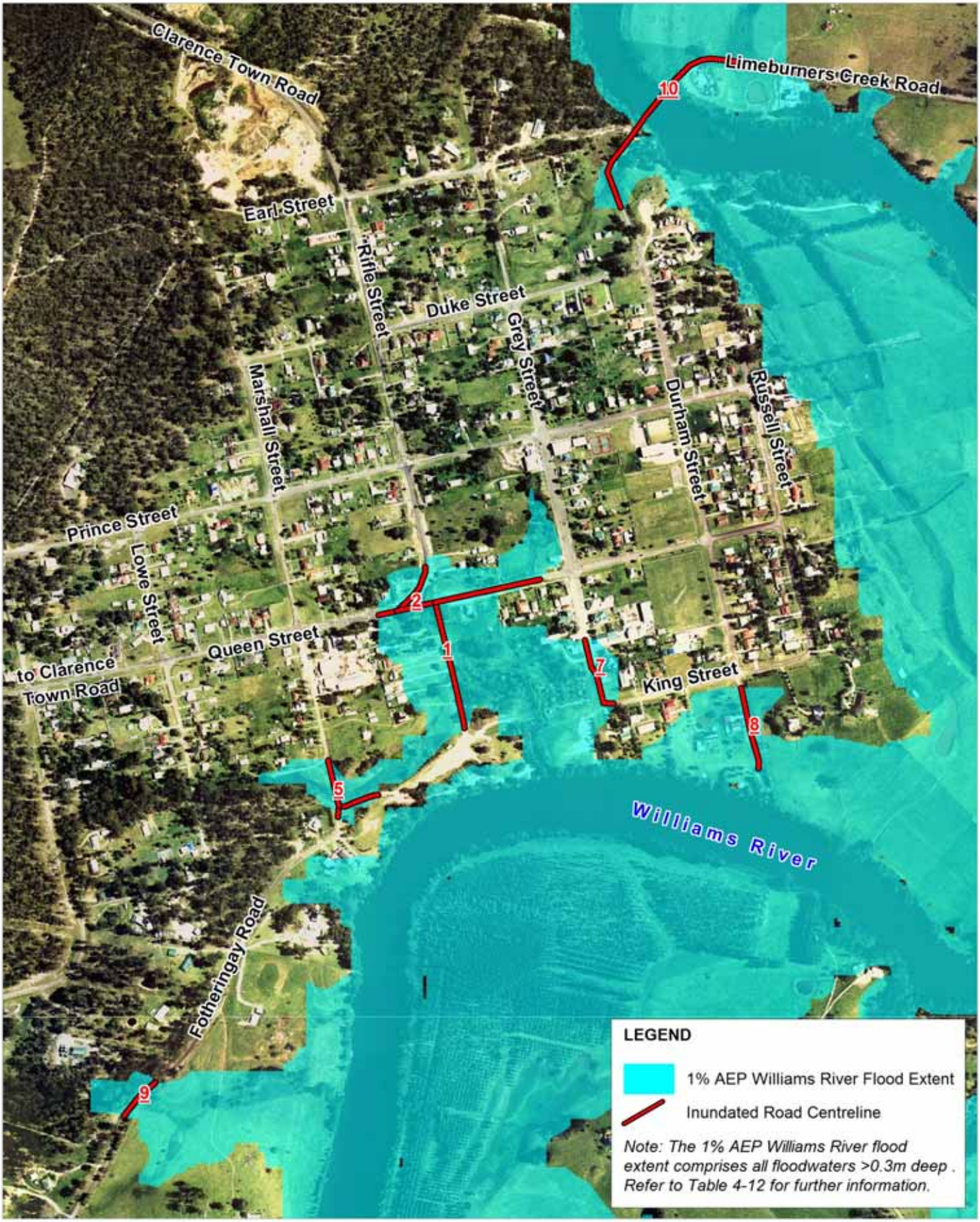

Title:

Road Inundation at 1% AEP Williams River Flood Level

Figure: **4-20**

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Road inundation as a result of local catchment flooding is expected to be short lived (<1 hour of inundation). The main roads affected by local catchment flooding are the Queen Street / Rifle Street intersection (shown in Figure 4-21 during June 2007 event) and the southern end of Rifle Street (shown in Figure 4-22 during June 2007 event).

Figure 4-21 Road Inundation June 2007 – Queen Street / Rifle Street Intersection

Figure 4-22 Road Inundation June 2007 – Southern end of Rifle Street

The remaining locations shown in Figure 4-19 experience shallow water inundation due to the rapid response to local catchment flooding with inundation again expected to be short lived (<1 hour of inundation). This includes road inundation along Prince Street and the Prince Street / Rifle Street intersection.

Although the roads shown to be inundated in Figure 4-19 could potentially result in some properties being isolated during a flood event (particularly the properties located on Grey Street, King Street, Russell Street and Durham Street), with limited opportunity for access, the period of isolation would be short lived (<1 hour).

Road inundation as a result of Williams River flooding is expected to occur for longer durations (up to 72 hours) depending on the location of the road in the catchment. Road inundation is also expected to significantly deeper for Williams River flooding (> 5m on southern end of Rifle Street). The main areas affected by Williams River flooding include the southern end of Rifle Street (approximately 5.5m inundation depth and 72 hour duration of inundation) and Queen Street (approximately 3m inundation depth and 20 hour duration of inundation) (shown in Figure 4-23 during the February 1990 flood event) and the southern ends of Grey Street (approximately 2.8m inundation depth and 18 hour duration of inundation) and Durham Street (approximately 2.1m inundation depth and 14.5 hour duration of inundation).

Figure 4-23 Road Inundation February 1990 – Queen Street / Rifle Street Intersection

The northern end of Durham Street (including the western approaches to the Clarence Town Bridge) and Limeburners Creek Road (including the eastern approaches to Clarence Town Bridge) are also expected to be inundated. Flooding in the vicinity of the Clarence Town Bridge during the February 1990 flood event is shown in FigX. Without detailed survey information for the Clarence Town Bridge it is difficult to predict whether the bridge itself will be overtopped but the use of the bridge during a major flood event would not be recommended in any case.

Figure 4-24 Clarence Town Bridge – February 1990

4.7 Future Catchment Development

There is the potential for future in-fill development with the Clarence Town study catchment. In-fill development generally involves the subdivision of existing residential lots which results in higher density urban residential developments. In-fill development has the potential to alter the flood behaviour in the Clarence Town catchment in a number of ways including:

- Providing additional impediments to existing mainstream and overland flowpaths (i.e. fence lines, buildings altering existing flowpaths);
- An increase in the percentage of impervious surfaces may affect the initial and continuing rainfall losses in the catchment (i.e. the volume of rainwater "absorbed" by pervious surfaces in the catchment at the outset of rainfall and throughout the rainfall event). This decrease in initial and continuing rainfall losses may result in increased surface runoff thereby resulting in increased pressure on existing stormwater drainage infrastructure; and
- Raising of ground levels can reduce the effective storage volume of the catchment.

A sensitivity test has been undertaken on the modelled flood behaviour in the Clarence Town catchment to assess the impact of in-fill development. The sensitivity test involved the alteration of the initial and continuing rainfall loss values for the urban residential hydraulic roughness zone (refer to Chapter 5 and Figure 5-2 in Clarence Town Flood Study (BMT WBM, 2012) for futher explanation) from 15mm and 2mm (i.e. an initial loss of 15mm and continuing loss of 2mm – as used for the base case design simulations) to 2mm and 0mm. This approach is considered to be a highly conservative approach as it effectively assumes that all rainfall that falls onto an urban residential loss after the initial loss of 2mm is "absorbed" will contribute to surface runoff in the catchment.

The sensitivity tests have been undertaken for the 1% AEP catchment rainfall event (2 hour duration). The results of the sensitivity tests are summarised in Table 4-14.

Table 4-14 Change in Peak 1% AEP Flood Levels under Future Catchment Development Scenario

Location	Peak Flood Level (m AHD)	
	Existing	Within Infill Development
US Upper Rifle St Culvert	13.76	13.76 (0.0)
US Prince St Culvert	11.67	11.67 (0.0)
US IGA Culvert	9.57	9.57 (0.0)
US Queen St Culvert	5.47	5.47 (0.0))
DS Lower Rifle St Culvert	4.52	4.52 (0.0))
US Marshall St Culvert	6.45	6.45 (0.0)
US Lowe St Culvert	10.55	10.55 (0.0)

Note: Bracketed value is change in peak flood level from standard design conditions

It is evident that the in-fill development scenario had no impact on the flood behaviour within Clarence Town. Notwithstanding, in-fill development has the potential to result in incidences of local nuisance flooding due to increased pressure on local drainage as a result of increased surface runoff associated with an increase in impervious surface areas.

5 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 and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis.

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.

5.1 Property Data

5.1.1 Location

Property locations have been derived from Council's cadastre information and associated detailed aerial photography of the catchment. Linked within a GIS system, this data enables rapid identification and querying of property details.

A property database has been developed detailing individual properties subject to flood inundation.

5.1.2 Land Use

For the purposes of the flood damage assessment, property was considered as either residential or commercial. Commercial properties have been identified from the property survey.

Public infrastructure and utility assets have been excluded from the damages assessment.

5.1.3 Ground and Floor Level

A floor level survey of identified property within the PMF Flood extent was undertaken by Carman Surveyors. The survey provided ground levels at the building, building floor level, geographic co-ordinate and photographic record to identify property type.

The distribution of surveyed properties within the study area with reference to the combined local catchment and Williams River PMF Flood extent is shown in Figure 5-1.

5.1.4 Flood Level

The design flood levels across the catchment were adopted from the Clarence Town Flood Study (BMT WBM, 2012) and the Williams River Flood Study (BMT WBM, 2009). 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. The resulting output was used to identify flooding characteristics such as the number and type of properties affected, frequency of inundation and the depth of inundation.

5.2 Property Inundation

A summary of the number of properties potentially affected by above floor flooding for a range of flood magnitudes is shown in Table 5-1 and Table 5-2 for local catchment flooding and Williams River flooding respectively. The tables distinguish between residential property and industrial/commercial enterprise. The distribution of the affected properties for each design flood event is shown in Figure 5-2 and Figure 5-3 for local catchment flooding and Williams River flooding respectively.

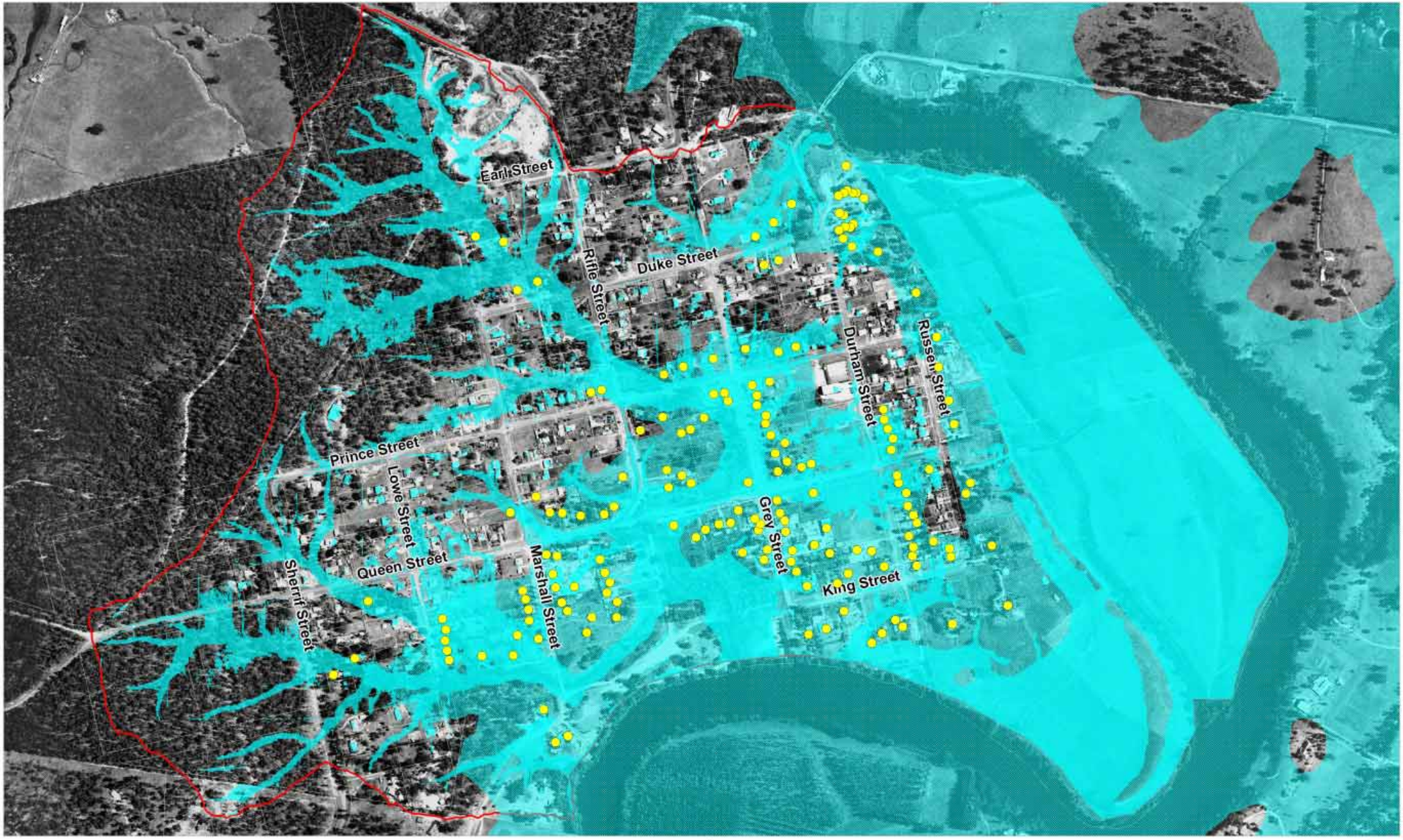
Table 5-1 Number of Properties Affected by Above Floor Flooding – Local Catchment Flooding

Design Flood Event	Building	
	Residential	Commercial
20% AEP	0	0
10% AEP	0	0
5% AEP	0	0
2% AEP	0	1
1% AEP	0	1
0.5% AEP	0	1
Extreme Flood	5	3

Table 5-2 Number of Properties Affected by Above Floor Flooding – Williams River Flooding

Design Return Period	Building	
	Residential	Commercial
20% AEP	1	0
10% AEP	1	0
5% AEP	2	0
2% AEP	4	1
1% AEP	6	1
0.5% AEP	13	2
Extreme Flood	107	20

Given the nature of the local catchment flooding, only a limited number of properties have been identified at risk of above floor flooding. In the case of Williams River flooding the flood events are up and including the 1% AEP event are generally contained within floodplain areas free of significant development however a significant increase in the number of affected properties occurs for the PMF event given the significant increase in peak flood level for this event.



LEGEND

- PMF Flood Extent (Combined Local Catchment and Williams River)
- Cadastre
- Surveyed Property Location
- Catchment Boundary

Title:
Location of Property Surveyed

Figure: 5-1

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Approx. Scale

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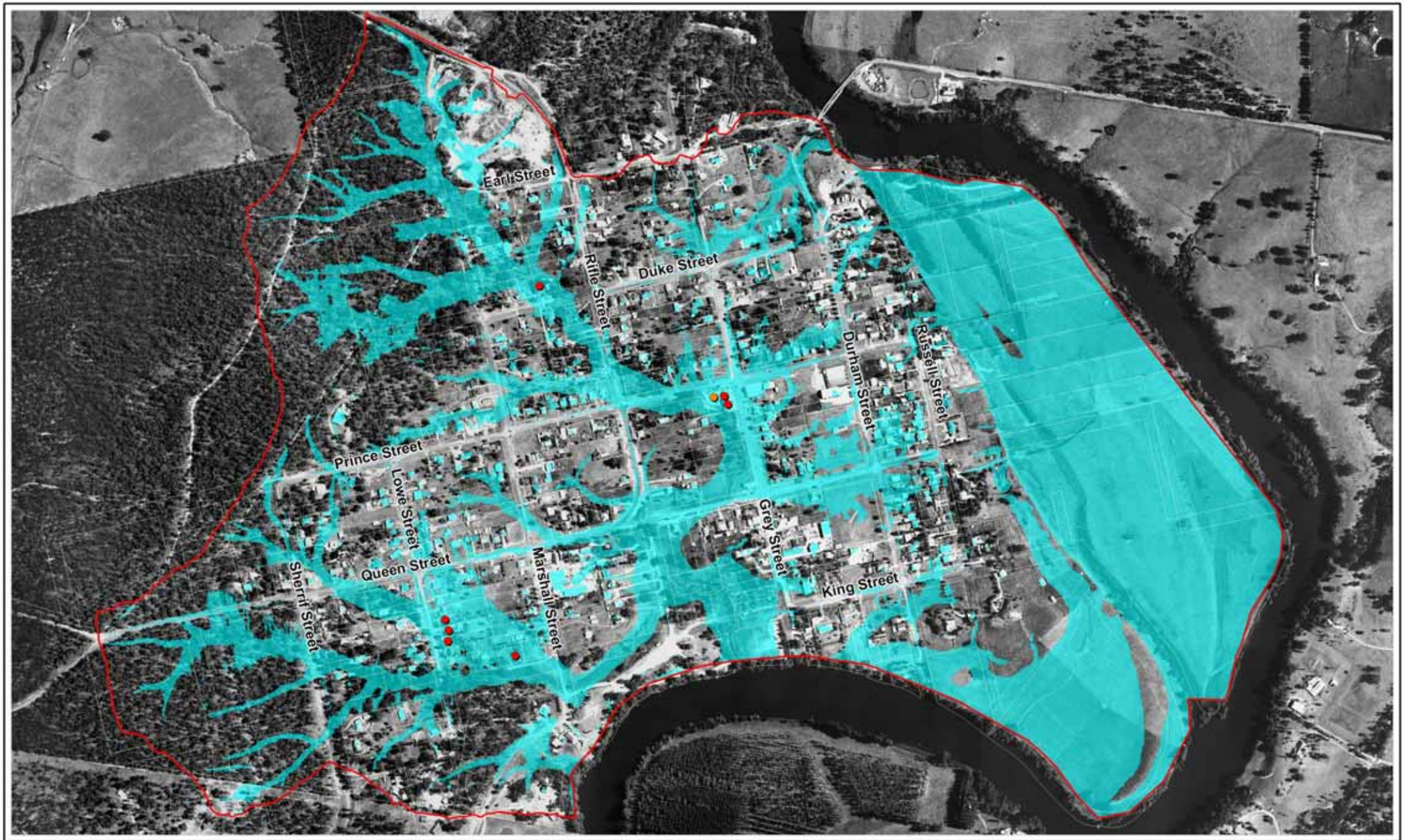

LEGEND

- Properties Inundated in a 5% AEP Flood Event
- Properties Inundated in a 1% AEP Flood Event
- Properties Inundated in a PMF Flood Event
- Cadastre
- Clarence Town Study Catchment Boundary
- PMF Local Catchment Flood Extent

Title:

Inundation Above Floor Level - Local Catchment Flooding

Figure: 5-2

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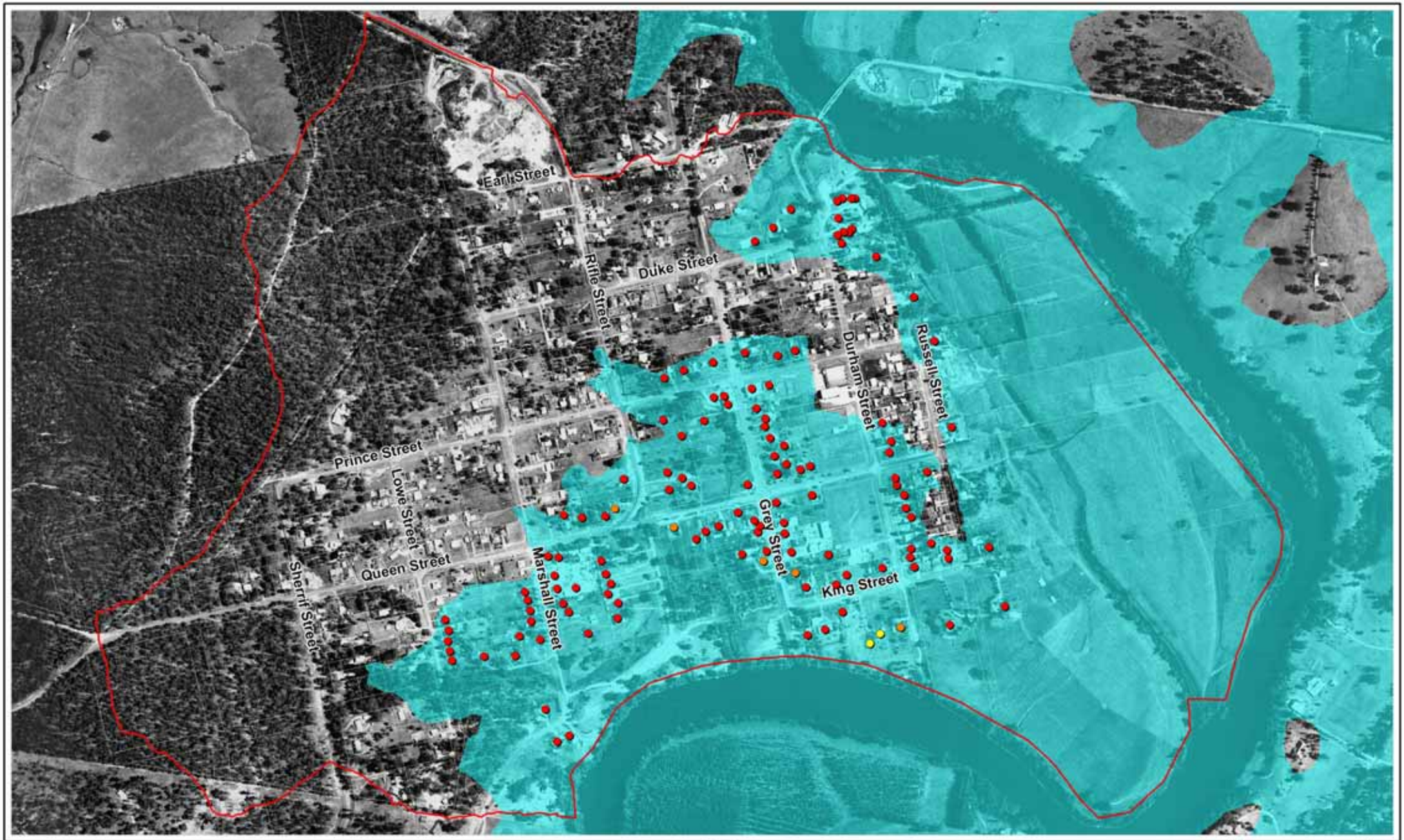

LEGEND

- Properties Inundated in a 5% AEP Flood Event
- Properties Inundated in a 1% AEP Flood Event
- Properties Inundated in a PMF Flood Event
- Cadastre
- Clarence Town Study Catchment Boundary
- PMF Williams River Flood Extent

Title:

Inundation Above Floor Level - Williams River Flooding

Figure: 5-3

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5.3 Flood Damages Assessment

5.3.1 Types of Flood Damage

The definitions and methodology used in estimating flood damage are summarised in the Floodplain Development Manual. Figure 5-4 summarises the “types” of flood damages as considered in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

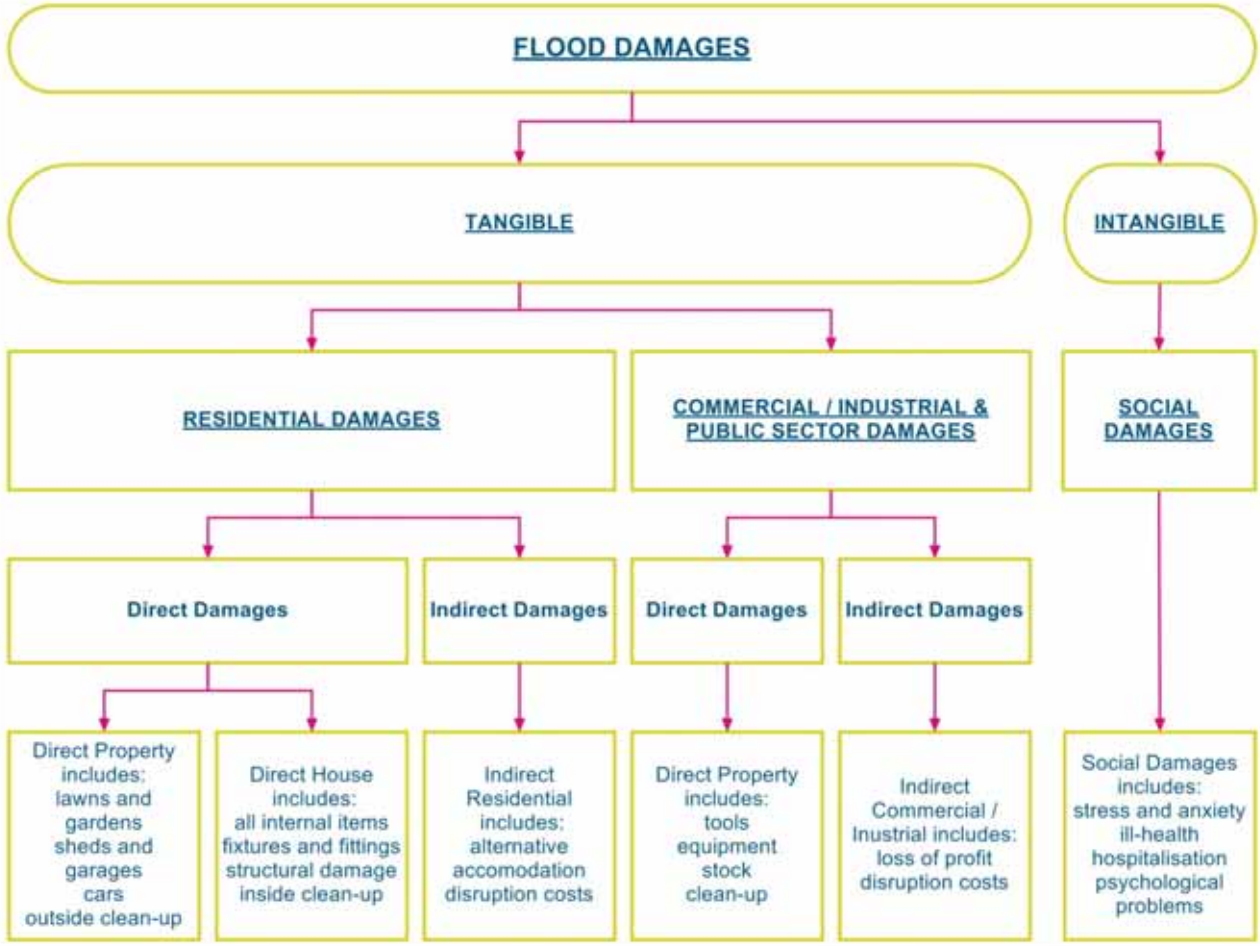


Figure 5-4 Types of Flood Damage

5.3.2 Basis of Flood Damage Calculations

Flood damages have been calculated using the data base of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular property type. Residential damage curves are based on the OEH guideline stage-damage curves for residential property.

Different stage-damage curves for direct property damage have been derived for:

- Residential dwellings (categorised into small, typical or raised categories); and
- Commercial premises (categorised into low, medium or high damage categories).

Apart from the direct damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:

- Indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- Infrastructure damage, based on a percentage of the total value of residential and business flood damage; and
- Intangible damages relate to the social impact of flooding and include:
  - inconvenience,
  - isolation,
  - disruption of family and social activities,
  - anxiety, pain and suffering, trauma,
  - physical ill-health, and
  - psychological ill-health.

The damage estimates derived in this study are for the **tangible damages only**. Whilst intangible losses may be significant, these effects have not been quantified due to difficulties in assigning a meaningful dollar value.

5.3.3 Summary of Flood Damages

The peak depth of flooding was determined at each property for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events and the Extreme Flood Event for both local catchment and Williams River flooding. The associated flood damage cost to each property was subsequently estimated from the stage-damage relationships. It should be noted that this flood damage assessment only took in to consideration above floor flooding (i.e. damages incurred to yards due to about ground flooding such as damaged fences and landscaping were not taken in to consideration). Total damages for each flood event were determined by summing the predicted damages for each individual property.

Table 5-3 provides a summary of the flood damages calculations for Clarence Town for local catchment and Williams River flooding.

The Average Annual Damage (AAD) is the average damage in dollars per year that would occur in a designated area from flooding over a very long period of time. 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 be major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the AAD).

Table 5-3 Predicted Flood Damages for Existing Conditions

Flood Mechanism	Damage in Flood Event ($,000)							
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	Extreme Flood	Average Annual Damage
Local Catchment	$0	$0	$0	$17	$29.5	$29.5	$724	$2.5
Williams River	$89	$123	$250.5	$581.5	$1,038	$2,057	$23,385	$124

The total estimated flood damage to occur in a 1% AEP local catchment flood event is $29,500, increasing to an estimated $724,000 worth of damage for the Extreme Flood. For the 1% AEP Williams River flood event the total estimated damage to occur is $1,038,000, increasing to $23,385,000 worth of damage for the Extreme Flood.

6 Review of Existing Planning Provisions

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 Clarence Town (as well as across the wider LGA).

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

- review the existing planning and development controls framework relevant to the formulation of planning instruments and the assessment of development applications in the Wollombi Brook floodplain, and
- make specific planning recommendations in regards to flood risk management, including an outline of suggested planning controls.

6.1 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 2013 (LEP 2013) (Dungog Shire Council, 2013) 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.

Clause 6.1 of the Dungog Local Environment Plan 2013 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 Management Plans that are applicable. Specifically Clause 6.1 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 that is shown 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) Subclause (5) applies to:

a) land shown as “projected 2100 flood planning area” and “projected 2050 flood planning area” on the Flood Planning Map; and to

b) other land below the projected 2100 flood planning level and the projected 2050 flood planning level as a consequence of projected sea level rise.

(5) When determining development to which this subclause applies, council must take into consideration any relevant matters outlined in subclause 3(a) – (e), depending on the context of the following:

a) the proximity of the development to the current flood planning area; and

b) the intended design life of the development; and

c) the scale of the development; and

d) the sensitivity of the development in relation to managing the risk to life from any flood, and

e) the potential to relocate, modify or remove the development.

(6) A word or expression used in this clause has the same meaning as it has in the NSW Government’s *Floodplain Development Manual* published in 2005, unless it is otherwise defined in this clause.

(7) In this clause:

flood planning area means the land shown as “Flood planning area” on the Flood Planning Map

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

Flood Planning Map means the Dungog Local Environment Plan 2013 Flood Planning Map.

projected sea level rise means the 2050 and 2100 sea level rise planning benchmarks as specified in the NSW Government's Sea Level Rise Policy Statement 2009.

6.1.1 Land Use

The Dungog LEP 2013 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 2013 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.

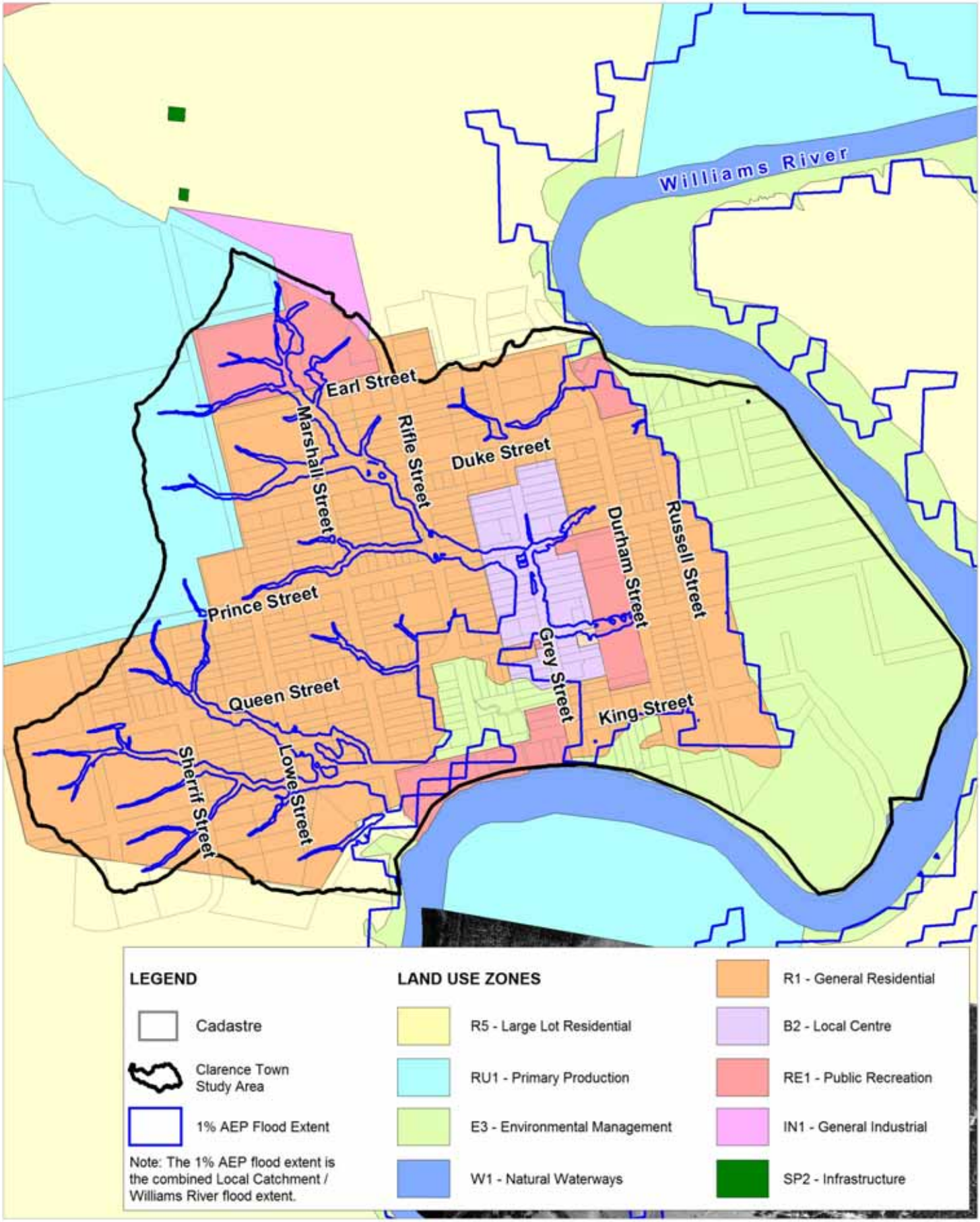
Within the Clarence Town Floodplain Risk Management Study area there are four main land use zones as described below and shown in Figure 6-1. The 1% AEP design flood extent is also shown on Figure 6-1 for reference.

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. This zone is to provide for only a limited range of development that does not have an adverse effect on the previously stated values.



Title:

Clarence Town Land Use Zones

Figure: 6-1

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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It is evident in Figure 6-1 that significant areas of land zoned as R1 (General Residential) and B2 (Local Centre) lies within the 1% AEP flood extent. In addition, a portion of this land is also classified as a Floodway (refer to Section 4.4.3) and typically would not be considered suitable for residential development. Future rezoning of this flood affected land to be more compatible with the flood risk should be considered.

A large proportion of the land zoned as RE1 (Public Recreation) and E3 (Environmental Management) also lies within the 1% AEP flood extent. However these land zones already have significant development restrictions applied to them, they are considered to be compatible with the flood risk.

For further information on land use zones refer to the Dungog Local Environment Plan 2013 (Dungog Shire Council, 2013).

6.2 Dungog Flood Prone Land Policy

The Dungog Shire Flood Prone Land Policy (Policy No. C3:12) was adopted and last reviewed on the 19th August 2003. The policy states the following:

OBJECTIVE:

To provide a policy for flood prone land within Dungog Shire

POLICY STATEMENT:

1. The 1 in 100 year criteria for defining flood liable land be retained pending receipt of further information from the State Government.

2. The requirement that the floor level of residential buildings to be erected on flood liable land be not less than 1 metre above the 1 in 100 year flood level be retained for areas in the Dungog Shire that are not covered by the Paterson River Floodplain Management Study and excludes Dungog and Clarence Town areas that are covered by adopted levels.

3. The Paterson River Floodplain Management Study and Plan be adopted.

4. The 1% Annual Exceedence Probability level for flooding in Dungog is adopted as 52m AHD and in Clarence Town as 7.57m AHD.

6.3 Development Control Plan

6.3.1 Dungog Shire Wide Development Control Plan No 1

A Development Control Plan (DCP) is prepared in accordance with Section 72 of the Environmental Planning and Assessment Act 1979 and Clauses 16 to 25 of Part 3 of the Environmental Planning and Assessment Regulation 2000. A DCP effectively complements an LEP by providing more detailed provisions with respect to development in particular areas, and is to be considered by Council in determining development applications.

The Dungog Shire Wide Development Control Plan No 1 (DCP) was adopted on the 18th May 2004 and combines into one document various policies and guidelines affecting development proposals within Dungog Shire.

6.3.2 Dungog Development Control Plan No. 1 - Managing Our Floodplains

The Dungog Development Control Plan No. 1 - Managing Our Floodplains is a DCP that relates directly to development within floodplains across Dungog Shire.

The Dungog Development Control Plan No. 1 - Managing Our Floodplains applies to whole of the Local Government area and was adopted on the 18th May 2004. The DCP provides general provisions relating to all the floodplains and specific provisions relating to individual floodplains which are subject to a Floodplain Management Plan.

The DCP states the following aims and objectives:

(a) Provide detailed controls for the assessment of applications on land affected by potential floods;

(b) To minimise the potential impact of development and other activity upon the aesthetic, recreational and ecological value of the waterway corridors;

(c) Specific criteria for consideration of applications lodged in accordance with the Environmental Planning and Assessment Act 1979;

(d) Alert the community to the hazard and extent of land affected by potential floods;

(e) Inform the community of Council's policy in relation to the use and development of land affected by potential floods;

(f) Reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods;

(g) Deal equitably and consistently with applications for development on land affected by potential floods, in accordance with the principles in the Floodplain Development Manual issued by the New South Wales Government;

(h) Increase public awareness of the potential floods greater than the 1% AEP flood and to ensure essential services and landuses are planned in recognition of all potential floods;

(i) Encourage the development and use of land which is compatible with the indicated flood hazard;

(j) Provide different guidelines, for the use and development of land subject to all potential floods in the floodplain, which reflect the probability of the flood occurring and the potential hazard within different areas;

(k) Apply a "merits-based approach" to all development decisions which takes account of social, economic and ecological as well as flooding considerations;

(l) To control development and other activity within each of the individual floodplains having regard to the characteristics and level of information available for each of the floodplains, in particular the availability of floodplain management studies and floodplain management plans prepared in accordance with the Floodplain Development Manual.

The DCP defines the following:

- Criteria for determining applications;

- Land use categories and floodplain management zones to be used to determine what floodplain management controls are to be applied to different catchment areas;
- What controls are to be applied to proposed developments;
- Specific requirements for fencing in the catchment; and
- The information that is required to be provided to Council with each development application to address the DCP.

The DCP identifies that different floodplain management controls are applicable to different land uses within different zones of the floodplain. For Clarence Town the DCP outlines the following procedure to assign specific controls to each property is as follows:

(1) Identify the land use category of the development. The DCP identifies seven major land use categories (separate to the land use categories discussed in Section 6.1.1) as follows (the DCP outlines what land uses may be included in each category):

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

(2) Identify what part of the floodplain the land is located within. The DCP identifies three management Zones for Clarence Town as follows:

1. **Floodway** means that part of the floodplain which conveys significant quantities of flow path and would pose significant hazard to property and persons as determined by an application of the principles contained within the Floodplain Development Manual.
2. **Flood fringe** means that area of the floodplain between the floodway and the 1% AEP flood plus 0.5 metres (free board).
3. **Outer floodplain** means that part of the floodplain above the 1% AEP flood plus 0.5 metres (free board) up to the extreme flood.

(3) Apply the controls outlined in Schedule 4 – Other Floodplain Areas Planning Matrix Controls (shown in Figure 6-1).

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 6-2 DCP Planning Matrix Controls

In regards to the 1% AEP design flood level for Clarence Town the DCP states the following:

The level at Clarence Town is more accurately known and is shown on a map dated 14th March 1989 as being 7.57 m AHD. The map also labels this level as the 1 in 100 year recurrence interval (1% Annual Exceedence Probability).

Council already has a policy (1985) that sets the minimum floor level of a habitable dwelling at the 1% AEP level plus 1 metre. This was superseded in the Paterson catchment when the flood study was completed. The above flood levels are now formally adopted for Dungog and Clarence Town until such time as the Williams River Study is completed.

The DCP also contains a list of flood compatible materials.

6.3.3 Clarence Town Local Area Plan

The Clarence Town Local Area Plan is a DCP relating only to the Clarence Town area. The Plan was adopted on the 17th May 2005. The aim of the Clarence Town Local Area Plan is stated to be:

to establish a desired future character for the land that is contained within the Investigation Zone. The Clarence Town DCP contains locality based performance criteria and controls which are designed to address key issues and achieve the desired character.

The Clarence Town Investigation Zone Development Control Plan (referred to as the Clarence Town DCP) forms part of the Clarence Town Local Area Plan. The Clarence Town DCP applies to all land in and adjoining the Village of Clarence Town which was zoned 9(a) Investigation Zone or Rural Lifestyle 1(l) under the provisions of the Dungog Shire Local Environmental Plan 2003.

The stated objectives of the Clarence Town DCP are as follows:

1. To ensure that development within the Investigation Zone is consistent with and promotes the principles of environmentally sustainable development.

2. To promote coordinated development that will be conducive to closer settlement patterns and/or changes in land uses in the future.

3. To ensure that development within the Investigation Zone is sensitive to the topographic and environmental characteristics of the land.

4. To safeguard indigenous vegetation, habitats and water courses.

5. To retain and protect the rural character of the area and areas with high visual significance.

6. To provide a network of safe access roads and shared pedestrian and cycle pathways within and between areas developed within the Investigation Zone.

7. To minimise the cost to the community of providing, extending and maintaining public amenities and services.

8. To ensure that development within the Investigation Zone does not prejudice the interests of agriculture within the zone and adjoining areas.

The Clarence Town DCP identifies flooding as an issue for the Clarence Town area with areas becoming isolated due to floodwaters. The Clarence Town DCP aims to minimise the impacts of flooding by undertaking the following:

- Providing adequate buffers and set-backs from watercourses, as per the DCP.
- Prohibiting further subdivision of the river foreshore areas – new lots with river frontage cannot be created.
- Encouraging foreshore areas to be kept in one title and zoned appropriately.

The Clarence Town DCP also identifies the need for additional residential lots within Clarence Town and its surrounds and divides the Clarence Town Investigation Zone into ten planning precincts for future development as shown in Figure 6-3. The ten planning precinct are predominantly located outside of the local Town Creek catchment.

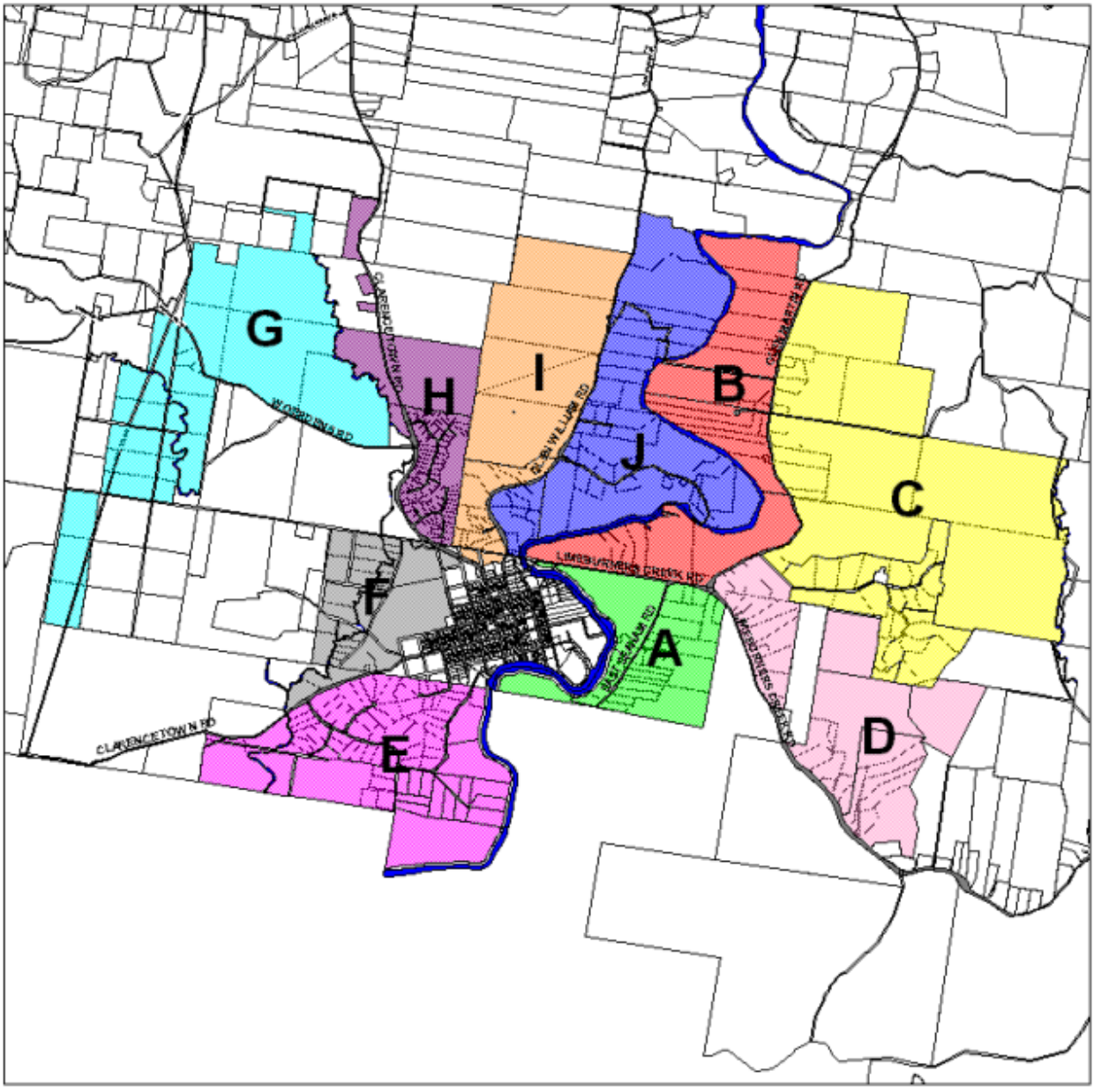

Figure 6-3 Clarence Town Planning Precincts

6.4 Future Catchment Development

The Dungog Shire Rural Strategy (Dungog Shire Council, 2003) was adopted on the 9th October 2003 to support and give detail to the Draft Dungog Local Environment Plan 2003. The purpose of the Rural Strategy is to provide a basis for sustainable and desirable rural growth throughout the Dungog Shire while retaining the regions original character. The Rural Strategy was designed to guide the location of future rural settlement within Dungog Shire and promote appropriate land use guidelines for rural development.

The aims of the Rural Strategy are as follows:

- To provide guidelines to enable identification of rural development opportunities, which provide a lifestyle choice for residents within Dungog Shire; and
- Protect the agricultural land, environmentally sensitive land, and water resources by ensuring that development will not compromise the rural character of the land.

The Rural Strategy outlines a number of steps involved in achieving the above objectives including minimising environmental impacts by ensuring that future development is situated in areas not subject to any ecological or physical constraints, and placing restrictions on developments to achieve this outcome. Accordingly, future catchment development is likely to be limited such that increased flood risk exposure through population growth may be small.

7 Potential Floodplain Management Measures

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 (depth, velocity) and includes flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment.

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 (zoning) or voluntary purchase.

Response modification measures: modify the community's response to flood hazard by informing flood-affected property owners 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.

The following sections provide a first pass assessment of options by determining if they would be applicable/suitable to the flooding characteristics of Clarence Town. For those options that were considered applicable/suitable, more detailed assessment was undertaken.

7.1 Flood Modification Measures

The majority of flood modification measures considered in the study relate to flood mitigation works at the specific "hot-spot" location of the area around the commercial buildings on the intersection of Prince Street and Grey Street. This area includes the Rural Transaction Centre commercial building which experiences above floor flooding at the 2% AEP local catchment flood level. Further discussion on existing flooding "hot spots' is presented in Section 4.2.

The flood modification measures considered include:

- Structure modification;
- Local drainage improvements;
- Channel modifications;
- Flood levee along Town Creek; and
- Construction of detention basins in the upper catchment.

These flood modification measures are discussed in more detail in the following sections.

7.1.1 Structure Modification

As discussed in Section 4.1, there are a number of cross drainage structures within Clarence Town that provide for significant control of floodwater levels, as evidenced by the local flattening of the simulated flood water level profile upstream of the structures (i.e. backing up of floodwaters behind the structures).

The most significant of these structures in terms of terms culvert size, embankment height, and influence on flood water levels, is the box culvert (1.8m x 2.0m) on the corner of Queen Street and Rifle Street. This structure (and associated road embankment) provides a major flow constriction resulting in elevated water levels upstream of Queen Street. However given that the floodwaters backed up behind this structure do not result in any above floor level flooding and taking in to consideration the difficulties and high cost that altering this structure would incur, no modification of this structure was considered.

Similar flow constrictions and resulting impacts on the peak water level profile occur at the culvert structure behind the IGA store adjacent to Grey Street and the culvert structure on Rifle Street approximately 50m west of the Prince Street intersection. Both of these structures have a major influence on peak flood levels in the vicinity of the commercial buildings on the intersection of Prince Street and Grey Street. Considering the existing flood risk in this area of the catchment, modification of both of these structures was identified as potential flood modification measures.

The change in the modelled peak flood levels associated with the removal of the two culvert structures for the 1% AEP local catchment design flood condition are presented in Table 7-1 and shown in the form of a longitudinal profile in Figure 7-1. The removal of the culverts was modelled by extrapolating between the upstream and downstream channel profile either side of the structure.

Table 7-1 Change in Peak 1% AEP Flood Levels – Structure Removal

Location	Peak Flood Level (m AHD)		
	Baseline	IGA Culvert Removed	Prince St Culvert Removed
US Upper Rifle St Culvert	13.8	13.8 (0.0)	13.8 (0.0)
US Prince St Culvert	11.7	11.7 (0.0)	11.6 (-0.1)
US IGA Culvert	9.6	9.4 (-0.2)	9.6 (0.0)
US Queen St Culvert	5.5	5.5 (0.0)	5.5 (0.0)

Note: Bracketed value is change in peak flood level from standard design conditions

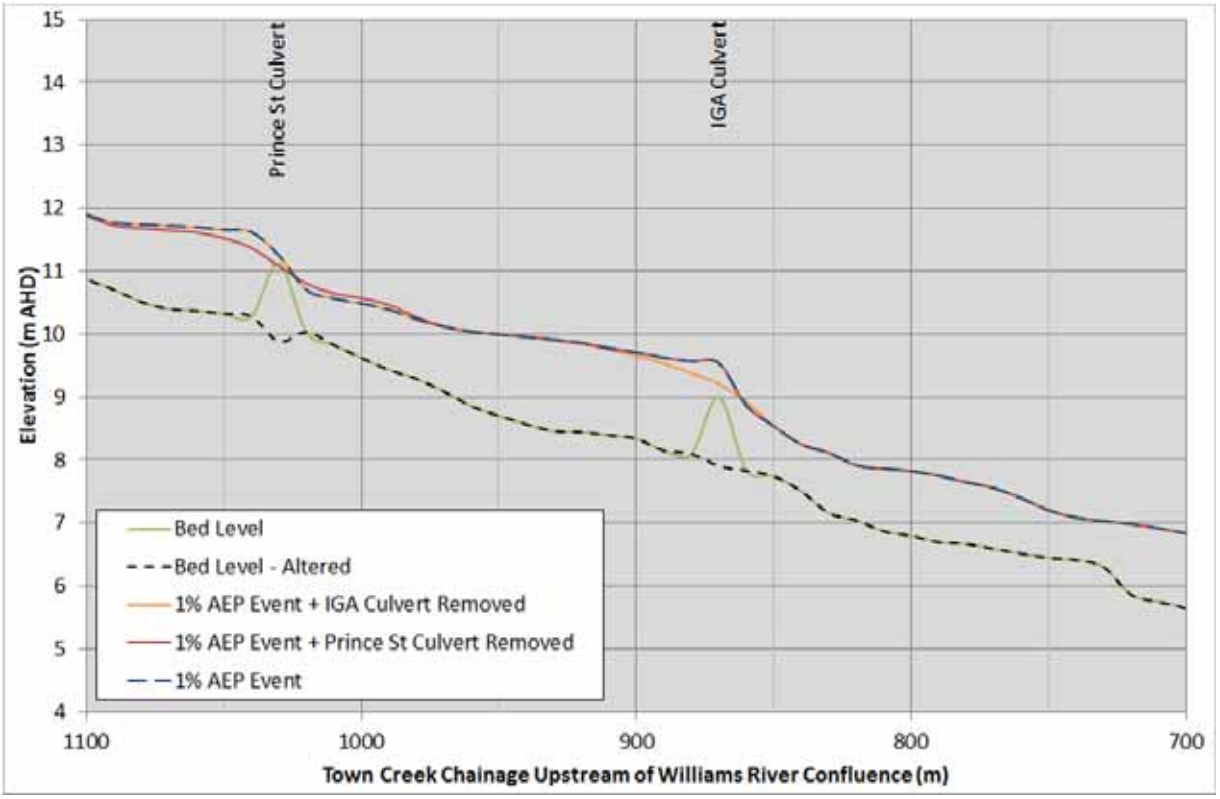

Figure 7-1 Design Flood Profiles – Removal of IGA and Prince Street Culverts

The change in peak 1% AEP local catchment flood level conditions as a result of removing the IGA culvert is presented in Figure 7-2. Removal of the IGA culvert effectively removes the structure as a floodwater control and prevents floodwaters from backing up behind the structure. This results in a decrease in peak flood level at the structure of approximately 0.4m and a decrease in floodwaters extending approximately 60m upstream of the structure. The removal of this structure is therefore recommended as a potential flood mitigation measure as it results in a decrease in flood levels along the length of Town Creek adjacent to the Rural Transaction Centre (especially in conjunction with in-channel works in Town Creek presented in Section 7.1.2).

Similar to the removal of the IGA culvert, the removal of the Prince Street culvert removes the structure as a floodwater control and results in a localised drop in flood levels both at the structure and immediately upstream of the structure. However, the removal of this structure allows a greater volume of water to flow downstream thereby resulting in a slight increase in flood levels downstream of the Prince Street structure and potential exacerbation of flood risk to the commercial buildings downstream.

The property immediately to the north-east of the Prince Street / Rifle Street intersection effectively acts as an informal detention basin during local catchment flood events thereby attenuating peak flood flows downstream (including the length of Town Creek adjacent to the Rural Transaction Centre). As the removal of the Prince Street culvert results in a greater volume of water to flow downstream, it effectively reduces the effectiveness of the informal detention basin. The removal of the Prince Street culvert is therefore not recommended as a potential flood mitigation measure as it could potentially result in an increase in flood levels and associated flood risk downstream of the structure (in the vicinity of the Rural Transaction Centre).

Title:

Change in Peak Flood Level
Removal of IGA Culvert (1% AEP Local Catchment Event)

Figure:	Rev:
7-2	A

N

0 m 37.5 m 75 m

Approx. Scale

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Title:

Change in Peak Flood Level - Removal of Prince St Culvert (1% AEP Local Catchment Event)

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7.1.2 Local Drainage Improvements

As discussed in Section 4.2, there is currently a flooding issue at the commercial buildings on Prince Street / Grey Street intersection that is caused by runoff from upper Grey Street being directed across the Prince Street / Grey Street intersection towards the front of the Rural Transaction Centre rather than continuing down Grey Street. This flooding issue can be resolved by undertaking some road re-profiling and alterations to stormwater drainage infrastructure in order to direct the flow to continue down Grey Street rather than flowing across the road and into the Rural Transaction Centre.

7.1.3 Channel Modifications

The hydraulic capacity of a river/creek channel to convey floodwaters can be increased by widening, deepening or re-aligning the channel. Increasing the hydraulic capacity of Town Creek to convey floodwaters will result in a reduction of peak flood levels and associated flood risk. Channel modification can also provide the community with additional benefits such as enhanced visual aesthetics by landscaping.

The channel modification options considered focussed on the 200m length of Town Creek extending from Prince Street to 50m downstream of the existing IGA culvert structure. This length of Town Creek effectively has two sections that that provide for significant control of floodwater levels, namely the existing IGA culvert and the channel bend that alters the direction of flow from west-east to north-south. Theses floodwater controls result in a local flattening of the simulated flood water level profile (i.e. backing up of floodwaters behind the culvert and bend).

The modification of the IGA culvert as a management option is discussed in Section 7.1.1. All channel modification measures assume that this culvert structure has been removed. The removal of the bend in the channel would involve realigning the channel from the Prince Street culvert to the IGA culvert. Given the existing topography, this channel realignment was considered to be impractical, as such channel widening and deepening was considered to increase the hydraulic capacity of the channel in order to remove the bend as a floodwater control.

Three channel modification options were considered (as presented in Figure 7-4):

- Option A – modification of the 80m length of Town Creek from 30m upstream to 50m downstream of the existing IGA culvert;
- Option B – modification of the 200m length of Town Creek extending from Prince Street to 50m downstream of the existing IGA culvert structure; and
- Option C –modification of the 200m length of Town Creek as per Option B but with wider channel profile.

The 200m length of Town Creek in question generally has a maximum top width (length from top of right bank to top of left bank) of 10m and a base width of 3m. Some sections however a smaller top and base width and therefore provide a constriction to flow due to a lower conveyance capacity. The channel slope is not consistent along the length of the channel which can also reduce the conveyance capacity of the channel.

Title:

Channel Modification Options

Figure: 7-4

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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Option A and B involved channel modifications to maintain the 10m top width and 3m base width channel shape and constant bed slope along the 80m (Option A) or 200m (Option B) section of Town Creek. Channel modification Option C involved further widening of the 200m length of Town Creek to have a top width of 12m and base width of 4m. For both Option B and Option C additional channel widening was undertaken on the bend in Town Creek with the top width increasing to 15m and 17.5m and the base width increasing to 6.5m and 8m for Option B and Option C respectively.

The change in the modelled peak flood levels associated with the three channel modification options for the 1% AEP local catchment design flood condition are presented in Table 7-2, shown in the form of a longitudinal profile in Figure 7-5 and presented in the form of flood afflux diagrams in Figure 7-6, Figure 7-7 and Figure 7-8.

Table 7-2 Change in Peak 1% AEP Flood Levels – Channel Widening

Location	Peak Flood Level (m AHD)			
	Baseline	Option A	Option B	Basin C
US Upper Rifle St Culvert	13.8	13.8 (0.0)	13.8 (0.0)	13.8 (0.0)
US Prince St Culvert	11.7	11.7 (0.0)	11.7 (0.0)	11.7 (0.0)
US IGA Culvert	9.6	9.2 (-0.4)	9.2 (-0.4)	9.1 (-0.5)
US Queen St Culvert	5.5	5.5 (0.0)	5.5 (0.0)	5.5 (0.0)

Note: Bracketed value is change in peak flood level from standard design conditions

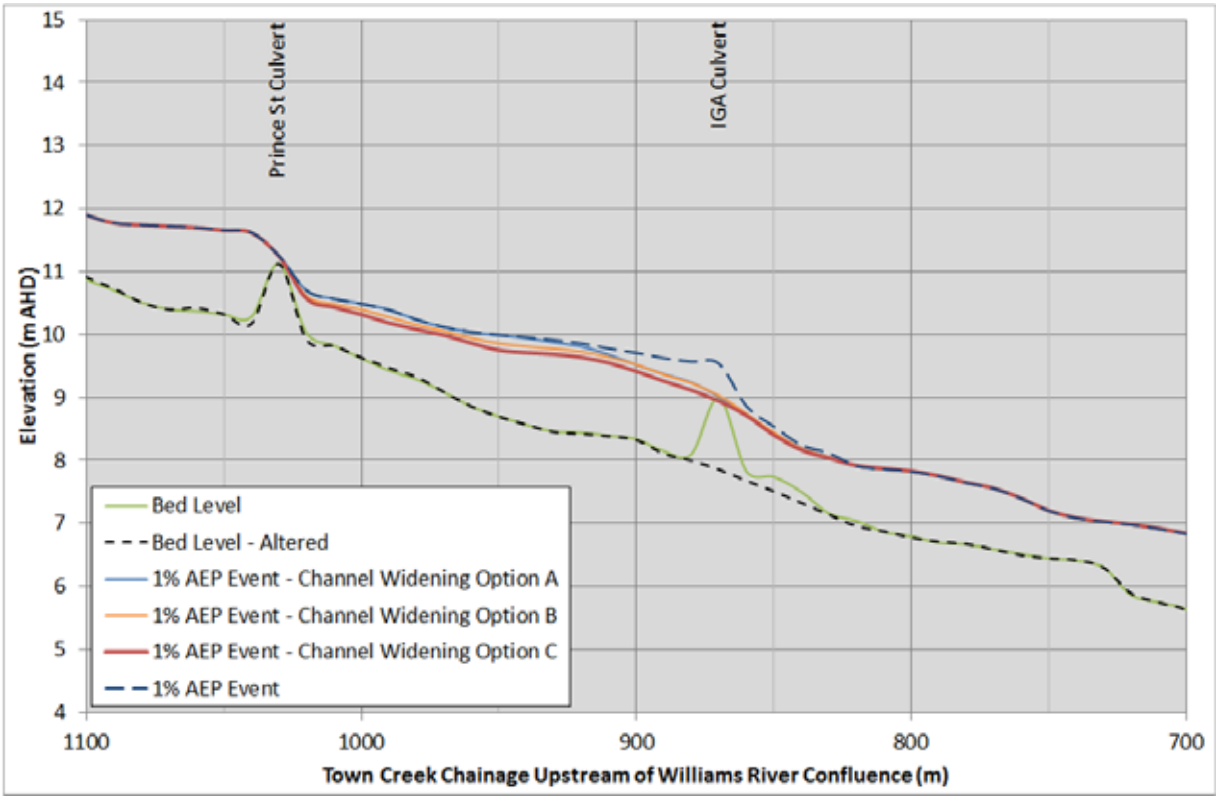

Figure 7-5 Design Flood Profiles – Town Creek Channel Widening

Title:

Change in Peak Flood Level - Channel Widening Option A (1% AEP Local Catchment Event)

Figure: 7-6

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Title:

Change in Peak Flood Level - Channel Widening Option B (1% AEP Local Catchment Event)

Figure: 7-7

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Title:

Change in Peak Flood Level - Channel Widening Option C (1% AEP Local Catchment Event)

Figure: 7-8

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All of the channel widening options only have a relatively localised impact, however, do provide for flood level reduction at the affected commercial properties on Prince Street. Option C providing for the largest channel conveyance has the most impact in reducing peak flood levels (reduction of 0.5m in peak 1% AEP flood level) and demonstrates the potential for this option to provide an effective flood mitigation solution for the properties affected by above floor flooding.

7.1.4 Flood Protection Levee

The channel widening discussed above provides for conveyance of the 1% AEP flows within the channel. A similar containment of flows may be achieved through construction of a levee or bund on the eastern bank of Town Creek. An indicative levee alignment extending from Prince Street to downstream of the IGA culvert is shown in Figure 7-9.

Levees are built to exclude potentially inundated areas from flooding up to a prescribed design event level. Provided the integrity of the levee can be assured, levees are very effective in providing direct protection of property to flood inundation to the levee design height. Structural failure of the levee, or overtopping of the levee from a flood event larger than the design standard, can result in rapid inundation of areas behind the levee. This can in fact provide a greater flood hazard to both people and property.

It is assumed a minimum levee design standard would be at the existing 1% AEP flood level plus an appropriate freeboard allowance (say 0.5m) to provide the desired standard of protection to the commercial properties on Prince Street. Given the required design height and allowing for appropriate side slope batters, a levee may have a considerable.

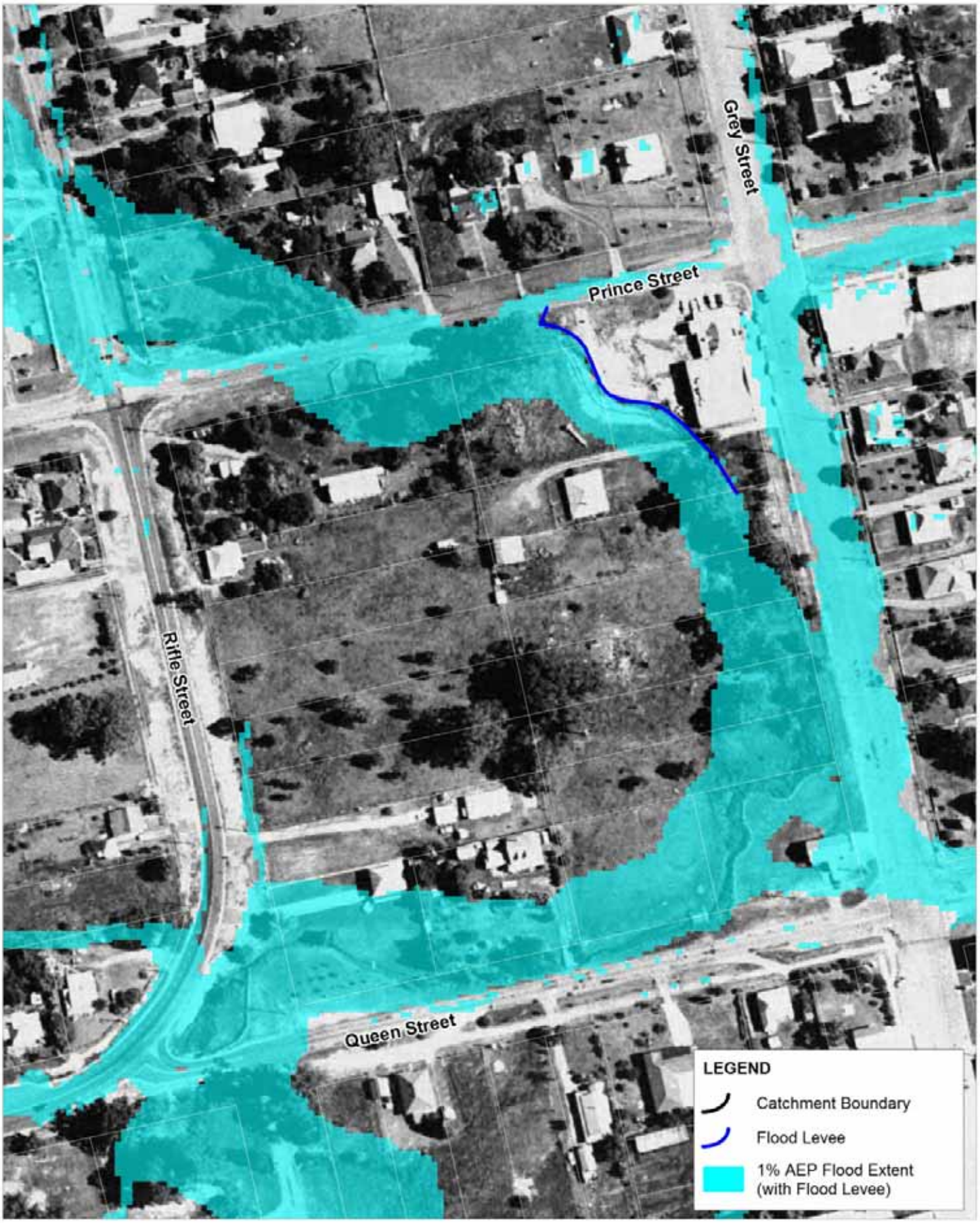
Local drainage behind the levee would also be impeded. Redirection of local drainage or provision of flap valves would be required to effectively drain runoff from areas behind the levee currently discharging to the channel. The channel widening option is considered to represent a better solution to providing in-channel conveyance, rather than the levee option.

7.1.5 Detention Basins

Flood detention basins provide additional temporary flood storage, thereby attenuating peak flood flows through the developed area of Clarence Town and reducing downstream flood levels and flood extents. As previously stated, the critical duration of flooding in the local catchment is relatively short (1-2 hours) and whilst peak flood flows are high, the runoff volumes are not as high as for longer duration events. Accordingly, the construction of temporary flood storage in the form of detention basins in the upper catchment may provide some effective flood attenuation.

The detention basin options investigated involved the simulation of detention basins at two locations on Marshall Street as shown in Figure 7-10.

The change in the modelled peak flood levels associated with the construction of the two detention basins for the 1% AEP local catchment design flood condition are presented in Table 7-3, shown in the form of a longitudinal profile in Figure 7-11 and presented in the form of flood afflux diagrams in Figure 7-12 Figure 7-13 Figure 7-14.



Title:

Flood Modification Measure - Flood Levee

Figure: **7-9**

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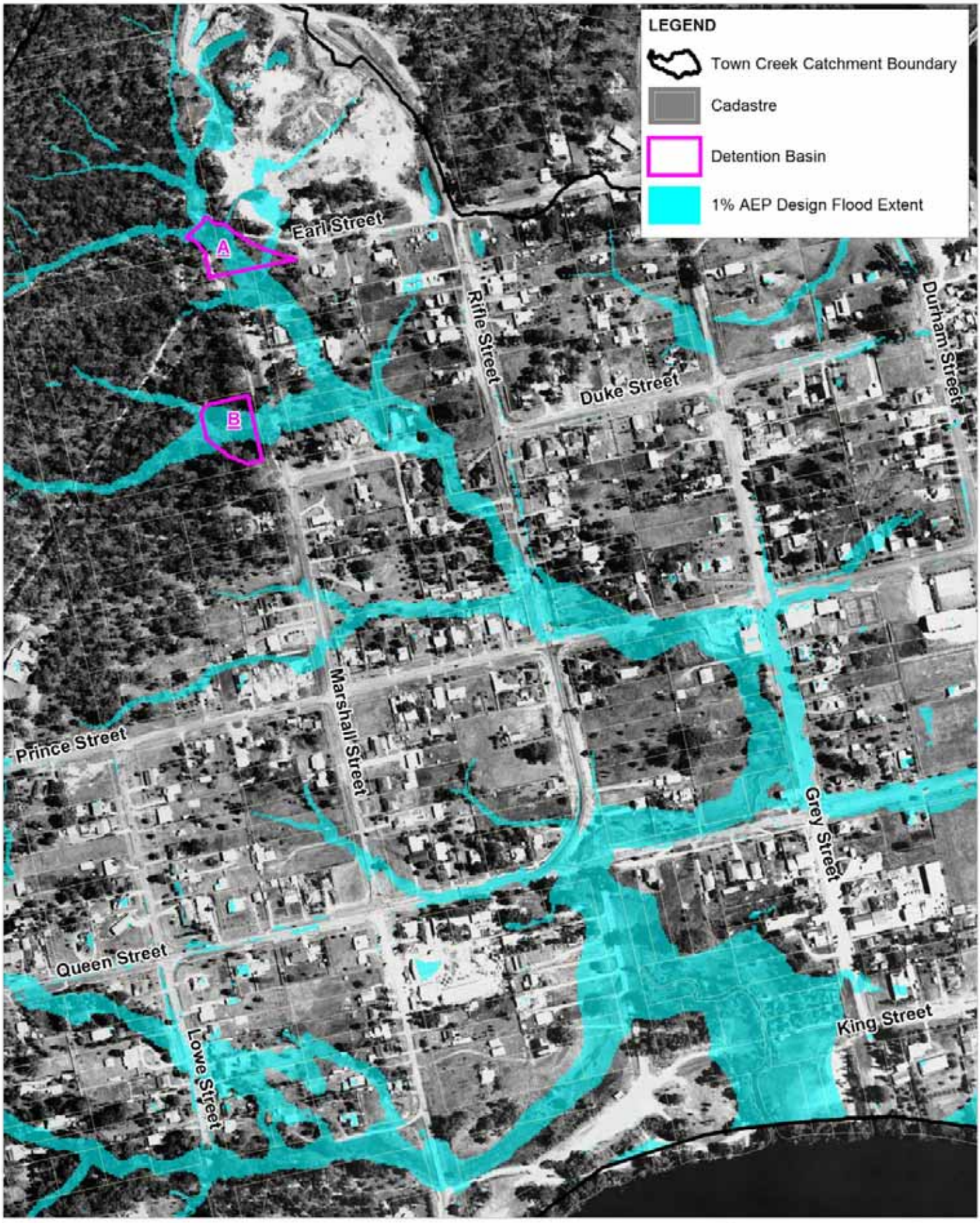

Title:

Detention Basin Locations

Figure: 7-10

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Table 7-3 Change in Peak 1% AEP Flood Levels with Increased Design Rainfall – Local Catchment Flooding

Location	Peak Flood Level (m AHD)			
	Baseline	Basin A	Basin B	Basin A & B
US Upper Rifle St Culvert	13.8	13.6 (-0.2)	13.6 (-0.2)	13.5 (-0.3)
US Prince St Culvert	11.7	11.6 (-0.1)	11.6 (-0.1)	11.5 (-0.2)
US IGA Culvert	9.6	9.5 (-0.1)	9.5 (-0.1)	9.4 (-0.2)
US Queen St Culvert	5.5	5.4 (-0.1)	5.4 (-0.1)	5.4 (-0.1)

Note: Bracketed value is change in peak flood level from standard design conditions

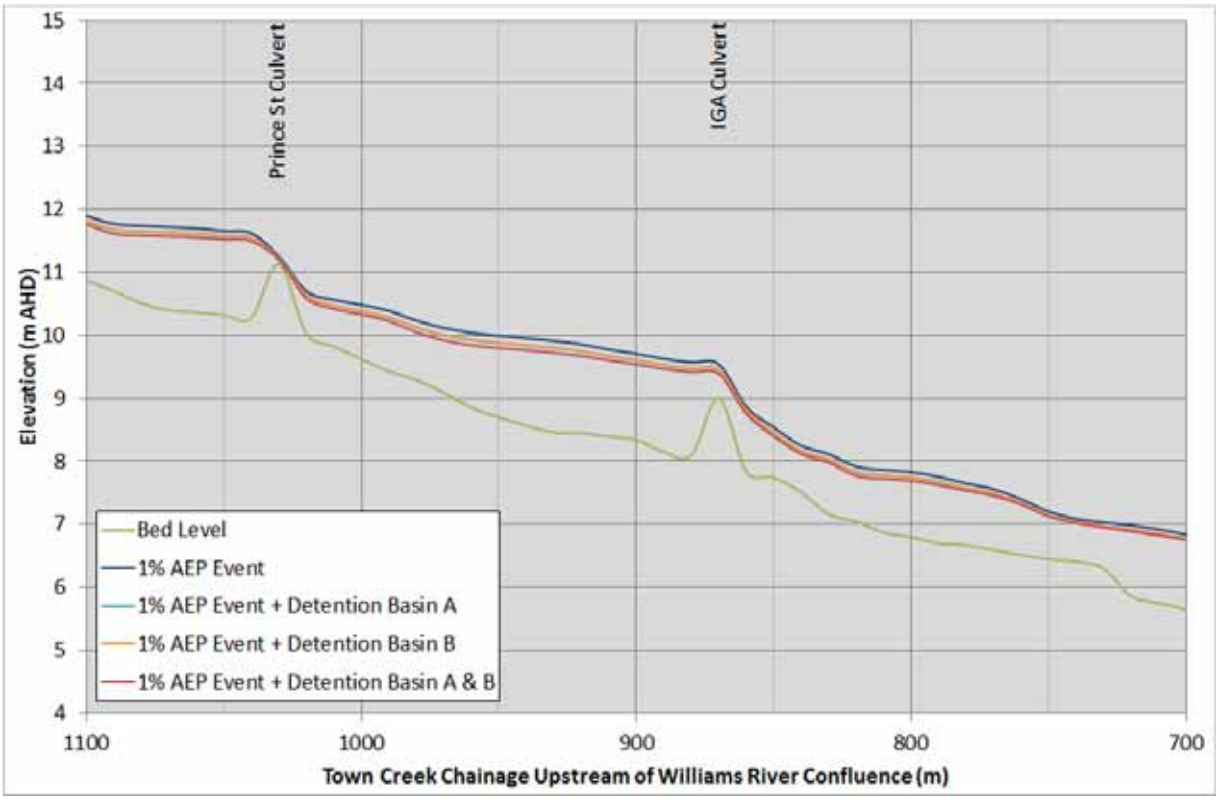
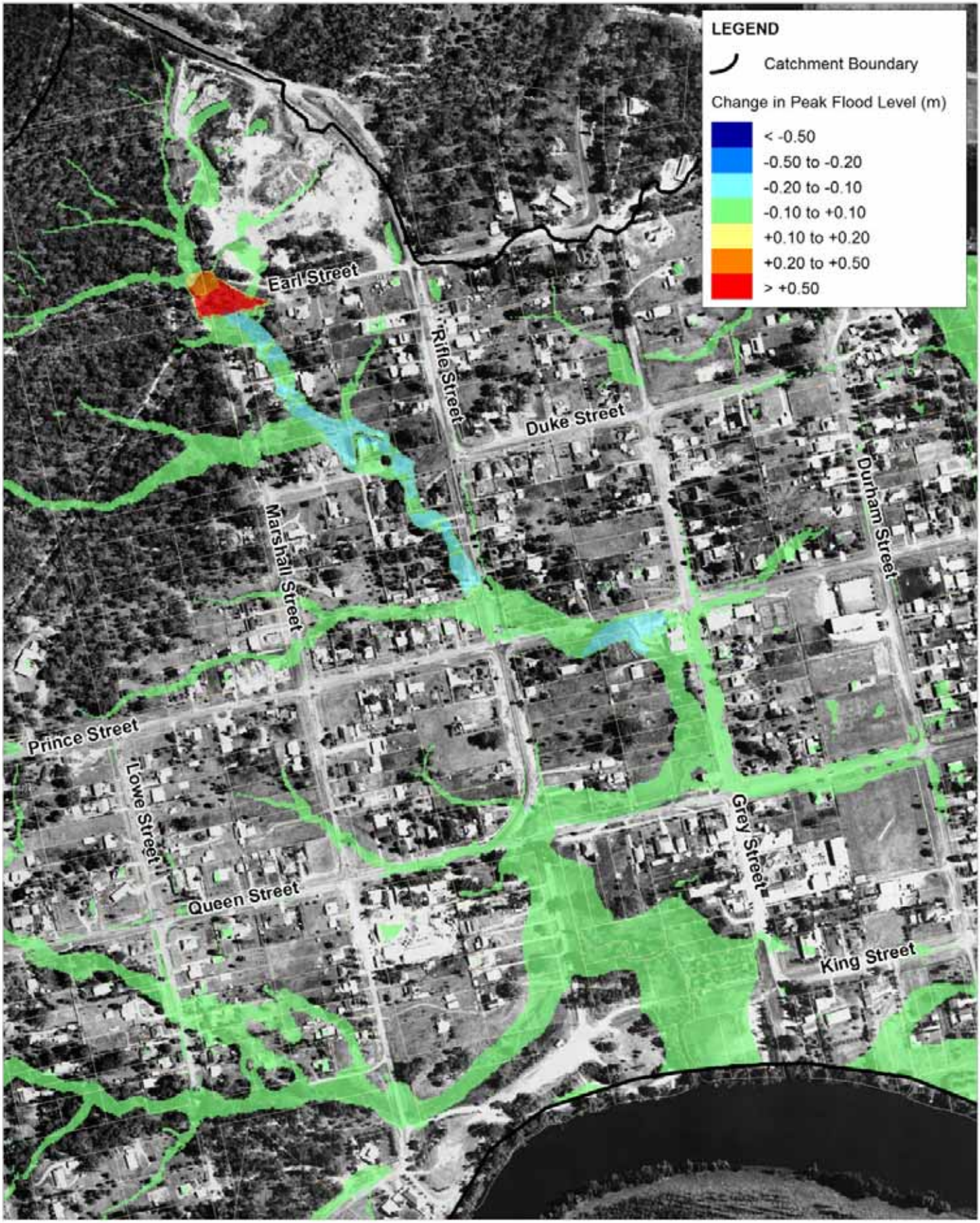


Figure 7-11 Design Flood Profiles – Detention Basins

Whilst providing for some general reductions in peak flood levels along the length of Town Creek, the detention basins only provide for modest reductions in peak flood levels for the commercial properties on Prince Street (up to 0.2m). These magnitude of reductions do not provide for a significant enough improvement in the flood immunity with consideration of the high capital cost of basin construction.



Title:

Change in Peak Flood Level
Detention Basin A (1% AEP Local Catchment Event)

Figure: **7-12**

Rev: **A**

N

0 125 250m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

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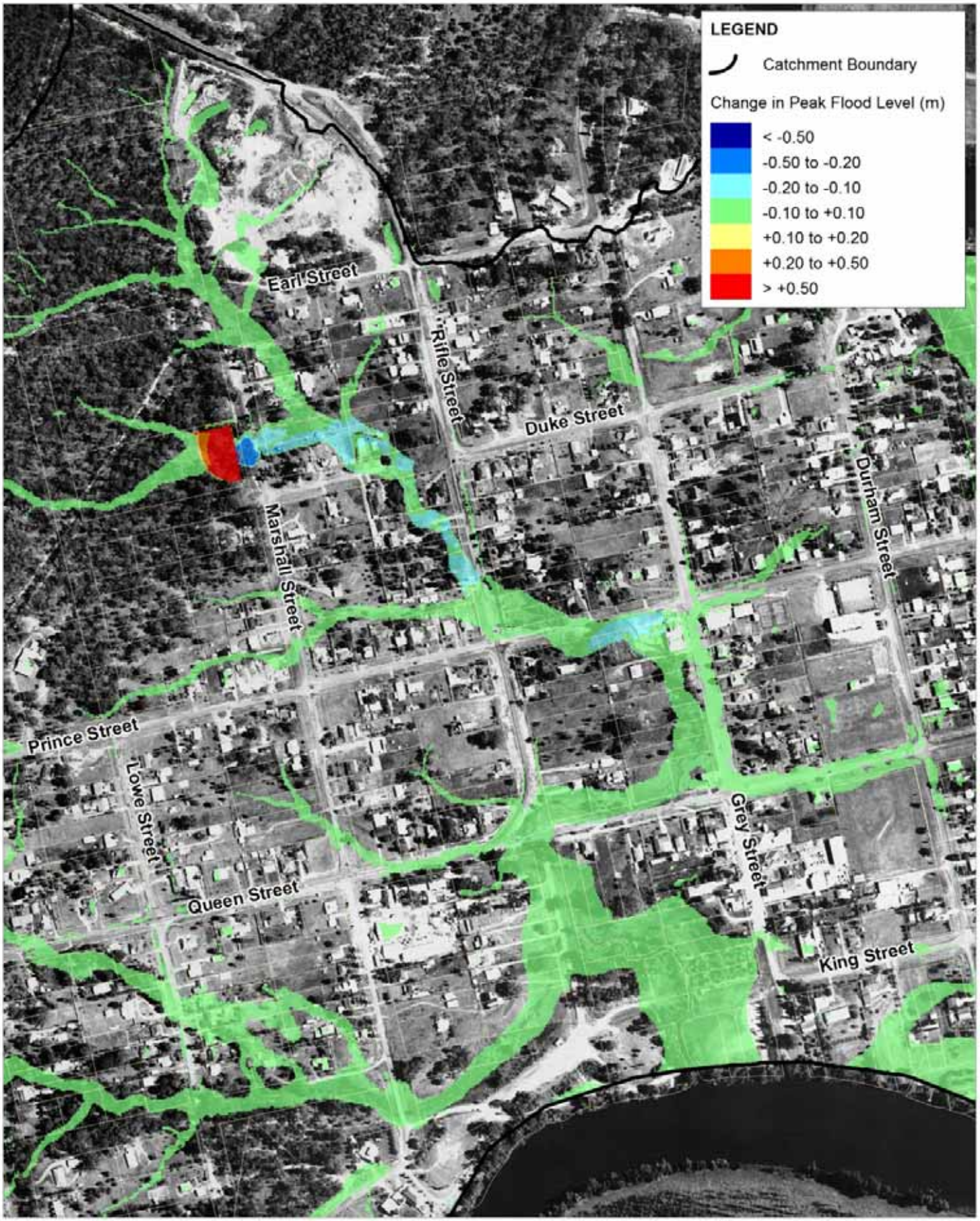

Title:

Change in Peak Flood Level
Detention Basin B (1% AEP Local Catchment Event)

Figure: **7-13**

Rev: **A**

N

0 125 250m

Approx. Scale

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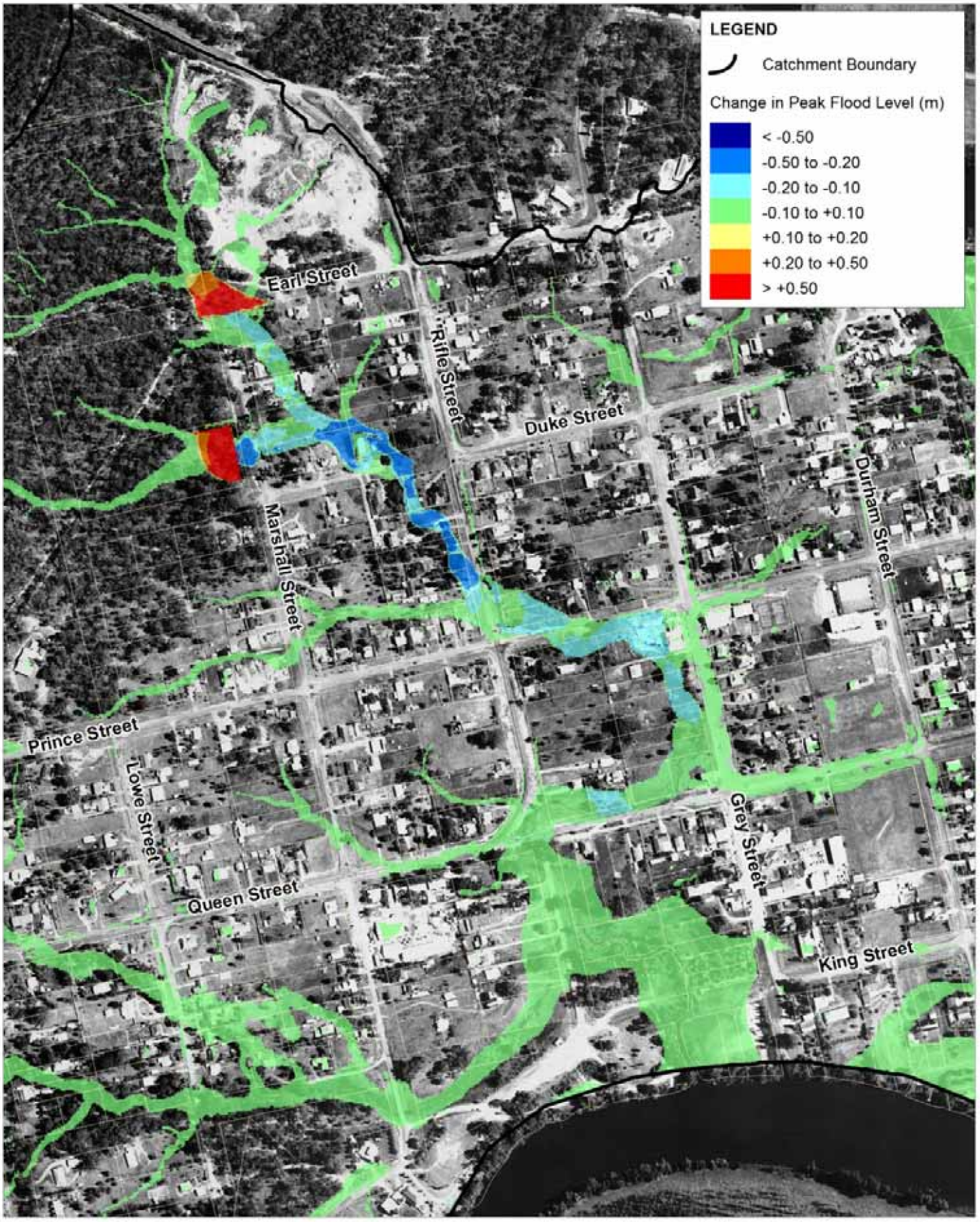
www.bmtwbm.com.au

Filepath : K:\N20044_Clarence_Town_FRMS\MI\Workspaces\Figures\DWG_024_Afflux_Basin_B.WOR



Title:

Change in Peak Flood Level
Detention Basin A & B (1% AEP Local Catchment Event)

Figure: **7-14**

Rev: **A**

N

0 125 250m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

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7.1.6 Other Management Options

Other potential options to be explored at a local detail include:

- formalisation of overland flow paths – investigation of opportunities to purchase easements, restriction on development (including property fencing) through planning controls;
- amplification of stormwater pipe lines; and
- Debris controls structures - There is potential for culvert and other hydraulic structures to become blocked by debris during floods. Fallen trees and other creek-side vegetation, shopping trolleys, garbage bins and floating cars can all potentially become trapped on the upstream side of culverts. Constructing debris control structures around the opening of potentially affected structures will reduce the likelihood of these structures becoming blocked, and will potentially lower flood levels.

7.2 Property Modification Measures

7.2.1 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the study area. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

As discussed in Section 6, Council currently has a number of land use planning and development controls in place to manage flood-affected areas within the Dungog LGA.

7.2.1.1 Flood Planning Level

Flood Planning Levels (FPLs) are used for planning purposes, and directly determine the extent of the Flood Planning Area (FPA), which is the area of land subject to flood-related development controls. The FPL is the level below which a Council places restrictions on development due to the hazard of flooding. Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which has usually been based on the 100 year ARI flood level for the purposes of applying floor level controls.

Adoption of a single FPL can provide for:

- unnecessary restriction of some land uses from occurring below the FPL, while allowing other inappropriate land uses to occur immediately above the FPL; and
- lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there are very few measures in place to manage the consequences of flooding above the FPL).

The latter point above is particularly relevant to Williams River flooding in Clarence Town. As discussed, the nature of flooding is such that there are significant increases in flood depth with increasing flood magnitude. For example, the 200-year ARI (0.5% AEP) flood level lies on average some 0.65m above the 100-year (1% AEP) flood level. Accordingly, even with a 0.5m freeboard provision above the 100-year level, above floor flooding would be expected for a 200-year ARI event.

It is important also to recognise the inherent uncertainties in design flood prediction. For example, climate change sensitivity tests on design rainfall depths (see Section 4.5) show the potential for large variations in peak flood levels over and above the adopted design levels. A 10% and 20% increase in the adopted 100-yr ARI design rainfall depth (within a typical range of sensitivity) provides for increases in predicted 1% AEP Williams River flood levels downstream of Prince Street of 0.5 and 1.0m respectively. It should be noted that this potential increase in design flood level is significantly lower upstream of Prince Street as it is dominated by local catchment flooding (i.e. it is beyond the extent of Williams River flooding). The increase in in predicted 1% AEP flood levels upstream of Prince Street is 0.1m.

Similarly, the Extreme Flood level for Williams River flooding lies some 6m above the 100-year ARI level. Typically this scale of event is used to assess risk to life, however, it must be considered in conjunction with other development controls applied at lower flood thresholds. Approving development within the floodplain (defined up to the Extreme flood level) inherently provides for flood risk. Some considerations of the impact of events of greater magnitude than the flood planning levels include:

- Evacuation opportunity – appreciating that with the combination of minimal warning times and potential access road inundation, residents would largely be confined to their property and immediate surrounds, with only pedestrian access. Given the local topography of Clarence Town, in most instances a constantly rising evacuation route (i.e. walk up the hill) will be available in the case of major flooding. Should residents fail to evacuate prior to property becoming inundated, there is the possibility that flood levels could exceed roof levels. Personal flood action plans should recognise this risk.
- Property damage – with potential for significant inundation above the FPL, structural integrity of property constructed on the floodplain is essential. Whilst evacuation is the primary objective, structural integrity of the property is required for people sheltering in place.

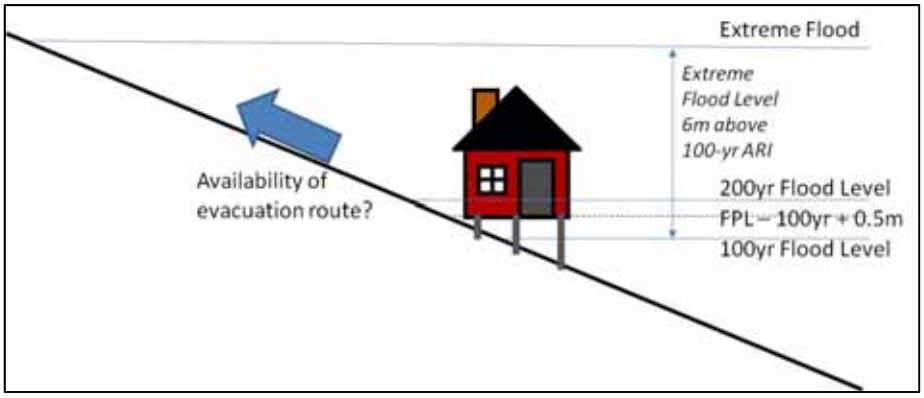


Figure 7-15 The FPL and relation to a range of flood event magnitudes

Based on the limited responses to the community questionnaire, the level of control that Council should place on new development (including the adoption of an appropriate flood planning level) is a contentious issue within the Clarence Town community with opposing opinions on the desired magnitude of future development within the area and level of control to be placed on future development. To some degree, the opportunity for future development is linked with design

planning levels, and as such, community confidence in the procedure to establish this level is important.

The current design planning level for Clarence Town defined in both Councils DCP and the Dungog Flood Prone Land Policy is 7.57m AHD. This level was taken from a hardcopy map in Council's office dated 14th March 1989, with the 7.57m AHD level labelled as the 1% AEP design flood level. This adopted level is over 0.5m below the 1% AEP flood level for the Williams River at Clarence Town and does not take in to consideration local catchment flooding. However, it is understood that following completion of the Williams River Flood Study and Clarence Town Flood Study, flood levels derived from these studies are used for development control purposes in Clarence Town.

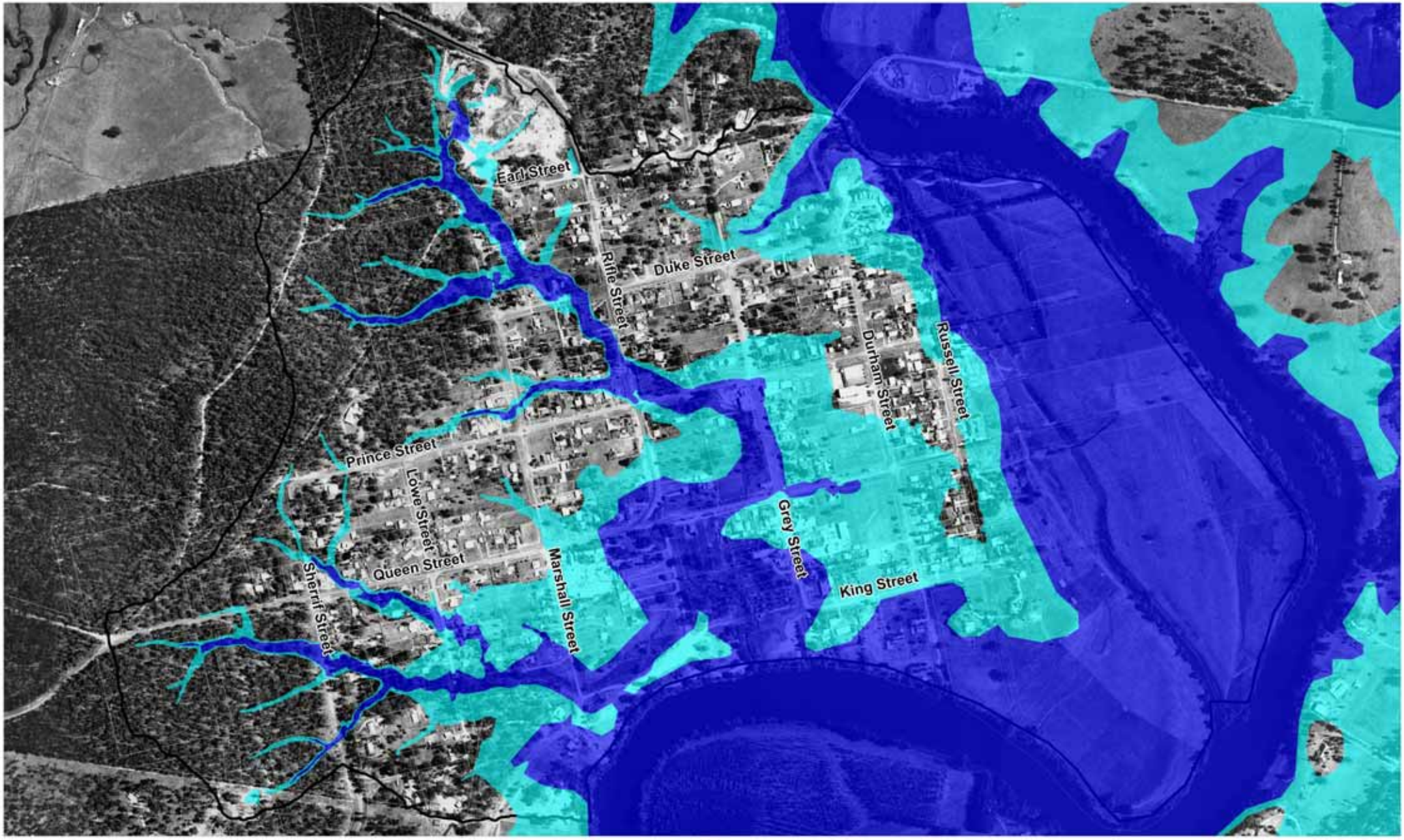
As discussed in Section 6, Council's DCP currently divides the floodplain into three floodplain management zones (floodway, flood fringe or outer floodplain) and defines design planning levels for each floodplain management zone based on a planning matrix (see Figure 6-2) (this approach is consistent across the Dungog LGA with the exception of the Paterson River catchment). The DCP defines four different flood planning levels depending on the position in the floodplain:

- 5% AEP flood level plus 0.5m freeboard provision (defined for recreational or agricultural development in the floodplain);
- 1% AEP plus 0.5m freeboard provision (defined for residential, commercial and industrial development within the floodplain); and
- Equal to or greater than the PMF level (also known as the extreme flood level) (defined for essential community facilities e.g. schools and hospitals; and critical utilities).

The above flood planning level definitions in conjunction with the adopted design flood levels from the Williams River Flood Study and Clarence Town Flood Study are considered to be suitable on the following basis:

- The level reflects an acceptable level of risk to property (in terms of potential flood damage) considering likelihood of flooding and relative consequences. The adopted flood levels represent the best estimates of design flood levels given available information and established by industry best practice.
- Risk to life more effectively managed by other controls/measures such as specific requirements for evacuation route provisions in the DCP, effective flood warning and emergency response. Risk to life is not managed effectively in the Clarence Town catchment through a raised flood planning level due to the nature of flooding (i.e. residual risks up to the Extreme Flood event).
- Consistency across the Dungog LGA is maintained.
- The setting of the flood planning level does not preclude property to be constructed at a higher level. Flood risk information across the range of flood events, including events greater than the 100-year event, should be made available to landholders and development proponents. DCP provisions may be included to encourage development at higher levels where opportunities exist on appropriate lots, noting available flood level information.

The recommended flood planning area (i.e. area under the recommended FPLs) is presented in Figure 7-16.



LEGEND

- Flood Planning Area
- PMF Inundation Extent
- Cadastre
- Clarence Town Catchment Boundary

Note: The Flood Planning Area and PMF inundation extent encompass both Local Catchment and Williams River flooding

Title:

Clarence Town Flood Planning Area
Based on the 1% AEP Event + 0.5m Freeboard

N

0 125 250m
Approx. Scale

Figure: 7-16

Rev: A

BMT WBM
www.bmtwbm.com.au

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7.2.1.2 Other Planning and Development Control Measures

As discussed in Section 6, Council currently has a number of land use planning and development controls in place to manage flood-affected areas within the Dungog LGA including a LEP (LEP 2013) and the Dungog Development Control Plan No. 1 - Managing Our Floodplains.

Council's existing matrix of planning controls (see Figure 6-2) used to define development controls within the floodplain (as defined in Councils DCP 1 – Managing Our Floodplains) currently defines 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;
- 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 is however some recommendations for additions to the development control matrix as provided hereunder.

Floor Levels

- Lowest habitable floor levels should be elevated 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).

Flood Effects

- The flood impact of the development (including any stormwater drainage works associated with new or existing developments) to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required. Figure 7-17 shows an example of stormwater drainage works on private property and the impact it has on the flood behaviour during the June 2007 flood event. It is evident that the series of culverts provides a significant floodwater control resulting in floodwaters backing up behind the structure thereby exacerbating the flood risk to properties further upstream.

Figure 7-17 Stormwater Drainage Works on Private Property

7.2.2 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood

proofing can be undertaken for new buildings or be retrofitted to existing buildings, however flood proofing is generally more effectively achieved during construction with appropriate selection of materials and design. Generally these works would be undertaken on a property by property basis at no cost to Council.

Of particular interest to building owners (and insurers) is making changes to building materials to reduce the costs of damages during flood. This would include for example replacing composite timber kitchen cupboards with solid timber cupboard, replacing carpet with floor tiles, replacing plasterboard wall lining with fibrous cement etc. These changes can often be done during building renovations, and at a relatively marginal additional cost.

Council's Development Control Plan already includes requirements for the use of flood compatible building components for new development in the floodplain. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Figure 7-18 shows the local catchment flooding in the vicinity of the Rural Transaction Centre during the June 2007 event. It is evident that the occupants have attempted to prevent floodwaters from flowing through the doorways by blocking the bottom of the door with a makeshift collection of materials. This building could effectively be flood proofed by installing a flood barrier at the doorway (and all other entrances that allow floodwaters to enter the property. There are a number of available flood barrier technologies including permanent fixtures such as automatic 'flip up' flood barriers as shown in Figure 7-19; or temporary fixtures that can be stalled in less than 5 minutes in the event of a flood such as the Floodgate technology shown in Figure 7-20. Flood barriers are easy to install at a relatively low cost and would be a recommended measure for properties that experience above floor flooding.

Figure 7-18 Rural Transaction Centre – June 2007

Figure 7-19 Permanent Automatic 'Flip up' Flood Barrier (source: http://www.spec-net.com.au/press/0212/flo_150212.htm)

Figure 7-20 Temporary Floodgate Flood Barrier (source: http://www.hydroresponse.com/floodgate.htm)

Whilst flood proofing may limit the damage to the building and its contents, the occupant (particularly in the case of commercial property) may still suffer from the social and economic disruption of flooding such as the closure of businesses and lack of access during and after flood events.

7.2.3 Other Property Modification Measures

Some of the other property modification measures (beyond development control measures and flood proofing) include:

- Voluntary Purchase Schemes: are generally applicable only to areas where flood mitigation is impractical and the existing flood risk is unacceptable. No property has been identified as suitable for voluntary purchase within the Clarence Town catchment and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan.
- Voluntary house raising - raising floor levels where practical to elevate habitable floor levels to required levels above the flood planning level. Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard (e.g. 1% AEP Flood Level +0.5m). Voluntary house raising generally only provides a benefit in terms of reduced economic damages but does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation and therefore the flood access and emergency response opportunity is still compromised. Not all houses are suitable for raising. Houses of brick construction or slab on ground construction are generally not suitable for house raising due to expense and construction difficulty (equates to approximately one third of properties located within Extreme Flood extent). Generally this technique is limited to structures constructed on piers, which is equates to approximately two-thirds of house located within the Extreme Flood extent. Given there is no residential property identified with over floor flooding at the 1% AEP flood level, no property has been identified as suitable for voluntary house raising within the Clarence Town catchment and therefore there is no recommendation for such a scheme in the Floodplain Risk Management Plan.

7.3 Response Modification Measures

7.3.1 Flood Warning

7.3.1.1 Existing Flood Warning System

The BoM Flood Warning Service provides different types of information to inform the community of type of flooding and the level of flood risk. The range of information may include (BoM, 2013):

- **An Alert, Watch or Advice** of possible flooding, if flood producing rain is expected to happen in the near future. The general weather forecasts can also refer to flood producing rain.
- **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. These types of 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 storm situations that may cause flash flooding. In some areas, the Bureau is working with local councils to install systems to provide improved warnings for flash flood situations.

- **Warnings of 'Minor', 'Moderate' or 'Major' flooding** in areas where the Bureau has installed specialised warning systems. 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 the expected height of a river** at a town or other important locations along a river, and the time that this height is expected to be reached. This type of warning is normally the most useful in that it allows local emergency authorities and people in the flood threatened area to more precisely determine the area and likely depth of the flooding. This type of warning can only be provided where there are specialised flood warning systems and where flood forecasting models have been developed.

There is currently a formal flood warning service for the Williams River provided by the Bureau of Meteorology (BoM) utilising the gauges at Dungog, some 38km upstream of Clarence Town, and at Glen Martin (Mill Dam Falls), some 7km upstream of Clarence Town.

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 SES classifies major, moderate and minor flooding according to the gauge height values at Glen Martin (Mill Dam Falls) as detailed in Table 7-4. The flood classification levels are described by:

- **Minor flooding:** 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:** flooding which inundates low-lying areas, requiring removal of stock and/or evacuation of some houses. Main traffic routes may be flooded.
- **Major flooding:** flooding which causes inundation of extensive rural areas, with properties, villages and towns isolated and/or appreciable urban areas flooded.

Table 7-4 Flood Warning Classification Water Levels (Williams River)

Flood Classifications				
Location	**Datum**	**Minor**	**Moderate**	**Major**
Glen Martin (Mill Dam Falls) Gauge	Gauge Level	6.1	7.6	9.1
	m AHD	7.0	8.5	10.0
Clarence Town (Town Creek Confluence)	m AHD	2.6	3.7	4.6

There are also a number of general warning services provided by the Bureau including:

- **Flood Watches –** typically provide 24-48 hour notice. These are issued by the NSW Flood Warning Centre providing initial warnings of potential flooding based upon current catchment conditions and future rainfall predictions.
- **Severe Thunderstorm Warnings –** typically provide 0.5 to 2 hours notice. These short range forecasts are issued by the Bureau's severe weather team and are based upon radar, data from field stations, reports from storm spotters as well as synoptic forecasts.
- **Severe Weather Warnings –** for synoptic scale events that cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low pressure systems off the NSW coast such as that which produced the 2007 flood in Clarence Town and the wider Hunter region.

No alterations to the existing flood warning system are recommended. However it is recommended that the SES review and update their response plans based on the outcomes of this study, e.g. to include risk-based prioritisation of resources and plans to manage the warning process, where there are likely to be insufficient resources to achieve the most efficient rate of emergency response and evacuation.

7.3.1.2 Available Flood Warning

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community as there is less opportunity to implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

The NSW State Flood Plan (SES, 2008) notes that in order to provide effective emergency flood response for the Williams River, twelve hours notice is required for water levels in excess of 6.1m AHD at Glen Martin, but typically only nine hours notice is generally available. This difference between required and available notice of significant flood events can limit the effectiveness of emergency services during major flood events.

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A high rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate.

Given the relative steepness of the Clarence Town local catchment, the flood response of the catchment to a local catchment flood event will be relatively fast. The progression of the flood through the catchment and subsequent increases in flood water levels can occur over a period of 1-2 hours.

To provide an indication of the relative rise of floodwater in the catchment associated with local catchment flooding, Figure 7-21 shows the simulated water level rise for 1% AEP local catchment flood event in response to the adopted design rainfall pattern. The result shown is for the approximate location on Town Creek adjacent to the Rural Transaction Centre. The critical storm duration resulting in the highest peak flood level conditions was found to be the 2-hour storm event.

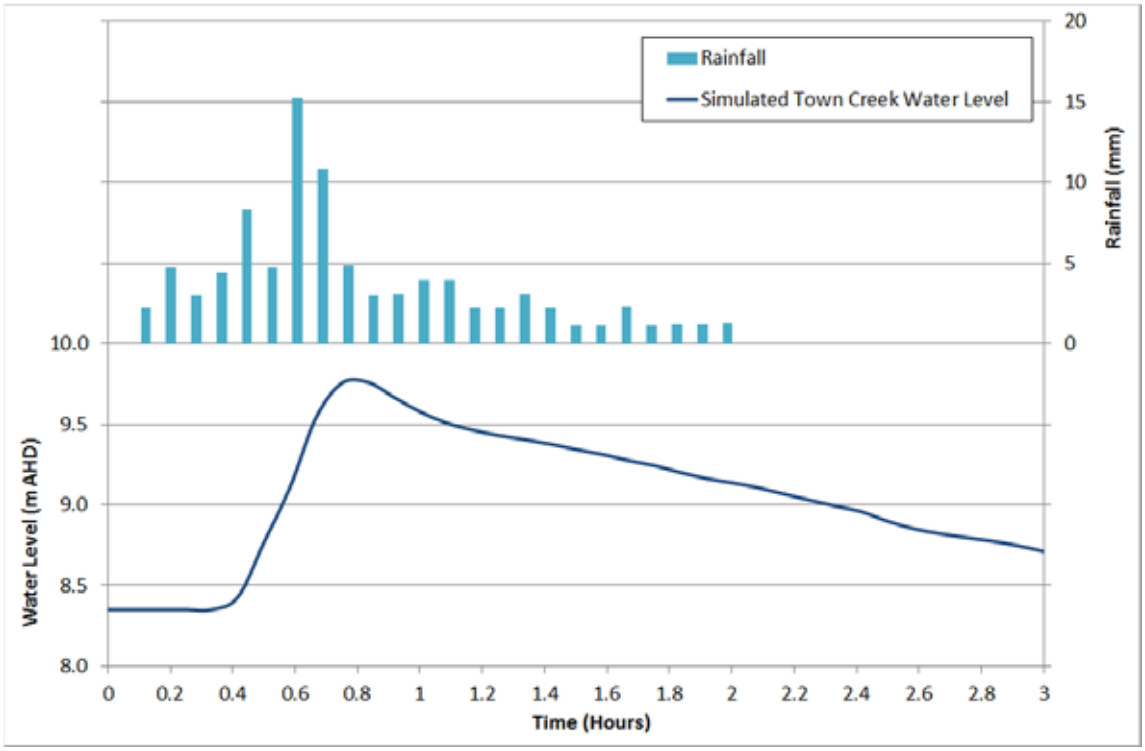


Figure 7-21 Rate of Rise of Floodwater (Design 1% AEP Local Catchment Flooding)

Utilising Figure 7-21 as an indicative catchment flood response, the expected peak flood conditions in Clarence Town may be experienced in under an hour after the onset of flood producing rainfall. It should be noted however, that inundation may happen sooner depending on observed rainfall conditions. Nevertheless, given these rates of rise it is anticipated that minimal flood warning time would be available for local catchment flooding.

However in regards to floodwaters emanating from mainstream Williams River flooding, the flood response of the catchment to rainfall will be significantly slower than the local catchment response. As previously stated, flooding in the Williams River in the vicinity of Clarence Town emanates from periods of prolonged rainfall across the wider Williams River catchment. The critical Williams River flood conditions within Clarence Town relate to longer duration events of the order of 24 to 36 hours.

To provide an indication of the relative rise of floodwater in Clarence Town associated with Williams River flooding, Figure 7-22 shows the simulated water level rise for 1% AEP Williams River flood event in response to the adopted design rainfall pattern. The result shown is for the approximate location of the Town Creek confluence on the Williams River. The critical storm duration resulting in the highest peak flood level conditions was found to be the 36-hour storm event.

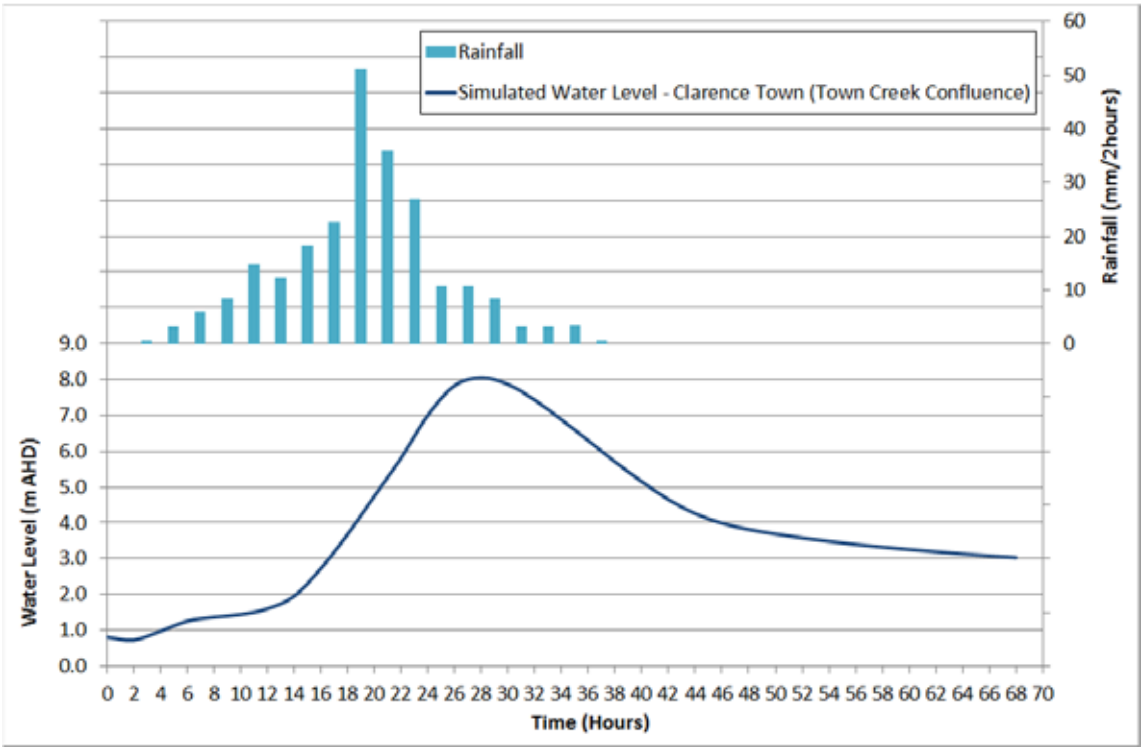


Figure 7-22 Rate of Rise of Floodwater (Design 1% AEP Williams River Flooding)

7.3.1.3 Method of Flood Warning

Flood warnings to residents can be issued by a variety of measures, from automated messaging to door knocking. A comparison of various warning methods is provided Figure 7-23.

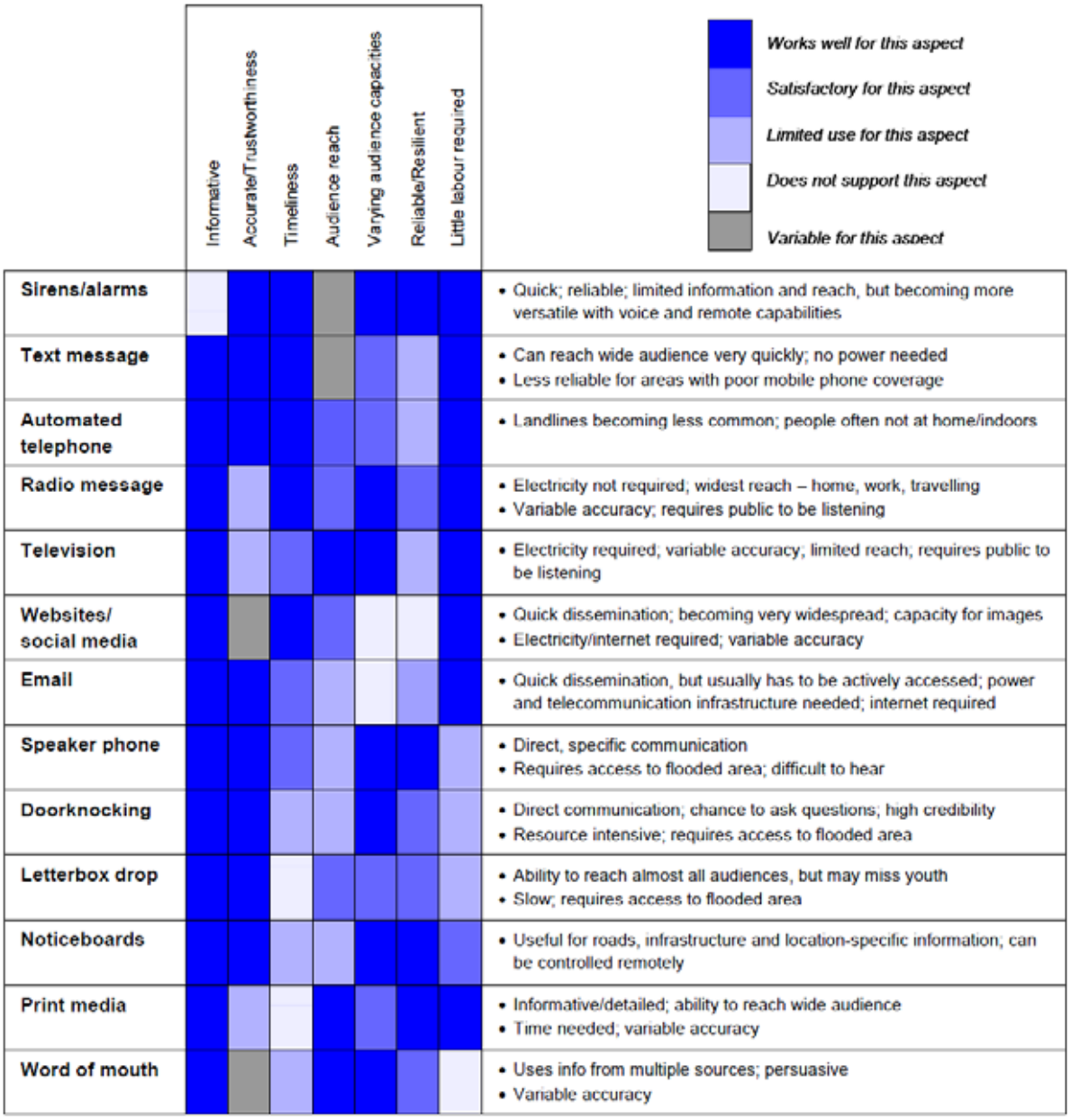
In recent riverine floods the NSW SES has used the new national telephone warning system Emergency Alert to issue flood warnings and evacuation orders in addition to traditional methods such as media broadcasts, internet postings and door knocking. During floods in NSW, Victoria and Queensland in 2011, social media emerged as a significant flood warning dissemination tool. The use of social media to enhance other warning dissemination channels should be considered further for Clarence Town.

7.3.1.4 Interpreting Flood Warnings

In order to get the most benefit from flood warnings people in flood prone areas will need to know what, if any, effect the flood will have on their property and some knowledge of how best to deal with a flood situation. Sources of such information could include

- Flood Bulletins/Warnings issued by the Bureau and/or the local Council or emergency services which often contain details of areas affected by flooding, road closures and other advice on what the community should do if they are likely to be flooded;
- Long term residents who may have experienced a similar flood in the past and remember how it affected them;
- Local Councils that have conducted flood studies and have maps of areas that are likely to be flooded by a range of floods; or

- Information pamphlets.



Office of the Queensland Chief Scientist, 2011

Figure 7-23 Comparison of Flood Warning Communication Methods

7.3.2 Emergency Response

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, Council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

There is currently no Local Flood Plan for Clarence Town specifically, however emergency management perations for Clarence Town are included in the Dungog Shire Local Flood Plan. The

Dungog Shire Local Flood Plan (DLFP) (SES, 2011) is a sub-plan of the Dungog Local Disaster Plan (DISPLAN) and covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Dungog LGA. Information contained in the DLFP is largely derived via local knowledge, historical record and completed flood studies.

A summary of the information contained in the DLFP is outlined below:

- Flood Preparedness – measures taken to prepare for flooding across the LGA including:
  - Maintenance of the DLFP;
  - Development of flood intelligence (including the undertaking of flood studies and floodplain management studies and plans across the LGA);
  - Development and maintenance of flood warning systems;
  - Public education; and
  - SES training.
- Response – measures taken to respond to flood events including:
  - Operational management including defining clear roles of responsibility during flood events (Clarence Town may be treated as an individual 'sector' of operation);
  - Provision of flood information and warnings (including issue and dissemination of flood warnings);
  - Road and traffic control (potential road closure information defined in Plan);
  - Flood rescue operations; and
  - Evacuation plans.
- Recovery – measures taken to recover from a flood event including recovery operations at a local, district and state level.

The DLFP also contains an overview of flood behaviour and flood history across the LGA; details of potential effects of flooding on the community (including specific details for Clarence Town); details of gauge monitoring sites for flood warning systems; evacuation arrangement; and design flood mapping.

The SES follows the LFP, using information from Flood Intelligence and BoM's predictions, to respond in actual flood events. Local flood intelligence needs to be updated with the flood level data derived from the Clarence Town Flood Study (BMT WBM, 2012) and Williams River Flood Study (BMT WBM, 2009). The flood mapping for Clarence Town currently contained within the DLFP is shown in Figure 7-24. It is evident that a greater level of detail and coverage of design flood information is available for Clarence Town and should be incorporated into the DLFP.

The DLFP should be updated to provide design flood data for the full range of events considered in the Flood Study and Floodplain Risk management Study (20% AEP up to the PMF). The property inundation database established in the current study will also be provided to the SES.

For rapid onset of local catchment flooding in Clarence Town (<1 hour warning time), it would not be realistic to expect the SES to be able to undertake much in the way of emergency response for the following reasons:

- The SES is principally a volunteer organisation and the time required to mobilise personnel exceeds the warning time available; and
- There is generally insufficient time to undertake tasks such as sandbagging or evacuation to reduce impacts on property or people.

Therefore the SES's role in local catchment flooding may be limited to executing rescues and assisting with recovery after the event. The flood intelligence contained in the Clarence Town Flood Study and Clarence Town Floodplain Risk Management Study and Plan will aid the SES in prioritising the areas of the local catchment with the highest flood risk.

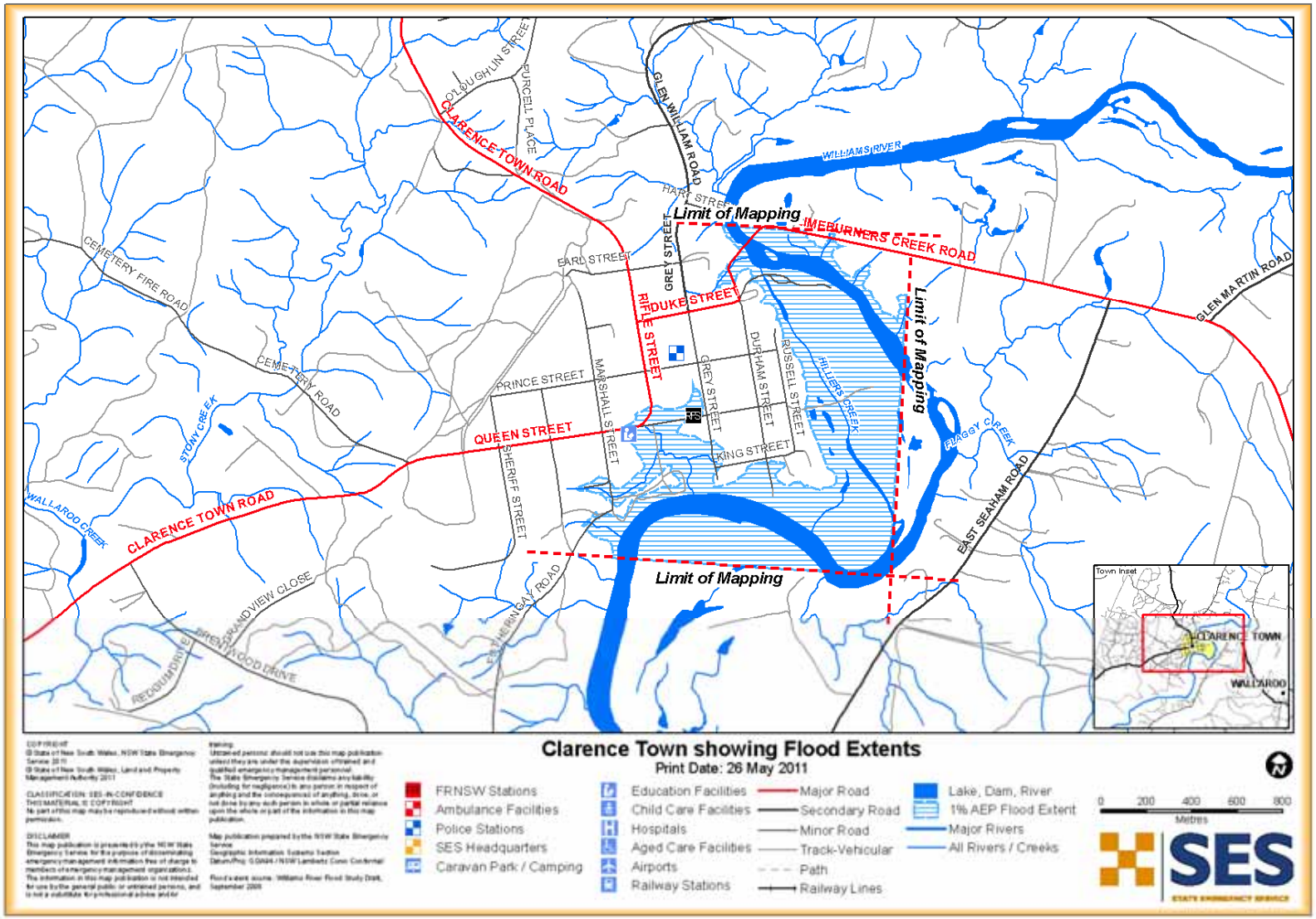
That is not to say that the flood warning system or the DLFP will not in some measure mitigate the impacts of local catchment flooding. What it does mean is that SES and DLFP cannot be relied upon alone to provide an appropriate level of protection, particularly the protection of lives. In the rapid onset of a flood, individuals and groups of people must essentially take appropriate actions to protect themselves.

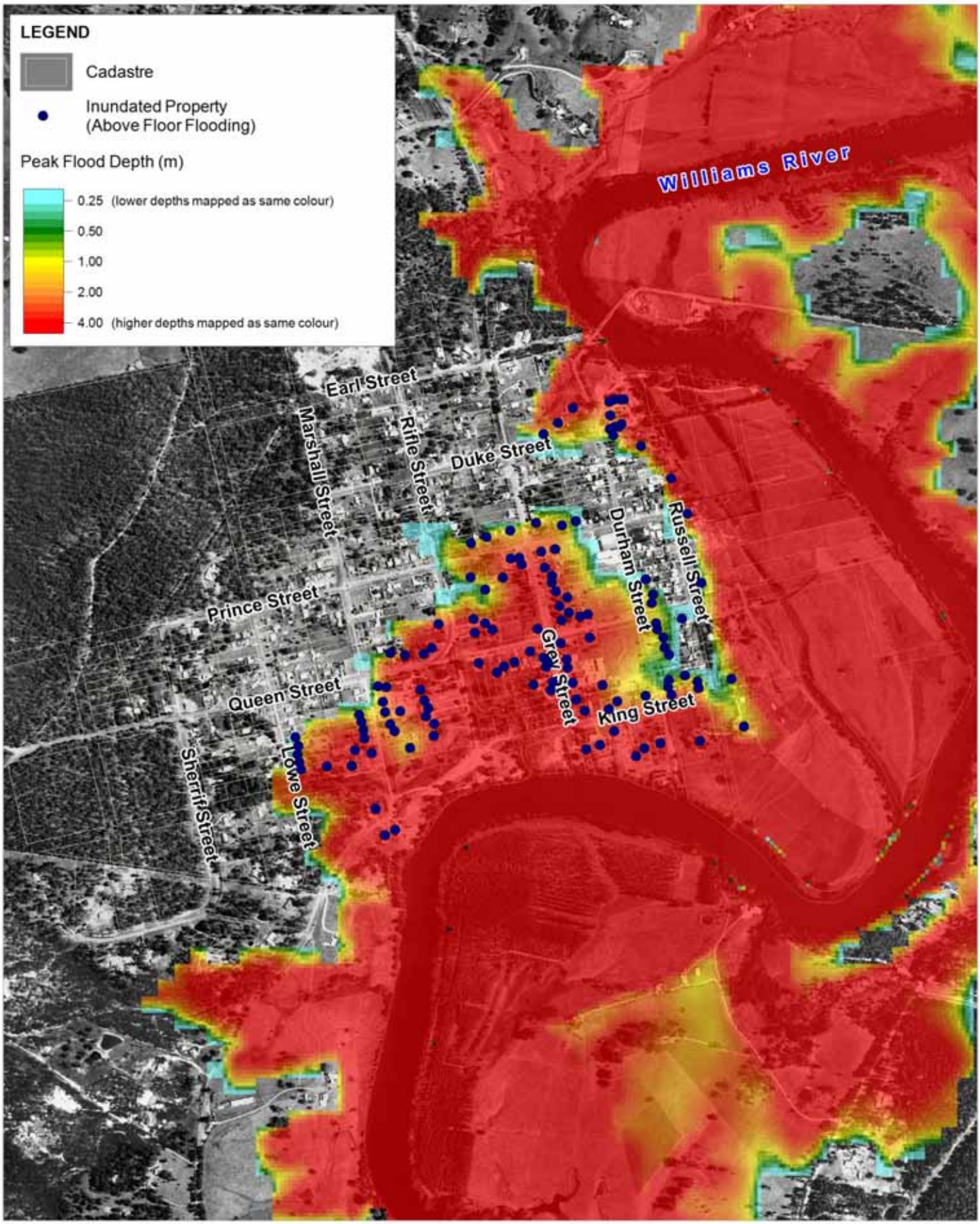
For Williams River flooding the flood warning information and emergency response measures are expected to be of greater use (given the 9 hour warning time available). Again the information contained in the Williams River Flood Study (BMT WBM, 2009) and Clarence Town Floodplain Risk Management Study and Plan will aid the SES in prioritising the areas of the Clarence Town with the highest flood risk.

The Williams River extreme flood event is likely to result in significant emergency response and evacuation requirements. The simulated peak flood depths and peak flood velocities for the Williams River extreme flood event are shown in Figure 7-25 and Figure 7-26 respectively. As discussed in Section 5, a total of 127 properties are expected to experience above floor flooding during the Williams River extreme flood event. It is evident in Figure 7-25 that a significant number of these properties are expected to experience peak flood depths in excess of 2m. However, it is evident in Figure 7-26 that the floodwaters are slow moving and given the slow rate of rise expected for Williams River flooding, sufficient warning time should be available to enable effective evacuation.

Occupants of premises within the flood prone areas should be encouraged to have private flood emergency response plans which have evacuation as the preferred initial response if that is practical. Should evacuation not be possible before floodwaters cut off evacuation routes then remaining in the building should be the alternative. While the NSW SES does not encourage people to stay inside flooding buildings, it acknowledges that a number of circumstances can prevent evacuation in some situations, and once trapped in a building, it is generally safer to stay inside than to exit into high hazard floodwaters.

Figure 7-24 Dungog Local Flood Plan – Flood Extent Mapping for Clarence Town





Title:

Williams River Peak Flood Depths - PMF Event

Figure: 7-26

Rev: A

N

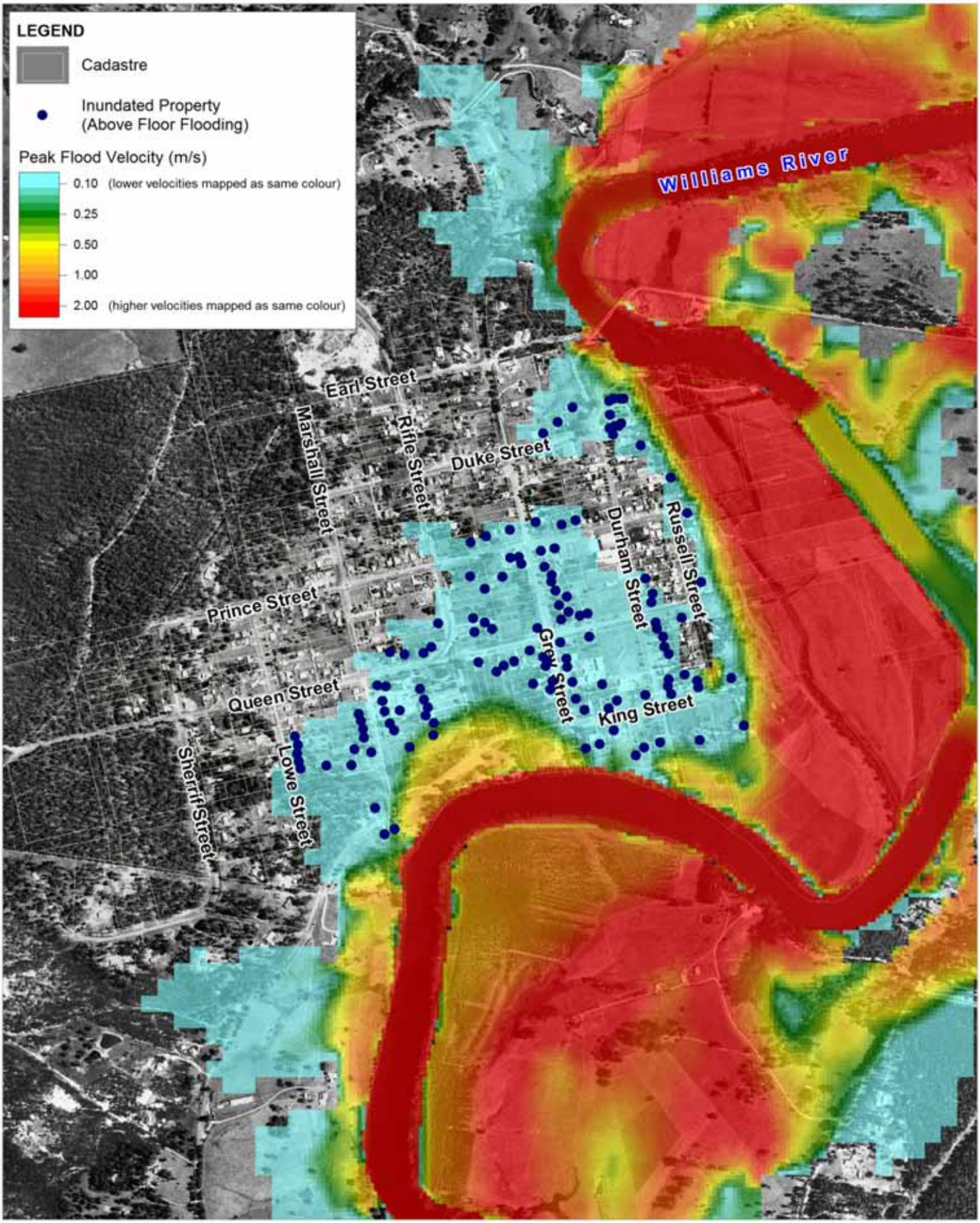
0 250 500m

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : K:\N20044_Clarence_Town_FRMS\MI\Workspaces\Figures\DWG_012_WilliamsRiver_PMFDepth.WOR



Title:

Williams River Peak Flood Velocities - PMF Event

Figure: 7-27

Rev: A

N

0 250 500m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N20044_Clarence_Town_FRMS\MI\Workspaces\Figures\DWG_013_WilliamsRiver_PMFVelocity.WOR

7.3.3 Community Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

The basic objectives of the community awareness program are to:

- Make people aware they are living / working in a flood zone
- Receiving, understanding and reacting to flood warnings
- Appropriate actions - e.g. where to evacuate to, what to do if caught in car

Community awareness is an on-going process and there is also the inherent danger of complacency between events. There are numerous mechanisms to inform the community, with the following recommended to be incorporated in the Clarence Town FRMP.

- Distribution of SES Flood-safe brochure / other brochures.
- Section 149 / Flood certificates - Consideration could also be given to providing information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.
- Flood mapping availability (Council website) - Consolidation of the recent flood risk mapping, flood data and flood damages database prepared during the floodplain management study into Council's computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.
- Community displays to provide easily interpreted flood risk information, e.g.
    - Tourist information displays which may assist with the transient population.
    - Historical Flood Height Markers - the installation of flood markers at various locations to indicate the height of past floods, act as a constant reminder of the threat of flooding.
- Flood information page on community websites (e.g. this can include links to BoM rainfall and flood warning pages, a how to guide in understanding and reacting to flood warnings. This may be extended to other media including community newsletters/publications (e.g. Our Own News) with Council providing regular input regarding flood awareness/preparedness, commemoration of historic events etc.

Dungog Shire Council in collaboration with Cessnock, Maitland and Port Stephens Councils has developed a dedicated emergency ready website (www.ready123.com.au). The website provides information to the community on how to prepare for an emergency, what to do in the event of an emergency and who is responsible for emergency services under different emergency situations. The site also provides links to other resources including Floodsafe Guides, SES Flood Plans, Emergency Action Guides and the Local Disaster Plan covering the Dungog, Cessnock, Maitland and Port Stephens LGAs. Useful additions to this emergency website could include the following:

- Links to download completed flood studies and floodplain management studies and plans;
- Links to download available flood mapping; and
- Links to BoM rainfall and flood warning pages.

There are a number of generic existing resources in addition to the above specific measures for Clarence Town. For people who live in flood prone areas, detailed information on flood preparedness, safety and recovery is available in the free booklet 'What to do Before, During and After a Flood' published by Emergency Management Australia (EMA) and available through the State Emergency Service (SES).

PART B – FLOODPLAIN RISK MANAGEMENT PLAN

8 Clarence Town Floodplain Risk Management Plan

8.1 Introduction

Clarence Town Local Catchment and Williams River Flooding Floodplain Risk Management Plan (the FRM Plan) has been developed to direct and co-ordinate the future management of flood prone lands in Clarence Town. The FRM Plan sets out a strategy of actions and initiatives that are to be pursued by Council, agencies and the community in order to adequately address the risks posed by flooding. Development of the FRM Plan has been guided by the NSW Government's Floodplain Development Manual (2005).

The FRM Plan covers the township of Clarence Town and considers both local Town Creek flooding as well as flooding emanating from the wider Williams River catchment.

The outcomes of the Study provide the basis for this FRM Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

The floodplain management measures and strategies that are recommended for inclusion in the FRM Plan are summarised below.

8.1.1 Flood Modification Measures

8.1.1.1 Town Creek Channel Improvements

The channel improvement works proposed are downstream of the Prince Street culvert within the reach adjacent to the existing commercial centre. The works include upgrade of the existing culvert (IGA culvert) and widening of the channel to increase flow capacity. The channel works have considered providing close to 1% AEP flow capacity in order to limit out of bank flows and provide greater flood immunity to the existing commercial properties on Prince Street. The assessment determined the required channel profile to convey the 1% AEP discharge and reduce flood impacts on the commercial centre.

Estimated Cost **- $100K** Responsibility **– Council** Priority - **Medium**

8.1.1.2 Local Drainage Improvements

The proposed works along Grey Street and Prince Street are to improve the management of overland flows, particularly the impacts on the commercial buildings on Prince Street. In high intensity storm events, the current road profiles and limited drainage provisions result in overland flows within the streetscapes to be directed towards the existing buildings. The works provide for road re-profiling to direct overland flows along Grey Street, modification to the low point in Prince Street and additional pipe drainage.

Estimated Cost **- $100K** Responsibility **– Council** Priority - **High**

8.1.2 Property Modification Measures

8.1.2.1 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within Clarence Town. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment.

The following planning measures are recommended:

- Adoption of 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard);
- Review of current land-use zoning with respect to Floodway areas;
- Inclusion of proposed floodplain risk management controls in Council's DCP. The recommended DCP provisions as summarised in Section 7.2.1 include:
  - Lowest habitable floor levels should be elevated above finished ground level; and
  - That development does not increase flood risk elsewhere.

Estimated Cost **– staff costs** Responsibility **– Council** Priority – **High**

8.1.2.2 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings. Generally these works would be undertaken on a property by property basis at no cost to Council.

Council's Development Control Plan already includes requirements for the use of flood compatible building components for new development in the floodplain. However, there are a number of non-structural options that can be retrofit to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Flood barriers are a form of flood proofing that is easy to install at a relatively low cost. Flood barriers can be permanent fixtures or temporary installations and effectively block floodwaters from entering through doorways assuming the rest of the building is constructed from flood compatible materials). Flood barriers are recommended in particular for existing buildings that experience above floor flooding such as the Rural Transaction Centre.

Estimated Cost **- $5,000** Responsibility **– Landowner** Priority – **High**

8.1.3 Response Modification Measures

8.1.3.1 Emergency Response

Information from the current floodplain management study (FRMS) and flood damages database will provide valuable data to enable specific Clarence Town catchment detail to be incorporated into the Dungog Local Flood Plan (DLFP). There is currently some level of Clarence Town specific

detail in the DLFP, however the information provided by the FRMS will enable flood mapping to be updated and aid the SES in prioritising the areas in Clarence Town with the highest flood risk under local catchment and Williams River flooding. Whilst this is normally the responsibility of the SES, assistance could be offered through the floodplain management committee to assist in the a review of the DLFP.

The flood mapping and property database including property locations, floor levels will be provided to the SES for incorporation into existing systems and emergency management procedures.

Estimated Cost **– staff costs** Responsibility **– Council/SES** Priority - **High**

8.2 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 2 to 5 year time frame.

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

(1) Council funds;

(2) Section 94 contributions;

(3) State funding for flood risk management measures through the Office of Environment and Heritage; and

(4) 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 Plan Review

The FRM Plan 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.

A thorough review every 5 years is warranted to ensure the ongoing relevance of the FRM Plan.

References

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Appendix A Flood Mapping

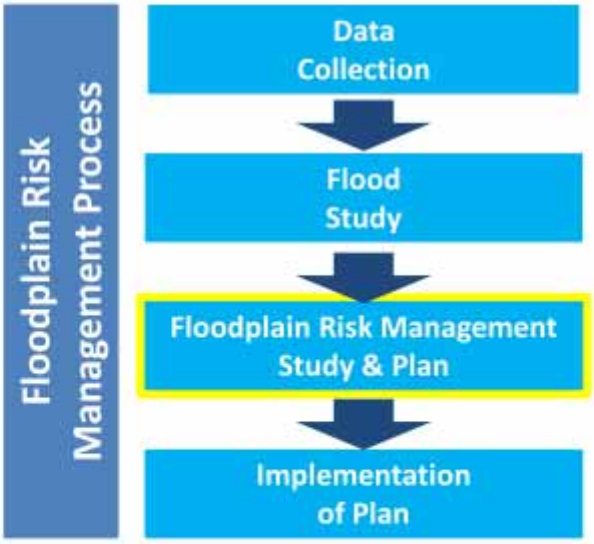
Appendix B Community Consultation Material

Clarence Town Local Catchment & Williams River Flooding Floodplain Risk Management Study and Plan Community Newsletter May 2013

What is the study about?

Dungog Shire Council is carrying out a Floodplain Risk Management Study to understand and manage flood risks in Clarence Town associated with both local (Town Creek) catchment and Williams River flooding.

The Clarence Town Flood Study completed in 2012 investigated in detail the flooding characteristics within the catchment and produced information on flood flows, velocities, levels and extents for a range of flood magnitudes. These design flood conditions will form the basis for assessing various options to reduce the risks and damage caused by flooding within Clarence Town and surrounds.



The next stage of the floodplain risk management process, which this study is focused on, is the assessment of a range options to manage these flood risks for existing and future development.

Who is responsible?

Dungog Shire Council will administer the project with input from the Williams River Clarence Town Catchment Floodplain Management Committee. The Committee will oversee the study, providing regular input and feedback on key outcomes. The Committee has a broad representation including Councillors, Council Staff, State Govt. representatives, stakeholder groups and community representatives .

BMT WBM, an independent company specialising in flooding and floodplain risk management, will undertake the study.

The NSW Office of Environment and Heritage is providing financial and technical assistance.

Rural Transaction Building June 2007

NSW GOVERNMENT Office of Environment & Heritage

BMT WBM

Key Study Outputs

Floodplain Risk Management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

The outcomes of the study provide the basis for the Floodplain Risk Management Plan, containing an appropriate mix of management measures and strategies, to help direct and coordinate the responsibilities of Government and the community in undertaking immediate and future flood management works and initiatives.

Information from the study will be used by the State Emergency Service (SES) during flood emergencies and will be used by Council to assist them to manage development in flood-affected areas.

Want more information?

For more information about the Clarence Town Local Catchment and Williams River Flooding Floodplain Risk Management Study and Plan, please contact:

Dungog Shire Council
Mr Paul Minett
Phone: 49957740
email: Paulm@dungog.nsw.gov.au

BMT WBM (Consultant)
Mr Darren Lyons
Phone: 49408882
email: Darren.Lyons@bmtwbm.com.au

Community input

Community involvement in managing flood risks is essential to improve the decision making process, to identify local concerns and values, and to inform the community about the consequences of flooding and potential management options. There are a number of ways you can be involved in the study:

•Pass on your knowledge and experience about previous flooding history and existing flood problem areas

•Provide any photographs or video of recent flood events to Council. These will be copied and returned.

Further information on the study outcomes will be provided at a later stage including public exhibition of the study which will provide further opportunity for feedback from the community.

Rifle Street June 2007

Corner of Rifle Street and Queen St June 2007

Office of Environment & Heritage

BMT WBM

Clarence Town Local Catchment & Williams River Flooding Floodplain Risk Management Study and Plan Community Questionnaire May 2013

Your views and experiences are important to the study

Dungog Shire Council is carrying out a Floodplain Risk Management Study to manage flood risks in Clarence Town associated with both local (Town Creek) catchment and Williams River flooding. This survey will help us to determine the flood issues that are important to you. Please take a minute or two to read through these questions and provide responses wherever you can. Please return form to the collection box at Clarence Town Post Office or by post to BMT WBM, PO Box 266 Broadmeadow NSW 2292. All information provided is confidential and used only for the purposes of the study.

Contact and Property Details

Name:.....

Address:.....

Phone or email:.....

1. Please tick your type of property :

☐ House ☐ Unit/Flat/Apartment

☐ Business ☐ Other (please specify)

.....

2. How long have you been at this property?

..... Years

3. If this is a business, which best describes your type of property :

☐ Shop ☐ Community Building

☐ Industrial ☐ Education Facility

☐ Care Facility ☐ Other (please specify)

.....

Previous Flooding Experience

4. Have you ever experienced flooding at this property?

☐ Yes ☐ No

If yes, what dates or years did this happen?

.....

.....

5. Do you think your property could be flooded in the future?

☐ Yes ☐ No

Flood Damage and Costs

6. Have you suffered any loss or costs due to flood damage?

☐ Yes ☐ No

If yes, did floodwater damage any of the following? (tick more than one if appropriate)

☐ Vehicles ☐ Carpet/flooring

☐ Furniture ☐ Electrical equipment

☐ Walls/ Building ☐ Stock / other goods

☐ Other parts of the property (please specify)

.....

.....

What was the approximate cost to you (at the time) from the damage caused by the flood ?

.....

.....

7. In previous flooding, did you or your employees (if a business) experience any of the following: (tick more than one if appropriate)

☐ Injury/health problem ☐ Unable to work

☐ Loss of trade ☐ Higher insurance

☐ Considered selling/moving

Protecting Your Property

8. In previous floods, what action did you take to protect your property against flood damage?

☐ None ☐ Used sandbags

☐ Moved Vehicles ☐ Lifted stock/equipment

☐ Other (please specify) .....

.....

.....

9. Are you aware of any works that has been carried out by either yourself, Council or the owner that you believe will reduce the flood problems at your property? (please tick more than one box if appropriate)

☐ Not aware of any measures

☐ Property built at specified floor level

☐ Property has been raised

☐ Flood compatible building materials used

☐ Stormwater pipe improvements

☐ Detention basins

☐ Other (please specify)

.....

.....

.....

10. Are there any works that you think Council should consider to reduce the flood risk at your property?

☐ Yes ☐ No

If yes, please provide details.

.....

.....

.....

.....

Council Development Controls

11. What level of control do you consider Council should place on new development to minimise flood-related risks? (please tick more than one box if appropriate)

☐ Stop all new development on land with any potential for flooding

☐ Stop all new development only in the most dangerous areas of the floodplain

☐ Place restrictions on development such as minimum floor levels and/or the use of flood compatible building materials

☐ Advise people of flood risks, and allow individuals to choose how they would reduce flood damage

☐ There should be no control on development in flood-affected areas

☐ Other (please specify)

.....

.....

12. What notifications do you consider Council should give about the potential flood affectation of individual properties?

☐ Advise every resident and property owner on a regular basis of the known potential flood threat

☐ Advise only those who enquire to Council about the know potential flood threat

☐ prospective purchasers of property of the know potential flood threat

THANK YOU FOR YOUR ASSISTANCE IN COMPLETING THE SURVEY. PLEASE PROVIDE ANY ADDTIONAL INFORMATION YOU FEEL IS RELEVANT TO THE STUDY

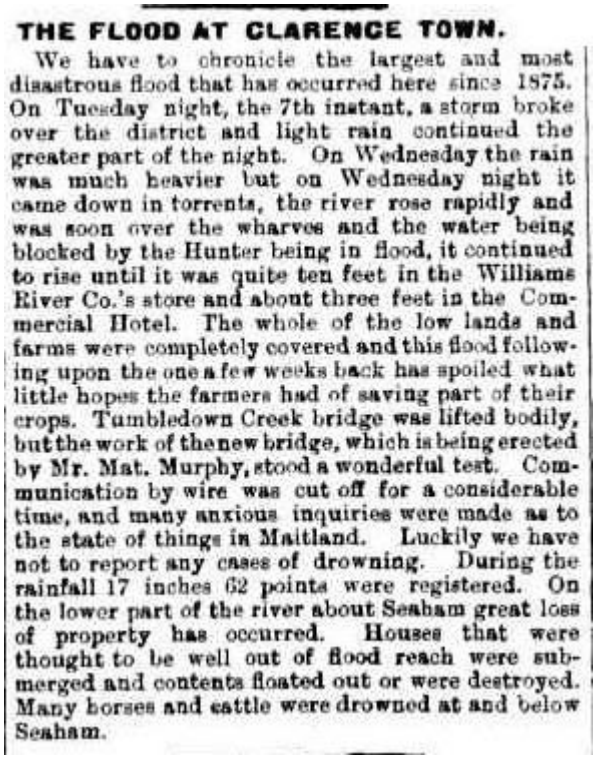
DUNGOG SHIRE COUNCIL 1958

BMT WBM

Appendix C Public Exhibition Submissions

Appendix D Historical Newspaper Articles

The Maitland Mercury & Hunter River General Advertiser (NSW : 1843 - 1893), Saturday 18 March 1893, page 4



THE FLOOD AT CLARENCE TOWN.

We have to chronicle the largest and most disastrous flood that has occurred here since 1875. On Tuesday night, the 7th instant, a storm broke over the district and light rain continued the greater part of the night. On Wednesday the rain was much heavier but on Wednesday night it came down in torrents, the river rose rapidly and was soon over the wharves and the water being blocked by the Hunter being in flood, it continued to rise until it was quite ten feet in the Williams River Co.'s store and about three feet in the Commercial Hotel. The whole of the low lands and farms were completely covered and this flood following upon the one a few weeks back has spoiled what little hopes the farmers had of saving part of their crops. Tumbledown Creek bridge was lifted bodily, but the work of the new bridge, which is being erected by Mr. Mat. Murphy, stood a wonderful test. Communication by wire was cut off for a considerable time, and many anxious inquiries were made as to the state of things in Maitland. Luckily we have not to report any cases of drowning. During the rainfall 17 inches 62 points were registered. On the lower part of the river about Seaham great loss of property has occurred. Houses that were thought to be well out of flood reach were submerged and contents floated out or were destroyed. Many horses and cattle were drowned at and below Seaham.

The Maitland Daily Mercury (NSW : 1894 - 1939), Saturday 23 February 1895, page 4

Flood Relief at Clarence Town.

(*From our Correspondent.*)

A very large and influential meeting, convened by the Clarence Town Progress Committee, was held in the School of Arts here on Thursday night last, to petition the Government for flood relief. Our worthy member, Mr. H. H. Brown, was present. Proposed by Mr. S. T. Robards, and seconded by Mr. W. Eagleton that Mr. S. W. Dark (President of the Progress Committee), take the chair.

The following resolutions were put to the meeting and carried unanimously:—

Proposed by Mr. W. Eagleton. "That Government be asked to afford some relief to flooded-out farmers of the Clarence Town district, who have been very heavy losers by recent flood." He said that the farmers on the Williams River had been visited with disastrous floods for the last four years. He thought they were entitled to some relief, as they had not asked for any since 1867.

Mr. W. Johnson seconded the proposition.

Mr. Brown also spoke on the subject. He expressed deep sympathy with the farmers in his electorate, and felt it his duty to attend all meetings, and do all he could to get relief for them.

Mr. H. Ruse proposed, and Mr. John Allen seconded, "That two delegates be appointed from this meeting to interview the Colonial Secretary with reference to the foregoing resolution."

Mr. John Clague proposed, and Mr. Joe Lea seconded, "That Mr. S. T. Robards and Mr. W. Eagleton act as delegates."

Mr. Robards was pleased to accept the position. He had himself lost almost everything off his farm for the last four years. This year he would not have taken £200 for his crops before the flood, which now were not worth one shilling. Mr. W. Eagleton also gladly consented to act, and would do his best for his fellow farmers.

A subscription was taken up to defray delegates expenses.

As to Local Government Mr. Brown suggested that while the delegates were in Sydney they should interview the Local Government Commissioners in reference to altering of shires. He suggested that instead of the present division the Paterson be reckoned as one shire, and all the Williams as another. He pointed out that the way it is divided now the Clarence Town or lower division would have to keep in repair the roads what are mostly used by the heavy traffic of the upper division, who would not have to pay anything towards it, whereas by taking the Williams in one shire all expenses would fall equally on the whole of the district.

Mr. Wansey proposed, and Mr. Robards seconded, "That the delegates for flood relief be empowered to act in the matter." Carried.

Mr. Brown proposed a hearty vote of thanks to the Chairman (Mr. Dark), which the meeting carried by acclamation.

Mr. Dark responded.

Mr. Ruse proposed a vote of thanks to Mr. Brown for attending the meeting.

Mr. Brown responded, and wished the farmers every success with the deputation. He would do all in his power to get what they wanted, and would not if he could possibly help it take a negative answer from the Government.

THE FLOOD AT CLARENCE TOWN.

LOSS OF LIFE.

Last evening we were favoured by Mr. Heugh with the following extracts from letters of Mr. S. N. Dark, of Clarence Town, to him. The flood in the Williams was evidently, from these letters, more terrible even than that in the Hunter, if possible.

"Clarence Town, Sunday Morning.

"I avail myself of an opportunity of sending you a few lines. The flood has risen here nearly over the third story of the Australasian Steam Navigation Company's store; it rose at the rate of three feet per hour It went over the shingles of my store at the mill. My house is full of refugees.

"The boiler of my mill, although I took the main lid off, and plug out, and used every precaution, yet both it and the engine are lifted out of place. One side of the mill is washed out. We are making the best we can of a bad matter. My punt took posts and all away.

"I believe hundreds are drowned. Intelligence has come in of twelve being drowned in one house. Houses, barns, trees, are all swept away, and lodgments are made in trees that are standing 50 feet above the bed of the river.

"To give you an idea of the height of the flood, it was two feet up Mr. Farquhar's counter. It was a lucky thing we had the Caroline's boat here, as a good many were saved by it.

"We are hard at it. I will write you more particularly by next post. You can send these particulars to the *Mercury* office. There is not the least exaggeration in anything I have written. Fortunately the Caroline was loaded."

"Clarence Town, Tuesday Morning.

"We are getting on as fast as the water will allow us in cleaning up, but there is still two feet water in the mill.

"It is a sad sight to witness the destruction in the different places. I had grain, &c., stored in the Flower of Wexford, which arrived here all safe. The Caroline is still lying here, the Chase is lying near Clode's; they are all right.

"I find the number of lives lost have been exaggerated, the nature of the country allowing people to flee to the mountains. George Ross, his wife, sister-in-law, and family, eight in number, were all swept away and drowned. Two children at Mr. Holmes's also. Singleton's mill is swept away, not a vestige remains. Allen's mill has lost its roof, and is severely injured.

"The boiler and engine of my own mill are in a sad state; the boiler of Aeburch's mill is entirely lifted out of place. It will take us a fortnight to put all to rights. Johnson's losses are also very heavy," &c., &c.

The Maitland Mercury & Hunter River General Advertiser (NSW : 1843 - 1893), Saturday 13 March 1875, page 8

The Flood at Clarence Town.

(From a correspondent of the Newcastle Pilot.)

On Monday, the 1st instant, this district was visited by the largest flood yet known, causing great destruction to the fine maize and other crops, which, till then, were looking so well. We had heavy rain from Thursday afternoon, and on Sunday morning there was a strong fresh in the river, which was still rising. In the afternoon of that day persons living within flood reach began to show some anxiety, owing to the continued downpour of rain. In the meantime the goods in the A.S.N. Co's store had been removed from the ground to the first floor, and were then considered safe.

Through the courtesy of Mr. Johnson, a telegram was sent to the office in West Maitland, inquiring as to the state of the river there; and the reply was to the effect that it was up 25 feet, and rising.

We had then but little doubt what to expect here. Mr. Dwyer, miller, then began to move a quantity of maize, &c., which he had in the mill, upstairs, and otherwise did all in his power to secure it from damage. He also moved most of his furniture, &c., which was stored upstairs in the New Company's store, where were also put 131 bags of maize, which had been left there for shipment.

On Monday morning a real flood presented itself. The water was in the lower part of the A.S.N. Co.'s store, and also in the mill and other buildings near the river, and rising at the rate of four feet an hour. It was then found necessary to move the goods still higher in the A.S.N. Co.'s store, and willing hands soon set to work. Flour, sugar, cases of goods, &c, &c., were first put aloft, which occupied, at the most, about 45 minutes, and then the water was on the floor to the depth of two feet, completely destroying 146 bags salt, and four bales hay.

A telegram from Dungog intimated an unprecedented flood there, so that it continued to rise in Clarence Town all day. By mid-day the torrent of water was making a straight course across the beautiful farm belonging to the Rev. Mr. Donald, destroying a splendid crop of maize, some oaten and lucerne hay, which was pressed, and stored in a shed used for that purpose, and which ultimately was knocked down by the strength of the current.

At Mr. Robards' Commercial Hotel, the water reached the roof of the verandah, but previously the furniture, &c., had been removed. At its highest the flood was some three feet higher than that of '57.

It is almost needless to state that *all* the farms on the Williams have suffered—most of the maize crops being completely destroyed.

This is indeed a great calamity to the unfortunate farmers, who have had to toil hard, and then see the fruits of their labour swept away, while they were powerless to prevent or save.

Mr. Dwyer had 229 bags of maize destroyed (that which had been put upstairs included). It was owned by Messrs. Wade, Walker, G. Otto, and Dwyer.

Much sympathy is felt for Mr. Dwyer, who had recently taken the mill on his own account, and had only commenced work after extensive repairs to the boiler and machinery. Although precaution was taken to pump the boiler full of water, it has been lifted right up out of the mass of brickwork into which it was built. The feed and steam pipes are broken, and much damage done to the machinery in the mill.

The loss at the H.R.N.S.N. Company's store consists of 131 bags maize, and 2 casks of tallow, which floated out into the current, the store door having been unhinged by the action of the water. Some bales of hay were likewise destroyed. All these goods, with the exception of the tallow, were upon the rafters.

In the A.S.N. Company's store, as before stated, 146 bags salt and 4 bales hay were lost.

Mr. Stonach, we understand, has lost some 17 bales oaten and lucerne hay.

On Monday night the water began to fall, and by Tuesday night had receded some 10 or 12 feet, after which time it fell more slowly. The river is now nearly down to its usual level. Through the flood-week we were entirely cut off from any communication with the outer world, the wire being down near the Paterson, and no mails till Saturday. You may imagine how eagerly we will read the news of the great flood of 1875.

Clarence Town, March 8th, 1875.

The Sydney Morning Herald (NSW : 1842 - 1954), Wednesday 17 April 1867, page 2

FLOOD IN THE WILLIAMS, AT CLARENCE TOWN.

I have to report that we are once more visited by a most disastrous flood. It has been a continuous rain here since Monday morning up to 11 o'clock last night, and the water now exceeds that of any other flood since that of '57; and although the rain has ceased, the river is rising at the rate of one foot per hour. At present it is not possible to estimate the amount of damage done to the maize crops; they are nearly all submerged, and in many instances it is feared that the roots of the plants and the soil round them are completely washed away. The quantity of pumpkins floating past is incredible: small stacks of hay, and other farm produce, may be seen floating past with rapid impetuosity.

Clarence Town, Friday morning.

The Great Flood in the Hunter.

A Devastated Territory.

ALTHOUGH the waters are slowly receding from the vicinity of Maitland and Morpeth, their disappearance adds to the depression caused by the flood, by reason of the revelations consequent on the removal of the watery covering. For the present many must adapt themselves to new and comfortless conditions. And in the future, when they can return to the old conditions, they must toil with a sense of loss, must begin again the task of saving and the arrangement of comfortable homes and pleasant domestic surroundings. It is very hard: it will be very hard. Of course some can bear loss better than others. But the destruction has been so general: there has been such havoc played among every description of the wealth of the community that for a long time to come economy will be enforced upon all sorts and conditions of men. The toil of retrieving their position will be great. From one aspect such folk can, however, discover a ray of light even amid the gloom of their lot. Their lives and those of their families are spared; the ability to work remains to them; but as the blow is, it is not so crushing as to put a long stop to the regular activities of the community, and that implies employment which will make daily bread sure; and there will be much repairing work to be done. Every member of the community has suffered, or will suffer, actual money loss. But the persons entitled to public help at present are clearly only those who have just now no present means of getting bread to eat and clothes to cover them, and, who when they are able to return to their homes will be in destitution. The less public charity is burdened by folk who are not fairly entitled to it, the more of its comfort will be available for those whose title is unmistakable. These words of caution are not superfluous. Those who have had experience in the past of the management of flood relief funds, know well that many persons who can dispense with aid are shameless enough to claim it if they are not sternly checked. We repeat that what relief committees are called on to do now is to ensure the supply of daily wants to a large family of refugees; by and by will properly come consideration of how and to whom a wider help may be extended.

Naturally the occurrence of such an inundation awakens once more the controversy about flood prevention. That controversy is largely profitless, and the opinions we have so far seen expressed are such as to make one long for an effective gag. However, it may be taken for granted that nothing will be attempted on the great scale, unless upon knowledge much more precise and authoritative than that of Cabinet Ministers who have merely glanced at the problem to be solved. Those who saw the mighty volume of water accumulated in the neighbourhood of Maitland and Morpeth on Friday and Saturday last may be permitted to doubt whether any ingenuity of man, any engineering work within his competence—and this altogether apart from the question of cost—would suffice to mitigate the destructive force of these visitations. Man does not attempt to control the earthquake or to rule the sea in its wrath. The hurricane and the cataract must have their way, unchecked by him. To such exhibitions of Nature's potency must this great flood be likened, we fear. However that may be, Mr. Lyne is very poorly informed when he talks about the feasibility of erecting the administrative machinery for the work of mitigation, by virtue of the provisions of this poor little bill to amend the Public Works Act. This scheme, and everything that respects mitigation, is, however, matter for future thought and arrangement.

With reference to the embankments at Maitland, the opinion is expressed that they stood remarkably well the pressure brought against them. In no place so far was any of the fascine work visible, showing that it was holding well. The embankments at Cummins', though comparatively a new one, stood until the water was a foot over the top of them, when it gave way. The embankment is from 800 to 1000 feet long, and when it was swept away there must have been 11 feet of water pouring across there.

The water had made a very large encroachment into the town between Cohen-street and Parnell's house, a distance of over 200yds., and nearly 100yds. in.

The river embankment from the Belmore Bridge to Gilligan's Port Maitland Inn in the Horseshoe Bend has remained intact, and save that the face of the stone escarpment is washed clean of all debris, it shows little signs of the severe wash of the river.

Following are additional notes about the flood. Enquiries of the business people in High-street reveal the fact that there has been an immense loss of stock. In most cases provision had been made for an ordinary flood, but the present one coming several feet over the record and toppling over the goods, as well as covering those not removed, caused the damage. In addition to the loss of stock, nearly every one suffers through damage to, or destruction of, furniture. Among the heaviest losers were David Cohen and Co's., where the water reached 5ft. 6in. on most of the ground floors; the damage being estimated at £10,000. Next door, Mr. Lipscombe, druggist and stationer, lost £1500 worth of stock. The well-known solicitor Mr. W. H. Mullen, is a heavy loser; also Mr. Solling, the solicitor. Stock valued at £2000 was destroyed at Benjamin and Son's store. At Savidge and Little's drapery shop (late Beckman's) the water was 7ft. 6in., and damaged £5000 worth. Rigney, the saddler, estimates his loss at £300; and Filmer, the seedsman, at £900. The loss at Sheather's Royal hotel (late Hodgson's) is put down at £900. 7ft. 6in. of water covered Dimmock's printing plant and paper, doing damage to the amount of £1500. W. H. Smith, the jeweller, lost heavily; also G. Moore, the confectioner. £400; F. Marsh, painter, £700; Mrs. M'Laughlan, bakery, £200; M. Moss, photographer etc., £200; W. T. Poulton, draper, £2500; Lane Brothers, drapers etc., £500; Norman and Sons, £300; J. E. Lee, grocer, £900; and W. Baker, boot merchant, between £700 and £800. Nearly every business place suffered; but those named are the heaviest losers.

The flood got into the machine and engine rooms of the *Mercury*, and it rose so rapidly that the proprietary were unable to get out Saturday's paper. The inundation injured some of the machinery and destroyed documents and papers. At M'Neall's coach factory just below the railway crossing the water was very high and caused great destruction. At the High-street railway crossing the water was some 3ft. 5in. in the station house and residence. The School of Arts suffered considerably in the damage to books, about 1000 volumes were wetted. At the Dominican Convent great damage was caused. Some 14 pianos and a harmonium have been rendered perfectly useless, and it is estimated that it will take £1000 or £1200 to render things the same as before. Outside the town proper the destruction of property was fearful, whilst the losses amongst stock

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