BANANA SHIRE FLOOD STUDY STAGE 2

Floodplain Management Plan

Prepared for:

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Limitations Statement

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Revision History

Revision	Date	Comment	Signatures			
			Originated by	Checked by	Technical Approval	Project Approval
A	30/11/2016	Issued for Client review	A. Chapman	H. Betts	A. Chapman	A. Chapman
B	25/01/2017	Reissued for comment	A. Chapman	J. Arunakumaren	A. Chapman	A. Chapman

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List of abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
AHD	Australian height datum
ALARP	As Low As Reasonably Possible
AR&R	Australian Rainfall and Runoff
ARI	Annual Recurrence Interval
BCP	Business Continuity Plans
BCR	Benefit-cost ratio
BOM	Bureau of Meteorology
BSC	Banana Shire Council
DEM	Digital Elevation Model
DEWS	Department of Energy and Water Supply
DFE	Defined Flood Event
DTMR	Department Transport and Main Roads
EA	Engineers Australia
IGEM	Inspector General Emergency Management
KBR	Kellogg Brown & Root Pty Ltd
km	kilometre
km^2	square kilometre
LDMG	Local Disaster Management Group
LiDAR	Light Detection and Ranging
LECC	Local Emergency Coordination Committees
m	metre
mAHD	metres in Australia Height Datum
m^3/s	cubic metres per second
mm	millimetres
PMF	Probable Maximum Flood
QRA	Queensland Reconstruction Authority
SRTM	Shuttle Radar Topography Mission

Executive summary

Over the past six years Banana Shire has suffered some of its worst flooding on record with many homes and businesses flooded, people displaced and agriculture devastated. Flooding has caused great distress and long-lasting impacts leaving some residents living in fear of a repeat event. Global warming could make heavy summer downpours more likely by the end of the century. But the changing climate isn't the only concern. The way we transform the environment and develop the floodplain can leave us more exposed to flood risk.

With these concerns in mind the Banana Shire Council (BSC) commissioned Kellogg Brown & Root (KBR) to undertake a series of flood studies, develop coherent flood mitigation strategies and develop a Floodplain Management Plan which is outlined in this document.

A number of deliverables and services have been produced as part of this flood study. This includes collection, compilation and review of a large assortment of data that was input to hydrologic and hydraulic studies. A range of hydrology and hydraulic models were developed and calibrated to historic flood information and used to estimate Design Flood conditions. Multiple structural mitigations measures were investigated and tested in the hydraulic models. The flood benefits of these were compared against conceptual cost estimates as part of the Benefit-Cost assessment. Several reports have been prepared to deliver each stage of the project and a large quantity of GIS mapping has been used to show various outputs of the study.

Throughout the Study key stakeholders and the community were provided with information pertinent to their area and given opportunity to comment on the Study. Two community drop-in sessions were conducted first in December 2015 and second in July 2016. Drop-in sessions were held at a number of towns throughout the Shire. Community feedback was promoted and encouraged through multiple communication channels. Additional materials prepared including project fact sheets, posters, letters to residents and stakeholders, website and media content.

The existing flood risk of each town assessed as part of this study is summarised in the following table. Annual Average Damage (AAD) is an estimate of the cost of flooding to a community over a number of years, averaged out as a cost per year. This is based on current damage analysis methods which include tangible costs such as property and building damage (direct damages) and interruptions such as loss of business (indirect damages). For Theodore, flooding from both the Dawson River and Castle Creek has been considered. The impacted properties and damages have been provided for both flooding sources in Table S1.

Table S1 Flood Risk for the DFE (1% AEP flood event with climate change)

Town	Residential buildings	Commercial buildings	AAD ($'000)	Critical Infrastructure below the recommended standard
Taroom	12	23	$230	Taroom Roadhouse (Commercial, DFE*)
Theodore	245	109	$1,380 DR	Hospital and Ambulance (Health, 0.2% AEP) Council of the Ageing (Aged Care, 0.2% AEP) Other critical infrastructure is marginal.
	31	29	$340 CC	
Moura	11	17	$110	
Baralaba	2	7	$130	
Biloela	219	16	$790	Council Shire Chambers (Emergency Mgmt, 0.2% AEP) Wahroonga Retirement Village (Aged Care, 0.2% AEP)
Thangool	16	5	$100	Thangool Primary School (Schools, 0.5% AEP)
Jambin	18	6	$180	Jambin Hall (Evacuation centres, 0.5% AEP)
Goovigen	5	0	$13	
Dululu	12	6	$63	Dululu Community Hall (Evacuation centres, 0.5% AEP)
Wowan	2	16	$42	Wowan State School (Schools, 0.5% AEP). Wowan Caravan Park.

* *Refers to the recommended flood immunity standard for different critical infrastructure classifications*

Structural flood mitigation measures change the way water flows by delaying runoff from entering streams, creating barriers to flood flows (levees) and upgrading floodplain egress routes, channelization and accelerating flows or modifications to existing buildings & sometimes voluntary resumption. Structural measures are usually undertaken when the residual risk is excessive. It is noted that a feasibility study undertaken separately by the Department of Energy and Water Supply investigated the flood mitigation benefits of dams in the Callide Valley.

A summary of the structural mitigation options is presented in Table S2 which shows the benefits and impacts of each. This includes levees and access upgrades, house lifting and voluntary resumption. A limited amount of time has been spent developing, testing, refining and costing each structural mitigation option. If an option is preferred by Council it is recommended that refinements to the alignment and function are investigated to reduce costs.

The benefit cost analysis (BCA) ratios depicted are based on preliminary cost estimates. The ratios exclude intangible benefits and evacuation benefits afforded by the mitigation schemes. It would not be unreasonable to increase the BCA ratios by a factor of 2 (or more).

Table S2 Summary of structural mitigation options

ID	Town	Location	Benefits	Impacts	Conceptual Cost ($M)	BCA
TAR-02	Taroom	House lifting	Most vulnerable properties protected	–	1.0	0.2
THE-01	Theodore	Gibbs Road & Levee	For those behind levee, plus enhanced evacuation for the town	Moderate	25	0.1
THE-Comb	Theodore	Town levee and house lifting (2% AEP event)	Houses protected up to the 2% AEP event	Moderate	16	0.3
THE-05	Theodore	House lifting (2% AEP event)	Houses protected up to the 2% AEP event	–	5.7	0.4
MOU-01	Moura	River Road Levee	For those behind levee	Minor	7.1	0
MOU-02	Moura	House lifting	Most vulnerable properties protected	–	0.9	0.1
BIL-Comb	Biloela	Baileys Lane, Tognolini Baldwin Road, Hills Ave	For those behind the levees	Moderate	40	0.1
BIL-04	Biloela	Raise Muirs Road	Extended evacuation	–	2.5	-
BIL-08	Biloela	Remove vulnerable homes at the end of Muirs Road	Reduced risk to life	–	1.2	0.1
THA-Comb	Thangool	School and town levee	School and town protected	Minor	6.8	0.1
THA-03	Thangool	House lifting	Most vulnerable properties protected	–	0.2	0.1
THA-04	Thangool	Relocate school	Removed from flood risk	–		
JAM-Comb	Jambin	Hotel levee and house lifting	Most vulnerable properties protected	–	2.3	0.3
DUL-01	Dululu	Town levee	For those behind levee	Minor	4.8	0.1
DUL-02	Dululu	House lifting	Most vulnerable properties protected	–	0.8	0.3
WOW-Comb	Wowan	School, Fuel station and house lifting	Removed from flood risk and less potential for environmental impact	–	0.7	0.1

The advantage of house lifting is that it can be rolled out progressively to suit council budgets, starting with the most vulnerable properties. Relocating the Thangool Primary School may be considered by the Department of Housing and Public Works. Buyback and removal of vulnerable homes at the end of Muirs Road (Biloela) is a key option to consider as residents here are exposed to extreme flood hazard.

Non-structural flood measures aim to change people's behaviour through land use planning, development controls, emergency management and community education. Recommendations for planning and development control measures include:

- 1% AEP flood event with climate change is adopted by Council as the Defined Flood Event (DFE)

- proposed Banana Shire Planning Scheme includes a flood code that sets performance outcomes and outlines acceptable solutions
- proposed Banana Shire Planning Scheme provides guidance on the information required to be submitted with Development Applications
- adoption of 500 mm freeboard for habitable rooms above the DFE and a 300 mm allowance above the DFE where the building is non-habitable and for overland flow paths.

Many communities in Banana Shire Council are aware of the existing flood risks in their town, but new residents need to be informed as well. This can be achieved by developing community flood education plans that improve flood and evacuation awareness. The plan would outline agreed strategies for residents to follow if a serious flood should become threatening. It is important to educate the community and help them understand warning messages so that individuals can act responsibly, quickly and efficiently to minimise overall losses, particularly for flash flooding locations. It is also recommended that a flood information page is created on Council's website to provide the community with easily accessible information they might otherwise not know how to find. This includes rainfall totals and river conditions, weather forecasts, flood warnings and dam levels. For more remove localities where internet access is problematic, we recommend hard copies be provided to residents.

The community education process is reinforced by the emergency management plan. Credible and simple flood warnings and evacuation orders will improve individual judgement of risk. It is also necessary to acknowledge that communication failures can occur and to plan for them. Access to the Biloela disaster coordination centre (Council Chambers) along Valentine Plains Road has lower flood immunity than usually required for such facilities. Access may only be disrupted for a short while (2–3 hours) but access via 4WD may be required if flood depths persist.

The flood warning triggers for towns along the Dawson River have been refined using the outputs of the flood modelling. This information can be shared with BOM flood warning officers to enhance the service provided. In addition, for areas at risk of flash flooding that do not receive a flood forecast from the BOM, a series of simple rainfall lookup tables using model results could provide some advance warning. A review of the flood risk profile for each town has been undertaken based on the population at risk, evacuation routes distance and immunity, available warning time and final refuge location.

Series of actions recommended for the Banana Shire Council area and individual townships is provided in this report with suggested timings and priority. Council may collate this into a database of actions, adding additional fields to reflect cost, responsibility, planned commencement date, etc. Sourcing funds is a key element to the success of implementing any structural measures and Council will need to develop business cases to support further investigation of preferred measures. Some of the schemes available include the Natural Disaster

Relief and Recovery Arrangements (NDRRA), Community Resilience Fund (CRF), and the Natural Disaster Resilience Program (NDRP).

It is recommended the Floodplain Management Plan is made available to the community to enhance public knowledge and provide opportunity for comment.

1 Introduction

1.1 PURPOSE

Significant flooding events in recent years have resulted in the Banana Shire Council (BSC) to upgrade its Disaster Management Plan and seek to strengthen the plan by improving flood knowledge. Accordingly BSC commissioned Kellogg Brown & Root (KBR) to undertake a series of flood studies, develop coherent flood mitigation strategies and develop a Floodplain Management Plan.

This report includes the Floodplain Management Plan (FPMP), which recommends and prioritises a series of actions to reduce the adverse impacts of flooding and to extend flood warning and evacuation time.

For the purposes of floodplain management in the Banana Shire Council (BSC) area the Plan recommends a range of land use planning, development control, community awareness, community consultation, disaster planning and preparation activities, liaison with other levels and agencies of government, and a series of structural measures intended to change the way flood water behaves.

While this report provides recommended actions and timelines, the assignment of priorities and detailed sequencing and timing of structural measures requires input and review by BSC and will depend largely on the availability of funds and other Council resources.

As part of this study, a risk management approach has been adopted to quantify the risk to towns and justify the undertaking of structural mitigation measures. The non-structural mitigation measures are prioritised based on other criteria and with consideration to legislative requirements and recommendations of the Queensland Floods Commission of Inquiry (Qld, 2012).

The objectives of this final report are to identify the preferred floodplain management measures and to develop an implementation program for these activities.

The Plan builds upon the detailed understanding of flooding in the BSC area, including the potential impacts of future climate change, and possible strategies developed so far for reducing the impact of flooding for existing and future development. The project will assist in building community resilience to flooding, and development of guidelines that will provide certainty for future land development and economic growth.

Section 2 of this report briefly summarises the previous work undertaken as part of this project. Section 3 outlines the method used to define flood risk that allows the township risk to be ranked. A general summary of the specific township risks are presented in Section 4. Section 5 presents a method for risk and disaster management, which leads to Section 6 and the development of a series of FPMPs for the general

BSC area and the individual towns. The conclusions and recommendations are presented in Section 7. Finally, a reference list can be found in Section 8.

It should be noted that arriving at a final accepted Plan is an iterative process and will require input from BSC at a technical and operational works level, from councillors and political advisors, from key stakeholders, and importantly from the communities within the BSC area.

1.2 SCOPE OF THE PLAN

This FPMP seeks to identify a number of further actions that the BSC can take to improve the flood resilience in its area of governance. These actions have been developed through consultation with BSC and are informed by the earlier work and reports outlined in Section 1.4.

The scope of the FPMP includes recommendations for:

- the publication of flood risk information to ensure the community is aware of the flood risk it faces
- undertaking awareness and education programs so that members of the various communities within BSC area are able to undertake self-protection measures and respond in the event of a damaging flood, and contribute to and participate in the advancement of flood management measures
- improving the awareness to flooding of recently arrived or transient residents including tourists
- ensuring the proposed Banana Shire Planning Scheme incorporates planning and zoning provisions that seek to protect existing and future residents and are acceptable to the Queensland Government and the community
- development control measures to be incorporated into the proposed Banana Shire Planning Scheme so that future development does not compromise and seeks to improve existing and future flood risk
- the provision of sufficient flood warning information and aids to understand the nature, magnitude and speed on an impending flood
- the protection and enhancement of flood evacuation time
- ensuring flood warnings can be formulated and disseminated effectively to the community
- investigate the extent of levees on the floodplain, the potential impact to flooding these may cause and commence governance of levee proposals
- the facilitation of voluntary house purchase or voluntary house raising programs in flood affected areas
- the development of business continuity plans for the BSC organisation and encouragement of government and commercial, industrial, mining and agricultural organisations and agencies to undertake similar plans
- review the flood risk of critical infrastructure including the Biloela emergency management centre

- prioritisation and construction of structural mitigation measures that will protect evacuation routes, reduce the risks to life, injury and property and avoid social trauma
- establishment of protocols for sharing information between BSC, mining companies, businesses, government departments and agencies so that those sectors share available flood knowledge that can be incorporated into disaster management plans.

1.3 SUMMARY OF COMMUNITY CONSULTATION

To be completed once timeframe for consultation on the Draft FPMP is defined by BSC.

1.3.1 Community consultation on the draft Floodplain Management Plan (FPMP)

BSC consulted with the community on the draft FPMP between XXX and XXX 2016. At this time, the community and stakeholders were invited to comment on the draft plan by:

- accessing Council's 'Banana Shire Flood Study' webpage where the following was made available
  - draft FPMP report
  - flood study frequently asked questions
  - fact sheets for all towns
  - animations depicting hydraulic models of town and regional areas during a defined flood event
- visiting a Council customer service office or library
- writing or phoning Council.

1.3.2 Community feedback received on the draft FPMP

BSC designed and distributed a community feedback form. The comments received through these feedback forms were summarised by BSC (Appendix D) and provided to KBR. The KBR technical team, together with BSC, has considered each comment in the finalisation of the FPMP and listed their responses.

1.4 BACKGROUND

The majority of the BSC Local Government Area is within the Dawson River catchment. There are several towns within the Shire that lie on the banks of the Dawson River and its tributaries. These include the main centres of Biloela and Moura and other smaller towns, many of which are exposed to some degree of flood risk. A locality map is presented in Figure 1.1.

The total catchment area of the Dawson River is approximately 50,000 km² meaning that widespread rainfall depressions can cause major flooding in the region. This was reflected in the December 2010/January 2011 event, which impacted Taroom, Theodore, Moura and Baralaba along the Dawson River. Flash flooding also occurs in

the smaller, steeper tributaries on the eastern side of the Dawson catchment, closer to the coastline. These catchments can experience severe storms with intense rainfall, which occurred in January 2013 and February 2015. The towns of Thangool, Biloela, Jambin and Goovigen were affected by these events and rapidly rising water in the Dee River caused damage in Dululu and Wowan.

During major flood events like those described above, communities can become isolated due to flooding and/or road damage. This impacts normal supply routes and limits access to essential services for residents and communities within the Shire. Crops, livestock and fencing can be destroyed and people displaced. Potable water, power and sanitation can also be affected, which occurred in Theodore in the wake of the January 2011 flood.

Despite the damage and disruption caused by these historic flood events, they provide a major opportunity to collect new information that can be used for hydrologic and hydraulic model calibration.

Towards the end of 2013, BSC advertised a new tender to conduct this study, which comprised a Flood Study and the development of a Floodplain Management Plan. This was awarded to KBR in June 2014. However due to funding arrangements the project did not begin until March 2015. Acceptance of the final version of this report by BSC will mark completion of the project (likely to occur before the end of 2016).

The Inspector-General Emergency Management (IGEM) submitted a report to the Queensland Government reviewing the circumstances of the 2015 TC Marcia flood event. As part of the work completed to address Recommendation No. 1 from the IGEM review, the Department of Energy and Water Supply (DEWS) is undertaking the Callide Valley Flood Mitigation Study (CVFMS). The purpose of the CVFMS is to determine whether or not it is feasible to operate Callide Dam as a flood mitigation dam, including alternative means of effecting improved community outcomes. KBR was engaged to provide preliminary mitigation outcomes for the CVFMS. BSC and DEWS have agreed to share data and model outputs to provide continuity and to make available the best set of modelling tools and information for both studies.

1.5 PROJECT DELIVERABLES

A number of deliverables have already been produced as part of this flood study. A summary of the various papers and reports is outlined below. The relationship between these reports is depicted in Figure 1.2.

1.5.1 Reports

- Flood Study Report – Hydrologic and Hydraulic Calibration and Design Flood Estimation including depth/level and velocity maps for historic and design events at each town (167 maps)
- Structural Mitigation Measures – including flood damages, option performance and benefit cost analysis with afflux and velocity change impact maps for each option (111 maps)
- Non-Structural mitigation measures – including land use planning, development control and emergency management

- Evacuation Capability Assessment – including Flood Risk and Hazard mapping with evacuation routes and critical infrastructure (71 maps)
- Floodplain Management Plan (this document).

1.5.2 Models

Three hydrological models were developed that extend across the entire BSC area. The hydrological models were developed to derive hydrological flow estimates, based on rainfall data, which were used as boundary conditions for a number of township hydraulic models. The models were developed for the:

- Dawson River catchment
- Dee and Don River catchments including the Callide Valley.

Township hydraulic models were developed for the following towns with flood animations created for selected events:

- Thangool, Biloela, Jambin and Goovigen (combined model)
- Wowan and Dululu (combined model)
- Taroom
- Theodore
- Moura
- Baralaba.

1.5.3 Community consultation

Throughout the Study key stakeholders and the community were provided with information pertinent to their area and given opportunity to comment on the Study. Two community drop-in sessions were conducted first in December 2015 and second in July 2016. Drop-in sessions were held at a number of towns throughout the Shire. Community feedback was promoted and encouraged through multiple communication channels. Additional materials prepared including project fact sheets, posters, letters to residents and stakeholders, website and media content.

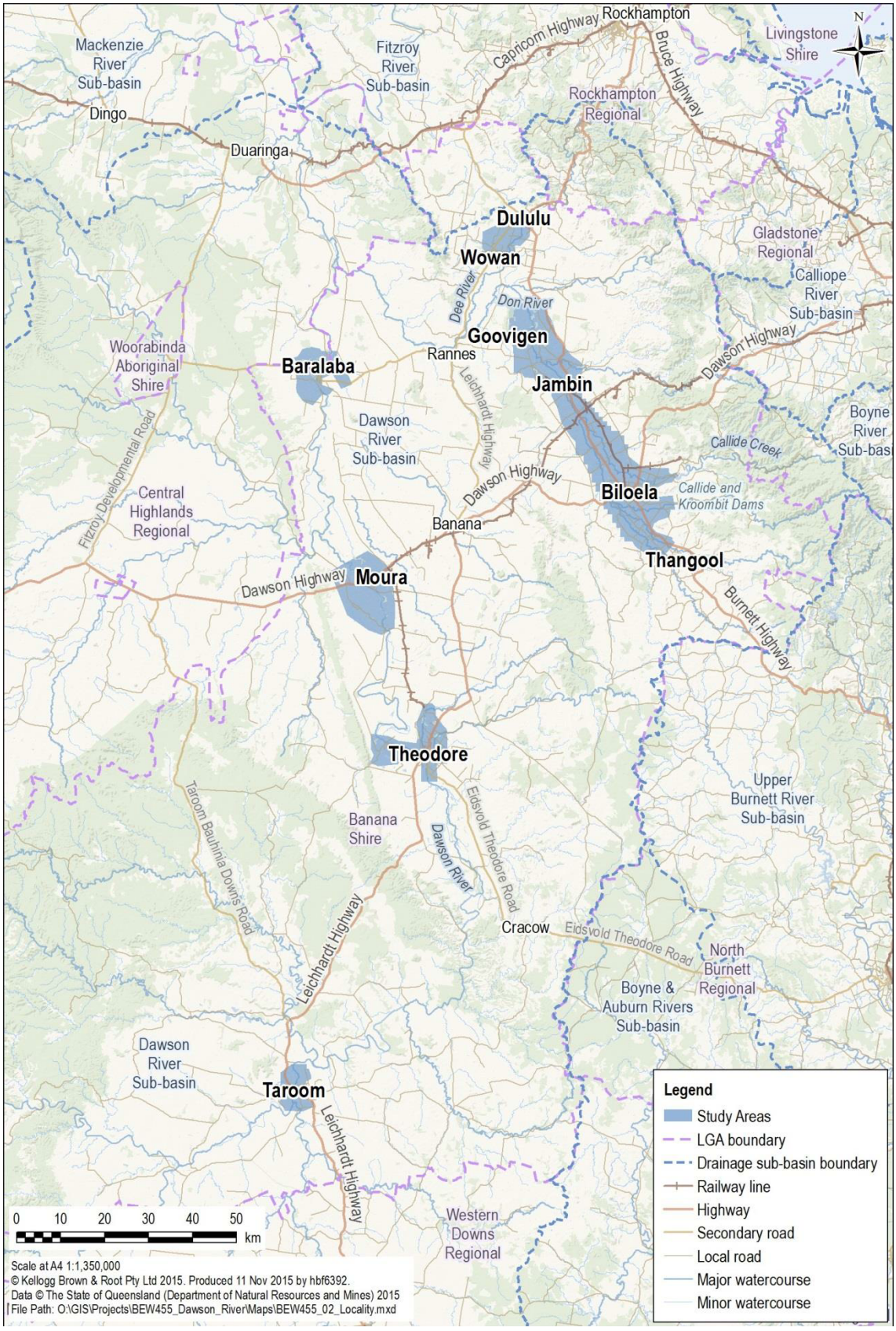

Figure 1.1
LOCALITY MAP

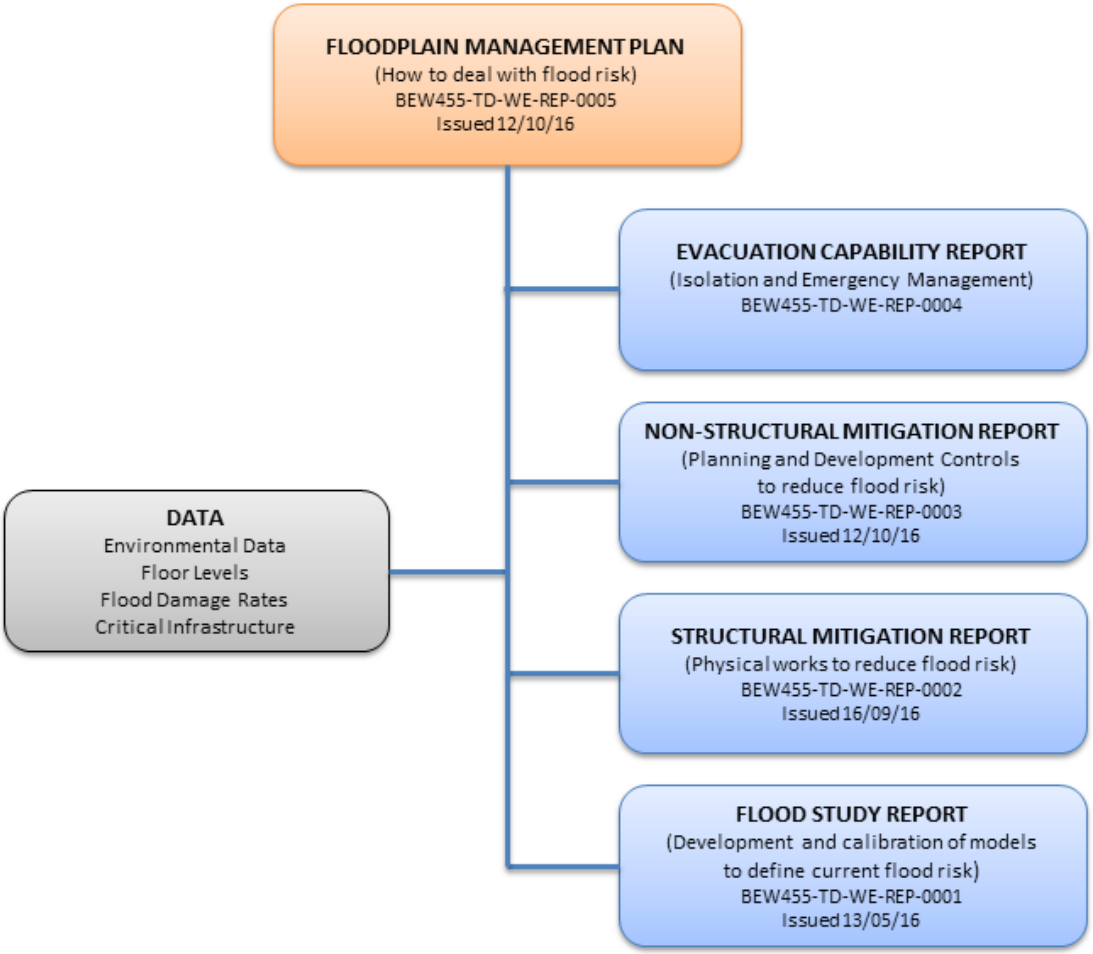

Figure 1.2
DOCUMENT HIERARCHY

2 Summary of previous work

2.1 DATA COLLECTION

A considerable amount of data was collected, compiled and reviewed to achieve the objectives of this flood study. The data collected included:

- topographic data (LiDAR) provided by the Queensland Government as part of the Inland Towns LiDAR capture project
- aerial photos taken the morning after Cyclone Marcia provided by BSC
- hydrologic data (rainfall, stream flow and reservoirs) collected by KBR
- historic flood height information (flood extent mapping) collected by KBR with a debris survey of the Callide Valley undertaken by BSC
- details of culverts, bridges and other relevant infrastructure from BSC, Department of Transport and Main Roads and Aurizon
- council documents including the planning scheme, Local Disaster Management Group operational plans and disaster management plan
- previous reports and models in the study area.

2.2 HYDROLOGIC MODELLING

Hydrologic modelling was undertaken for the entire BSC area and was ultimately used to derive river flow estimates, which were incorporated into the hydraulic models. The models were developed for the:

- Dawson River catchment
- Dee River and Don River catchments including the Callide Valley.

Calibration was undertaken for each of these models using the streamflow data provided by the Department of Natural Resources and Mines (DNRM) and water storage discharge data provided by SunWater. Detailed information with respect to the calibration procedure can be found within the hydrologic calibration report (KBR, 2016a).

The transition from the calibration hydrological models to the design models was based upon standard practice and was used to derive design hydrological flow estimates for various Annual Exceedance Probability (AEP) events, which were developed for input into the township hydraulic models.

The scope of work as part of the hydrological study is outlined below:

- Dawson River catchment calibration to the 2010 and 2013 flood events

- Don-Dee Rivers catchment calibration to the 2015, 2013 and 2010 flood events
- design flow estimation for the 10%, 5%, 2%, 1%, 0.2%, 0.05% AEPs and the Probable Maximum Precipitation (PMP) event
- the DFE recommended by KBR for adoption by BSC is the 1% AEP flood with an allowance for the adverse impacts of climate change as represented by an increase in design rainfall intensities of 20% (being a 5% per degree Celsius rise in mean global temperature of 4°C to the year 2100). This is in accordance with the Inland Rivers Study (Qld, 2010) recommendations of the Qld Chief Scientist and is the position adopted by Central highlands Regional Council.

2.3 HYDRAULIC MODELLING

This flood study involved the development and calibration of six hydraulic models encompassing ten towns in the BSC area. The models were developed to represent present day (i.e. existing) conditions to estimate design flood levels and velocities for a range of design AEP events. The hydraulic models were then used as a tool to better inform emergency planning, establishing evacuation routes and to test the benefit of flood mitigation solutions.

Two dimensional hydraulic models were developed for the following towns within BSC:

- Callide Valley (includes Biloela, Thangool, Jambin and Goovigen)
- Taroom
- Theodore
- Moura
- Baralaba
- Wowan (includes Dululu).

Calibration data was available for all hydraulic models, with the most rigorous calibration undertaken for the Callide Valley model and Theodore model. This was due to the severity of recent floods and quality of calibration data available.

The hydraulic models were used to prepare flood maps and for analysis to inform opportunities to improve community flood resilience through non-structural and structural mitigation options. The flood mapping is provided within a separate report (KBR, 2016a).

2.4 FLOOD HAZARD MAPPING

As part of this project's flood modelling outcomes, a series of Flood Hazard maps have been prepared. The hazard mapping can support constraint mapping for strategic planning in floodplain areas for land use planning purposes.

The degree of flood hazard at each town investigated in this flood study varies depending on the source of flooding (river or creek) and its connection to the floodplain. The primary criteria is safety and so we recommend that development should be designed and constructed so that users are not exposed to a greater degree of hazard than the method defined in a Guideline that accompanies the Australian

Emergency Management Handbook 7 (COA, 2013) to quantify flood hazard. This method was adopted by the Queensland Government (Qld, 2016).

Flood hazard maps for each town have been prepared using the flood model outputs and vulnerability classifications identified above. These maps include critical infrastructure such as hospitals, schools, airports, power stations and rail. The maps are presented in the Non-Structural mitigation measures report (KBR, 2016c).

2.5 FLOOD DAMAGE ASSESSMENTS

Flood damage assessments were undertaken to provide an appreciation of the magnitude of the damage that occurred during flood events and also the possible flood damage that might occur under each design flood. These estimates included residential, commercial and industrial damages but excluded damage to infrastructure and agriculture, forestry and mining as there was insufficient data to justify their inclusion.

Cost estimation associated with indirect and intangible effects of the flood events is difficult to determine, but general allowances for these provide an upper estimate of the financial impact on the community.

Damage estimates were used in the development of benefit/cost analyses of structural mitigation measures.

Flood damages to residential and commercial/industrial land parcels were assessed by taking into account:

- property information (property area (i.e. size), type and use of the building)
- floor level data (actual survey, or estimated by other means)
- flood level data for a range of flood events (using the hydraulic models prepared in this study)
- various stage-damage curves (depending on building type, use and area), which were based on information provided by Geoscience Australia and through application of standard methods.

Property information, combined with floor and flood levels were analysed using Geographical Information System (GIS) techniques with stage-damage curves applied to each property and building. With respect to building damage this was to:

- determine if overfloor flooding is expected for each building
- calculate the depth of overfloor flooding
- calculate associated flood damage.

This process was repeated for each design event. The sum of the individual property damage was then aggregated to give the total damage for each flood probability. This allowed for the calculation of Average Annual Damage (AAD) costs expressed in dollars per year.

This represents the level of investment that could be provided for flood mitigation each year. It should be noted that the AAD presented does not include damage

associated with infrastructure or agriculture. Furthermore, intangible damage is excluded from the calculation of AAD.

Table 2.1 presents the count of buildings located within the floodplain based on the results of the flood damage estimate which used surveyed and estimated floor level data.

Table 2.1 Number of buildings in the floodplain for each design event

Town	5% AEP	1% AEP	0.2% AEP
Theodore	28	289	357
Biloela	10	145	261
Jambin	5	21	29
Moura	0	18	–
Taroom	3	12	–
Wowan	0	12	23
Thangool	2	11	22
Dululu	0	11	21
Baralaba	4	8	–
Goovigen	0	4	6

2.6 FLOOD MITIGATION INVESTIGATIONS

2.6.1 Structural mitigation assessment

The focus of the Structural Measures report (KBR, 2016b) is to provide BSC with details of potential structural mitigation strategies that are intended to reduce residual risk, to improve safety and minimise damage by reducing peak flood levels and depths, improving warning times and reducing flow velocities within the BSC area.

Structural flood mitigation measures are generally directed to changing the way water flows through a catchment, as distinct from non-structural measures that are generally directed to changing people's behaviour. Structural measures include delaying runoff from entering major streams, providing barriers to flood flows, channelisation and accelerating flows from the catchment.

Structural flood mitigation was investigated for all towns included in the flood study. The structural measures consisted of a series of levees (typically up to approximately 1.5 m in height), low concrete walls, raising road pavements, minor drainage improvements and house relocation/raising.

The first stage of investigation for structural measures is to assess the likelihood of achieving positive results without adversely impacting adjacent properties or land use such as agriculture. The next stage is to undertake preliminary sizing and cost estimates for the mitigation elements. Flood damage assessments are finally required to assess the benefit/cost assessment for each structural mitigation measure.

The towns mostly likely to benefit from structural mitigation were considered to be Biloela, Jambin, Dululu, Taroom, Theodore and Moura. Optimisation and further public consultation is required.

The structural measures investigation strategy follows the risk identification and treatment process. This involves identifying the risk and then treating or eliminating the risk such that risk-impacts are reduced or that the vulnerability or exposure to the community is lessened.

Table 2.2 presents a high level summary of the benefit-cost analysis for all towns with structural flood mitigation options/combinations. The benefit-cost ratio (BCR) for all structural mitigation options is less than 1.0 and therefore cannot be justified on economic grounds alone. It should be noted that structural flood mitigation options rarely have a positive BCR and a ratio substantially less than 1.0 could still be viable because there has been no account of intangible benefits.

The highest BCR is 0.4 for Theodore (THE-05) and there are a few options with a BCR of 0.3. The remaining options have a BCR less than or equal to 0.2 due to a high construction cost estimate or less flood benefits than envisaged. However, if the intangible benefits are included, then some options may be considered viable.

The BCR ratios depicted are based on preliminary cost estimates. The ratios exclude intangible benefits and evacuation benefits afforded by the mitigation schemes. It would not be unreasonable to increase the BCR ratios by a factor of 2 (or more).

The structural flood mitigation options presented are those considered by KBR and Council that could be delivered within a reasonable time period. Options that would require major expenditure or measures such as dams are not tabled. The development of flood mitigation options with low BCR might be taken as opportunities arise, for instance, development of a levee when spoil becomes available.

Table 2.2 Summary of benefit-cost analysis for all structural mitigation options

Mitigation Option Name	Description of Option	Mitigated Flood Event	Number of buildings saved in the Defined Flood Event (DFE)		AAD savings	Cost Estimate (+/-40%)	Benefit-Cost Analysis	Comments
			Residential	Commercial	($'000)	($'000)		
BIL-Combined1	Local levees around Biloela to protect residential buildings	DFE	111	0	233.5	39,516	0.1	The levees protect a large number of buildings; however the estimated cost is high.
BIL-08	Voluntary House Purchase and House Raising for vulnerable homes on Muirs Rd	DFE	5	0	7.7	1,190	0.1	There are some properties at the end of Muirs Road that are in a very high risk zone. The benefit-cost analysis is low but it is recommended this option is further investigated.
THA-Combined1	Local levees to protect Thangool residential properties and the Primary School	DFE	2	1	29.5	6,849	0.1	Whilst there are some protected buildings and properties, the benefits are insufficient for the cost.
THA-03	Raise flood affected homes	DFE	2	0	0.8	160	0.1	Based on the available information, there are only two properties below the DFE in Thangool. While the benefit-cost analysis is similar to THA-Combined 1, this option could still be implemented in stages.
JAM-Combined1	Jambin Hotel levee and lifting flood affected homes	DFE	11	1	47.1	3,066	0.3	This option protects a number of buildings. The benefit cost analysis is higher than most other options.
THE-01	Evacuation along Gibbs Road with local levee to protect residential and commercial buildings around the engineering works and timber mill	DFE	8	12	177.4	25,254	0.1	This option protects a number of buildings. The estimated cost is very high because it includes upgrading Gibbs Road to become the evacuation route for Theodore. Also the levee around the engineering works and timber mill makes allowance for intermittent traffic. Further refinement is recommended to reduce the construction cost.
THE-02	Castle Creek Levee at 142 mAHD	2% AEP Dawson River	0	0	54.1	25,560	0	This option attempts to restrict flow from Castle Creek entering town. There is a minor benefit to water levels in town in the DFE

Mitigation Option Name	Description of Option	Mitigated Flood Event	Number of buildings saved in the Defined Flood Event (DFE)		AAD savings	Cost Estimate (+/-40%)	Benefit-Cost Analysis	Comments
			Residential	Commercial	($'000)	($'000)		
THE-Combined1	Town Levee and lifting flood affected homes	2% AEP Dawson River	0	0	186.8	16,460	0.3	This option seeks to protect the town up to the 2% AEP event from Dawson River and Castle Creek flooding. There is a negligible difference to water levels in town during the DFE.
THE-05	Raise flood affected homes	2% AEP Dawson River	0	0	125.8	5,680	0.4	This option involves raising homes assumed to be lower than the 2% AEP flood (71 in total). The benefit cost is better than most other options and house lifting can be implemented in stages.
DUL-01	Local levee to protect residential buildings	DFE	9	2	35.9	4,846	0.1	This levee needs to be up to 2.0m high so the cost estimate is high compared to the number of buildings saved.
DUL-02	Raise flood affected homes	DFE	10	0	13.4	800	0.3	Based on the available information a number of buildings in Dululu are below the DFE and could be lifted. This option could still be implemented in stages.
WOW-Combined1	Local levees around the school and fuel station plus lifting flood affected homes	DFE	1	3	6.3	736	0.1	Building small levees for the school and fuel station is not cost effective. Based on the available information there are limited residential buildings at risk from the Dee River DFE. It is recommended that flooding from Pocket Creek is investigated as this may cause greater impacts.
TAR-01	Local levee to protect residential buildings	DFE	12	5	37.5	9,136	0.1	This levee needs to be very high (up to 4.5m) and would be impractical for access to the roadhouse.
TAR-02	Raise flood affected homes and relocate roadhouse	DFE	12	0	9.4	960	0.2	Based on available information a number of properties below the DFE in Taroom could be raised. The benefit cost analysis is slightly better than TAR-01 and this option could still be implemented in stages.

Mitigation Option Name	Description of Option	Mitigated Flood Event	Number of buildings saved in the Defined Flood Event (DFE)		AAD savings	Cost Estimate (+/-40%)	Benefit-Cost Analysis	Comments
			Residential	Commercial	($'000)	($'000)		
MOU-01	Local levee to protect residential buildings	DFE	7	6	5.7	8,123	0	This levee is not very high (up to 1.0 m) but is very long to protect the rural residential properties along River Road and Salesyard Road. The benefit cost analysis of this option will improve as more properties are at risk that has been assumed.
MOU-02	Raise flood affected homes	DFE	11	0	6.7	880	0.1	This option provides the greatest benefit to Moura.

2.6.2 Non-structural mitigation

Non-structural mitigation measures available to BSC and their communities include:

- risk transfer processes through flood insurance and transfer of property to others by sale or lease
- seeking behavioural changes via community education, and involvement
- enhance emergency management, warning and evacuation procedures
- governance through land use planning, development control and legislation to regulate development and land use in potentially hazardous areas.

Affected communities within the BSC area need to be made aware that flood protection is necessary and of the types of structural measures available. This information should be taken to the community along with the background information for them to be aware of the future flood risk.

Where structural measures are recommended, only non-structural mitigation measures will be available until the structural works are developed. The community needs to be made aware of the possible need to evacuate, the scale of the evacuation, and what individual families need to accomplish to become safe in an impending flood.

The communities also need to be aware of what resources will be available for them so they can plan accordingly. Community education and awareness programs will be an essential part of this process and need to be conducted prior to each flood season.

2.7 EXISTING FLOOD RISK

The majority of Biloela is located outside of the floodplain during large events. However due to its location between two major creeks it can become isolated as roads become flooded. There are some residential areas that are directly impacted by flooding and how they are to be addressed needs to be considered.

Flooding in Thangool is caused by breakout flow from Kariboe Creek that occurs approximately 1 km upstream of town. The breakout flow arriving at Thangool and the main channel are disconnected by the perched channel banks at Thangool.

In Jambin, the Hotel and surrounding properties are located on slightly higher terrain than the general floodplain. However this area is between the Callide Creek main channel and an eastern secondary channel that overtops local roads and can cut access. During large events the area becomes completely inundated. At Goovigen, large flood events in Callide Valley mostly cut access to the town.

Out of bank flows from Bell Creek travel via a breakout channel upstream of the confluence with Callide Creek, bypassing the stream gauge at Goovigen.

Taroom is located adjacent to the Dawson River at a significantly higher elevation, with most of the town approximately 10 m above the floodplain. During large events, a few properties on the western side of town are vulnerable to flooding and access can be cut for several days.

Theodore is vulnerable to flooding in large events as high flows struggle to pass through a natural constriction, causing upstream areas to act as a flood basin. As flow

increases, water levels upstream rise, which floods farmland and eventually properties in the main town. Access to the town can be cut for several days.

Moura is not vulnerable to flooding from the Dawson River. It is located approximately 7 km from the main channel and 30 m above the floodplain. However, a group of rural residential properties adjacent to the Dawson River are at risk during large flood events.

The majority of Baralaba is located above the floodplain and is not directly impacted by floodwater. Access west across the floodplain can be cut for several days during large flood events.

The Dee River at Dululu is characterised by a 13 m deep main channel that spills onto a 1.7 km wide floodplain. A small gully runs through Dululu itself, conveying overflow from the Dee River to the downstream floodplain.

The majority of Wowan is located outside of the Dee River's floodplain and is not vulnerable to regional flooding in most storm events. However local flooding from Pocket Creek should be investigated further as this may present a more significant flood risk to the town.

3 Township prioritisation and risk assessment

Through the risk assessment process, outlined in Appendix B, a risk rating has been assigned to each town to prioritise risk treatments. Assessments of townships are supported by a risk matrix that conforms to the National Risk Assessment Guidelines (CoA 2010) and the Risk Management Standard ISO 31000; and tables that form the Floodplain Management Plan. These tables nominate treatment actions for each risk. These are determined using likelihood and consequence criteria to calculate a risk rating, which can be revaluated to define the residual risk, after the identification of control or mitigation measures.

3.1 LIKELIHOOD

Likelihood of occurrence is based on a short term (five year) timeframe.

Current risk assessments have been undertaken in the context of the 1% AEP flood occurring within the next five years. The future/potential risk assessments at the end of the five year period assume that the structural and non-structural measures set out as actions in the respective floodplain management plans have been completed.

For the purposes of the analysis, it is assumed that mitigation measures constructed in the next five years will have no progressive effect but will be fully effective thereafter. This quantification is based on the likelihood of occurrence as illustrated in Table 3.1.

The recommended Defined Flood Event (equivalent to the 1% AEP flood magnitude in the year 2100) is in the likelihood range of 'Possible'. The 2010/11 flood in the Dawson River and the 2015 flood in the Dee-Don Rivers system are also in the likelihood range of 'Possible'.

Table 3.1 Flood likelihood

Likelihood level	Frequency	Average Recurrence Interval	Chance of occurrence in any 5 year period
Almost certain	Once or more per year	<3 years	100%
Likely	Once per 10 years	3 – 30 years	41%
Possible	Once per 100 years	31 – 300 years	4.9%
Unlikely	Once per 1,000 years	301 – 3,000 years	0.5%
Rare	Once per 10,000 years	3,001 – 30,000 years	0.05%
Very rare	Once per 100,000 years	30,001 – 300,000 years	0.005%
Almost incredible	Less than once per million years	300,000 years	0.0005%

The likelihood has been assigned based on a single event for all of the towns; e.g. a 1% AEP event equates to a likelihood of occurrence of 4.9% in the next five years.

3.2 CONSEQUENCE

The consequence levels and elements provided in Appendix Table B2 are simplified to reflect the following considerations.

People

In recent major floods in the Dawson River sub-basin include the 2010/11, January 2013 and February 2015 flood events. As far as KBR can determine there were no fatalities in the BSC area associated with any of these floods. As there were cases of displacement, the impact rating is assigned 'Moderate' for Theodore, Biloela, Jambin and Taroom and 'Minor' for the other towns. This element can be interpreted as the AAD costs expressed in dollars per year.

Environment

This is assessed as 'Minor'.

Economy

The economic losses across the whole of the BSC area were substantial, particularly for the agribusiness sector in 2015 and infrastructure damage. The overall economic loss to the BSC area is assessed as 'Moderate'.

Public administration

Under the descriptors provided in Appendix Table B2, a consequence rating of 'Moderate' is assessed.

Social setting

This is assessed as 'Moderate' given the ongoing impacts of insurance company decisions and community frustration.

Infrastructure

The impact is assessed as 'Minor' given that there were isolated infrastructure failures of short to mid-term duration only.

These six elements have to be applied across the major towns within the BSC area and for the purposes of this analysis have been distilled into two measures.

For simplicity, the consequences of flooding are based upon the number of buildings likely to be inundated by floodwater and also the critical duration of flooding in the town, which is used in this analysis as an indicator of likely flood warning time.

The two aspects of flood consequence used in this assessment are outlined in Table 3.2.

Table 3.2 Aspects of flood consequence

Consequence rating	1	2	3	4	5
AAD costs ($'000 per year)	≤ 100	101–200	201–500	501–1,000	> 1,000
Critical duration (hours)	≥ 48	47–24	23–12	11–6	< 6

The flooding of 50 dwellings (buildings) in a smaller town has a proportionally greater community impact than the flooding of 50 buildings in a larger town. Although the direct economic consequences may be similar, the social setting and local administrative impacts may be more severe. Conversely, the available warning time is more critical for larger towns where proportionally, more people may need to be evacuated.

A consequence has been assigned for both aspects and totalled with a maximum of 5. A weighting has been adopted, which favours the number of buildings affected (90%). A weighting of only 10% has been assigned to the critical duration. This is intended to minimise the assignment of consequence in towns where limited property flooding is expected. It has not been totally excluded, because flood warning time available is a critical factor and the approach adopted allows this to be considered in a way that identifies the most vulnerable towns. The overall categories of flood consequence are outlined in Table 3.3.

Table 3.3 Flood consequence categorisation

Insignificant	Minor	Moderate	Major	Catastrophic
<0.7	0.8–1.5	1.6–3.0	3.1–4.5	> 4.5

These weightings and categorisations are somewhat arbitrary and sensitivity tests were undertaken. It was found that if the categorisations were changed the rankings for some towns would change, but the categorisation presented in Table 3.3 was adopted for the weighted results.

Based upon the methodology outlined above and using data extracted from the hydrological and hydraulic modelling study, a flood consequence category has been assigned for each town as outlined in Table 3.4. This is based on the DFE event. Even if no buildings are flooded in a town, a score of one was assigned to cover the social, environment, economic, administrative and infrastructure aspects.

The flood warning time at Theodore, Goovigen and Wowan was reduced given the potential susceptibility of a local storm event occurring in these towns at the same time as a smaller regional flood.

Table 3.4 Township flood consequence

	AAD ($/yr)	Consequence	Weighted	Critical duration	Consequence	Weighted	Total	Consequence category
Theodore^	1381	5	4.5	6.0 hrs	4	0.4	4.9	Catastrophic
Biloela	792	4	3.6	4.5 hrs	5	0.5	4.1	Major
Taroom	234	3	2.7	72 hrs	1	0.1	2.8	Moderate
Jambin	175	2	1.8	12 hrs	3	0.3	2.1	Moderate
Baralaba	134	2	1.8	72 hrs	1	0.1	1.9	Moderate
Moura	107	2	1.8	72 hrs	1	0.1	1.9	Moderate
Thangool	100	1	0.9	4.5 hrs	5	0.5	1.4	Minor
Dululu	63	1	0.9	3.0 hrs	5	0.5	1.4	Minor
Wowan^	42	1	0.9	3.0 hrs	5	0.5	1.4	Minor
Goovigen^	13	1	0.9	3.0 hrs	5	0.5	1.4	Minor

* *indicates buildings (residential, commercial and industrial) with over floor flooding*

^ *potential susceptibility of a local storm event*

3.3 TOWNSHIP RISK RATING

With the assignment of consequence and likelihood ratings, a risk rating can be determined through application of the risk matrix identified in Table 3.5, which is discussed in Appendix B.

Table 3.5 Risk rating

		Consequence level			
Likelihood level	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very rare	Low	Low	Low	Low	Medium
Almost incredible	Low	Low	Low	Low	Low

The risk identified for each town has been assigned in Table 3.6. Theodore is the most vulnerable town with twice the AAD compared to Biloela (refer to Table 3.4) and level of consequence greater than most other towns (refer to Table 3.5).

Based on the As Low As Reasonably Possible (ALARP) principle, the particular risk assigned will define the appropriate management activity. This is summarised below in Table 3.7. A 'High' risk rating event will require 'prioritised corrective action'. This may include actions such as reducing the likelihood of the event occurring by physical methods (limiting usage to within the asset's capacity (e.g. through regulation of development using the proposed Banana Shire Planning Scheme and other planning instruments; increasing monitoring and maintenance practices (e.g. emergency management); reducing consequences (e.g. preparation and prevention), preparing response plans, etc.; and/or sharing the risk with others (e.g. insuring against risk).

Table 3.6 Township risk rating

Town	Consequence	Likelihood	Risk
Theodore	Catastrophic	Possible	High
Biloela	Major	Possible	High
Taroom	Moderate	Possible	Medium
Jambin	Moderate	Possible	Medium
Baralaba	Moderate	Possible	Medium
Moura	Moderate	Possible	Medium
Thangool	Minor	Possible	Minor
Dululu	Minor	Possible	Minor
Wowan	Minor	Possible	Minor
Goovigen	Minor	Possible	Minor

Table 3.7 Management and control procedures

Extreme risk	Intolerable/immediate corrective action
High risk	Prioritised action
Medium risk	Tolerable subject to ALARP
Low risk	Broadly acceptable

The degree to which risk is accepted or tolerated is very much dependent on the frequency, magnitude and controllability of the hazards involved. It is also influenced by the length of time that has elapsed since the last significant hazard impact—the more recent the event, the lower the threshold of acceptance or tolerance.

While the risk ratings derived in Table 3.6 are subjective and arguable, they do form a basis on which other considerations can be overlayed to align the derived rating. The assessment has shown that prioritised corrective action is required for Theodore and Biloela.

Each town has its own forms of risk. A series of risk exposures are outlined in Section 4 for each town, which are informed by the specific consequence of flooding. Section 5 presents the tools available for risk and disaster management.

4 Existing flood risk by Locality

Table 4.1 presents the method defined in the Australian Emergency Management Handbook 7 to quantify flood hazard which was adopted by the Queensland Government (Qld, 2016). We recommend that development should be designed and constructed so that users are not exposed to a greater degree of hazard than shown in the table.

Table 4.1 Hazard vulnerability classifications

Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

4.1 BILOELA

Flooding at Biloela is primarily caused by the Washpool Gully breakout from Kroombit Creek, approximately 9 km east (upstream) of Biloela that runs through the town. Callide Creek can also flood a large area when the full supply level of Callide Dam is exceeded and major flows are released.

The majority of Biloela itself is located outside of the floodplain of even larger events. However, due to its location between two major creeks, it can become isolated as roads become flooded.

During the 2015 severe flood event, the Callide Dam spillway gates opened due to the flood of water from the catchment. This caused flood levels in Callide Creek near Biloela to rise and spill onto the floodplain. A short while later the Callide Creek water level was reported to have risen very rapidly due to increased releases from the dam. The timeframe in which this occurred was very short meaning some residents, like those at the end of Muirs Road, were significantly exposed to flood risk.

Biloela is not flood affected by the Washpool Gully breakout for events up to the 5% AEP flood event. During a 2% AEP flood event, breakout flows from Washpool Gully quickly impact properties along Bailey's Lane and those fronting Tognolini Baldwin Road. A larger number of properties are affected by the 1% AEP flood event; however

the majority of properties within Biloela are located above the Probable Maximum Flood (PMF) flood event.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the Banana Shire Council Chambers and Wahroonga Retirement Village.

Flood depths and velocities are such that flood affected developed areas will be subject to predominately H3 and H4 hazard vulnerability classification in the DFE event. Classification H3 is unsafe for all vehicles, children and the elderly. The H4 classification is unsafe for all people. Properties at the end of Muirs Road are exposed to classification H5 which also represents a risk of structural damage to buildings.

4.2 THANGOOL

Flooding at Thangool is primarily governed by breakout flows from Kariboe Creek.

The majority of Thangool itself is located outside of the Kariboe Creek floodplain and remains flood free for more frequent flood events. However, due to its location, it can become isolated as roads become flooded.

Properties within Thangool are not affected by flows from Kariboe Creek for flood events up to the 5% AEP. Break out flows from Kariboe Creek in a 5% AEP flood event affect the runway at Thangool Airport. During a 2% AEP flood event, some properties adjacent to Kariboe Creek are inundated, including the Primary School and the majority of Thangool Airport runway is inundated. For increasing flood events, more properties become flood affected.

During a 5% AEP flood event, the Burnett Highway (north) towards Biloela is cut. Thangool becomes completely isolated during a 2% AEP flood event as the Burnett Highway in both directions is cut by flood water. During large flood events, access to Thangool could be cut for several days.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the Thangool Primary School and the Thangool Aerodrome. Flood affected developed areas will be subject to predominately H3 hazard vulnerability classification in the DFE event. Classification H3 is unsafe for all vehicles, children and the elderly.

4.3 JAMBIN

Jambin is affected by flooding from the upstream Callide Creek and Kroombit Creek catchments. The town is situated between the Callide Creek main channel and an eastern secondary channel. During significant events, flood levels are influenced by the existing railway embankment that traverses the floodplain at Jambin and the Burnett Highway embankment.

There is a portion of Jambin that is inundated in the 10% AEP flood event and the entire town is completely inundated in a 2% AEP flood event.

The Burnett Highway (south), Jambin Dakenba Road and Biloela Duaringa Road are all cut during a 10% AEP event. Jambin becomes completely isolated during a 5% AEP flood event as the Burnett Highway in both directions is cut by flood waters. During large flood events, access to Jambin could be cut for several days.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the Jambin Hall and Jambin Hotel. Flood affected developed areas will be subject to predominately H4 and H5 hazard vulnerability classification in the DFE event. Classification H4 is unsafe for all vehicles and all people while classification H5 represents a risk of structural damage to buildings.

4.4 GOOVIGEN

Flooding at Goovigen is primarily governed by local flooding from Camp Creek. Flooding from Callide Creek has an impact on residents' ability to access areas outside of the Township.

Goovigen is flood affected by Callide Creek when floods approach a 0.05% AEP flood event. Some of the properties along Biloela Duaringa Road and Stanley Street are flood affected during a PMF event.

The main access roads from Goovigen (Biloela Duaringa Road and McCabes Road) are severed for all modelled flood events. During large flood events in Callide Creek, access to Jambin could be cut for several days.

There may be alternative access to the west of Goovigen via either prospect Creek Goovigen Road and Patersons Road. However, flood free access on Patersons Road may be compromised by local Camp Creek flooding. The Queensland Reconstruction Authority's (QRA) Goovigen Level 2 Flood Investigation (Report number 0914-01-E) shows that Patersons Road is cut during a 2% AEP local flood event from Camp Creek.

There are no key buildings or facilities susceptible to overfloor flooding in the DFE. There are no flood affected developed areas in the DFE event.

4.5 WOWAN

Wowan is situated approximately 1.5 km west from the Dee River floodplain. The Dee River floodplain conveys significant flows from the upstream river breakouts. The majority of Wowan is located outside of the Dee River floodplain and is not vulnerable to regional flooding in most storm events. Flooding in Wowan is primarily governed by local flooding from Pocket Creek (a tributary of the Dee River).

Wowan remains flood free up to the 5% AEP flood event. In the 2% AEP flood event, Pocket Creek breaks its banks and inundates properties with the township. Peak flood levels within Wowan are governed by breakout flows from Pocket Creek.

The Leichhardt Highway east is cut at Dululu in a 5% AEP flood event and to the west in a 2% AEP flood event. Westwood Wowan Road to the north of town is cut during a 1% AEP flood event.

It should be noted that flooding from Pocket Creek was not the focus of modelling in this study. The regionally focussed study indicated that flooding in Wowan begins in the 2% AEP flood event. However, this may occur for more frequent flood events focussed on the Pocket Creek catchment. It is recommended flooding from this creek is investigated in more detail.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the fuel station, Wowan State School and the Multipurpose Centre.

Flood affected developed areas are subject to predominately H1 and H2 hazard vulnerability classification in the DFE event. Classification H1 is generally safe while classification H2 is unsafe for small vehicles. The Wowan Caravan Park is vulnerable to flash flooding from Pocket Creek and subject to hazard classification H4 in a DFE event which is unsafe for all vehicles and people. BSC should consider relocating the Caravan Park as people in tents and caravans are vulnerable to flash flooding.

4.6 DULULU

Flooding in Dululu is primarily governed by breakout flows from the Dee River. A small gully runs through Dululu, conveying breakout flows through town to the downstream floodplain.

The town is flood affected in a 2% AEP flood event, which impacts the majority of the buildings in Dululu.

The Burnett Highway both south and east of Dululu is cut in a 5% AEP flood event. Access west via the Leichhardt Highway is restricted in a 2% AEP flood event.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the Dululu Community Hall. Flood affected developed areas will be subject to predominately H3 and H4 hazard vulnerability classification in the DFE event. Classification H3 is unsafe for all vehicles, children and the elderly. The H4 classification is unsafe for all people. A few homes are exposed to classification H5 which also represents a risk of structural damage to buildings.

4.7 TAROOM

Taroom is located significantly higher than the surrounding Dawson River floodplain to the west of the town. Flooding at Taroom is affected by the Leichhardt Highway crossing of the Dawson River.

A small number of properties within the lowest lying areas located on the western side of Taroom (around Lion's Park and some lower areas to the west of Dawson Street) are inundated in the 5% AEP flood event. The majority of Taroom remains flood free up to the PMF.

The Leichhardt Highway north from Taroom is significantly inundated in the 5% AEP flood event. During large flood events, access to the north would be cut for several days.

Key buildings and facilities susceptible to overfloor flooding in the DFE are the fuel station and local IGA supermarket. Flood depths around Lions Park are such that flood affected areas will be subject to predominately H3 hazard vulnerability classification in the DFE event. Classification H3 is unsafe for all vehicles, children and the elderly. The depth of floodwater increases quickly in this area and the hazard vulnerability classification is much worse (H5) a short distance from the affected homes.

4.8 THEODORE

Flooding at Theodore is primarily controlled by the Theodore Weir on the Dawson River for flood events contained within the river's banks. As floodplain flow is activated, flooding is controlled by the natural constriction point in the terrain

approximately 1.5 km downstream of the weir. Theodore is vulnerable to flooding in large events as high flows struggle to pass through the constriction point, causing upstream areas to act as a flood basin. As flow increases, water levels upstream rise, flooding farmland and eventually properties in the main town.

The lower lying areas surrounding Theodore are inundated in the 5% AEP event as well as low lying areas of the Theodore township around Eleventh Avenue. Most of Theodore, up to Third Avenue, is inundated in the 2% AEP event and by the 1% AEP event, the entire town in flooded.

During a 2% AEP flood event, there is an isolated, flood free area at the southern end of The Boulevard which has the highest elevation in the town.

Flood inundation of Eidsvold Theodore Road and the Leichhardt Highway north occurs during the 10% AEP flood event. As a result, flood free access from Theodore is only available via the Leichhardt Highway from the south for flood events up to and including the 5% AEP flood event. Theodore becomes completely isolated during a 2% AEP as the Leichhardt highway is cut off by flood water. During large flood events, access to Theodore would be cut for several days or weeks depending on damage to roads sustained by flooding.

Local flooding from Castle Creek has also been investigated. Flows are well-contained within the creek and the floodplain by raised irrigation channels and private flood protection works up to the 2% AEP flood. In terms of Castle Creek, DFE flows break across these raised embankments and inundate agricultural land and a small number of houses at the north of town. Some of the raised embankments may be susceptible to erosion and collapse during overtopping. The Leichhardt Highway is accessible up to the 5% AEP flood.

Because the town is flooded by the DFE, a number of key buildings and facilities are susceptible to overfloor flooding in the DFE:

- fuel stations on Fifth Avenue and Ninth Avenue
- Theodore Primary school
- Theodore Hospital and Ambulance
- the Police and Fire stations
- Theodore RSL Hall, Hotel and Library
- Early Learning Centre and Council of the Ageing
- supermarkets at Fifth Avenue
- the Water Treatment Plant and Sewage Treatment Plant (KBR understands that following the 2010/11 flood, modifications were made to the switchboards and other critical components of these treatment plants to provide better flood immunity).

Flood depths and velocities are such that flood affected developed areas will be subject to predominately H3 and H4 hazard vulnerability classification in the DFE event. Classification H3 is unsafe for all vehicles, children and the elderly and H4 is unsafe for all people. The northern part of town around Eleventh Avenue and Hamilton Street is subject to the H5 classification which represents a risk of structural

damage to buildings. Properties across Castle Creek near Railway Parade are also subject to the H5 classification.

4.9 MOURA

Flooding in the Dawson River at Moura is controlled by both the Moura Weir and the Dawson Highway crossing of the Dawson River. Moura is not vulnerable to flooding from the Dawson River. It is approximately 7 km from the main channel and 30 m above the floodplain.

There are a small number of rural residential properties on Saleyards and River Road to the west that are flood affected in a 1% AEP flood event. Moura remains flood free in the PMF event.

Access on the Dawson Highway to the west of Moura is cut in a 5% AEP flood event. During large flood events, access to the south would be cut for several days or weeks depending on damage to roads sustained by flooding.

There are no key buildings or facilities susceptible to overfloor flooding in the DFE. Flood affected developed areas will be subject to predominately H2 and H3 hazard vulnerability classification in the DFE event. Classification H2 is unsafe for small vehicles and H3 is unsafe for all vehicles, children and the elderly.

4.10 BARALABA

Flooding in the Dawson River at Baralaba is controlled by the Neville-Hewitt Weir located at the town and the Baralaba anabranch weir located approximately 1.7 km upstream. The anabranch directs water to the north-west around the Baralaba Mine, re-joining the main channel 5 km downstream of Neville-Hewitt Weir.

Baralaba is located adjacent to the Dawson River and sits mostly above the Dawson River floodplain. During large flood events (events rarer than the 1% AEP event), the lower part of the Baralaba State School is vulnerable to flooding.

Access from Baralaba across the Dawson River is cut even in smaller flood events including the 5% AEP event. During large flood events, access to the north would be cut for several days.

The key building and facility susceptible to overfloor flooding in the DFE is the lower part of Baralaba State School. The school buildings do not appear to be impacted. There are no flood affected developed areas in the DFE event.

5 Risk and disaster management

This section reviews the planning requirements of risk and disaster management applicable to the BSC area. These assessments are founded on the hydrologic and hydraulic models developed are part of the project and need to be maintained and updated on a regular basis.

Regarding risk and disaster management, Sections 3 and 4 of this report look at the existing risks to towns in the BSC area; defining a methodology specific to the situation, identifying risk profiles and providing priority categorisation for each town. Where a risk is identified, or a town is considered to be at risk of flooding (particularly if that risk is assessed as 'High' or 'Extreme') action must be taken to mitigate that risk. These recommended actions are defined in the FPMP (Section 6 of this report).

However, while control measures or risk mitigation measures can be implemented and actions taken to reduce the level of risk faced by a community (both structural and non-structural), there will always be a residual risk. There is always a chance that the level of protection offered will be insufficient to protect against a given event. Or that the proposed protection measures while designed appropriately may not be effectively implemented by the time the design event occurs. As such, contingency plans must be in place. This report recommends the use of the PPRRRR model (*'Prevention, Preparedness, Response, Relief, Recovery and Resilience'*) to define a suit of management tools to help treat residual risk and develop appropriate plans.

Documents, plans and preparatory measures which result from the PPRRRR model, have and should be included in the FPMP.

5.1 PPRRRR MODEL

Risk management and counter disaster planning have numerous overlapping aspects, which sometimes are expressed as part of a PPRRRR model. Key components of this model are described as follows.

Prevention includes: risk management through risk identification, analysis, evaluation, treatment, acceptance, mitigation, transfer, monitoring and communication

Preparedness involves: emergency management planning within an organisation's sphere of influence incorporating links to area Disaster Management Plans and engaging with the communities

Response considers: monitoring threats and initiating response with enactment of the Disaster Management Plan and review and modification of emergency risk management plans

Relief is: a control mechanism to avoid people over stressing themselves during an emergency. It also includes external support for essentials (food, water, shelter)

Recovery means: returning to near as normal, or a new normal, following a disaster as quickly as possible

Resilience relies on: building additional capacity into the community, infrastructure and social and management fabric as part of the recovery process

The tools available as a part of the PPRRRR model can include:

- Flood Risk Management Plan

  That seeks to identify, classify and analyse all risks to determine those which are unacceptable risks and then identify appropriate risk mitigation (treatment) measures.

- Disaster Management Plan

  Which is a contingency plan to deal with the residual risks and sets out planned responses to an incident that require resources beyond the ability of the work groups or a local authority to provide. It must include response actions and communication protocols and can include detailed descriptions of the hazards faced, emergency resource plans, logistical information, evacuation plans and hospitality plans.

  The current disaster management paradigm generally confines its scope to the PPRR (Planning, Prevention, Response and Recovery) activities and betterment of assets is considered an add-on and is constrained by the current federal-state-local government disaster recovery funding model.

- Standard Operating Procedures (SOP)

  For work areas and hazardous work, which include immediate advice, should an incident occur and reference the appropriate section of the Emergency Management Plan.

- Business Continuity Plans (BCP)

  Focussed on the duration of an emergency, a BCP is a logistic plan of how an organisation will continue to provide its essential services during an emergency and restore interrupted, or maintain, critical functions within a predetermined time following the onset of an emergency. The process can reduce operational risk by improving controls, information security and provide synergies with risk management practices.

- Business Recovery Plans (BRP)

  As an extension to a BCP, a BRP seeks to re-establish normal operations as quickly as possible. Whilst a BCP is essentially a logistic planning exercise, a BRP includes sections on financial recovery, data recovery, human and physical resource recovery, and for local authorities, recovery planning for their communities.

In development of the documents relating to the PPRRRR process, the local authority should have an emergency planning framework that links to, and is mutually supportive of its strategic, corporate, financial, asset and business plans.

5.2 LOCAL GOVERNMENT'S ROLE

With respect to all emergencies, wherever possible Council should:

- assist with facilities and services for the health and welfare of the local community, including critical infrastructure
- assist the welfare and well-being of individuals and groups
- where practicable take measures to protect the area from natural and other hazards and to mitigate the effect of such hazards
- deal with the environment in an ecologically sustainable way and improve amenities
- support organisations that benefit people in the area
- encourage businesses and residents to prepare business continuity and business recovery plans
- participate with other levels of Government in achieving their objectives
- co-ordinate with the planning and delivery of services by other levels of Government to facilitate sustainable development and protection of the environment.

Disaster resilience has become foremost in disaster management thinking with mitigation being a consequence of the identification of hazard typologies, their probability, impact, and ultimately where effort should be directed to reducing the threats to the community. Response and recovery strategies will still be required as not all incidents or disasters can be averted.

5.3 FLOODPLAIN MANAGEMENT PLANS

As per Section 6 of this report, a series of FPMPs have been developed for the BSC area as a whole and for the various towns within the Council area. This is the initial plan and over time as new and better data becomes available that will improve the accuracy of the Floodplain Management Study (FPMS), it will be necessary to update the various FPMPs.

Hydrologic and hydraulic models should be updated whenever it becomes possible to improve model calibration, update flood frequency analyses or when physical damages occur in a flood plain or river system. A new flood provides additional calibration data and physical changes are made to floodplains and the way water is conveyed. The FPMS and FPMP should be reviewed at least every three years, or more regularly if there are substantive changes to circumstances such as when recommended actions have been undertaken that include building relocation or the creation of major infrastructure.

For each non-acceptable risk the plans identify the:

- existing risk rating
- existing treatment actions
- treatment actions proposed

- residual risk rating once the risk treatment options have been undertaken.

It should be noted that overall assessments of existing and residual risks are subjective assessments across the range of hazards applicable to the asset. An assessment based on a slightly different methodology may see overall risk ratings remaining the same even though mitigation strategies are applied successfully. This is attributed to the broadness of the definitions of likelihood and consequence adopted.

5.4 TREATMENT PRIORITIES

In any risk mitigation process, priority should be given to reducing as many High individual risk ratings as possible. KBR has adapted the SMAUG criteria (Seriousness, Manageability, Acceptability, Urgency and Growth) in order to define priorities of the measures to be implemented. Manageability has been taken as meaning the ease by which individual risk treatments can be implemented but does not include the ease by which funding can be obtained. Acceptability is taken to reflect a community attitude to failure. The community is more likely to accept failure from a *force majeure* situation than the omission of a planned maintenance operation. Growth reflects the question: 'is the problem becoming larger over time?'

In development of the FPMPs, the priorities allocated to treatments reflect the SMAUG assessment. They ignore operational concerns as these reflect the ease or capacity of Council to implement them and these are matters for Council to budget and implement.

Many of the treatment measures have common themes with minor variations in accordance with location needs. This allows Council to establish 'higher level' thematic approaches for application at individual locations.

5.5 ADDITIONAL INFORMATION

While not referenced specifically in the risk management sections of this report, registers have been compiled to provide a more detailed picture of the flood risks that the BSC townships are exposed to. These help provide an understanding of specific infrastructure items and their susceptibility to flooding and may be beneficial to BSC in development of the plans identified as part of the PPRRRR process. A summary of the information provided is as follows.

Further information regarding evacuation capability and route analysis for high risk towns is presented in the 'Evacuation Capability Report' (KBR reference BEW455-TD-WE-REP-0004) prepared for BSC.

Key Buildings Risk Register (Appendix C)

This register incorporates all key buildings within each town and helps to identify the buildings most vulnerable to flood risk across BSC area. The historic and design flood levels presented in this table are representative of flooding for the critical infrastructure listed. This information is provided as a guide to the flood immunity of critical infrastructure.

Floor level information is not available however this could be estimated at a later stage by the addition of 0.2 m to the Digital Elevation Model (DEM) level at the approximate building centroid. Preferably floor level data for the most vulnerable

buildings is captured by a registered surveyor so that the list can be updated and the flood risk defined.

Major Road Link Immunity

The results of the hydraulic models were inspected to determine flood depths at key highway crossing locations in the BSC area leading to/from each town. The results of this assessment provide an indication of the likely scale of flood risk and relate directly to the operational issues of evacuation, resupply and rescue.

An assessment of the most vulnerable residential areas in each town has led to the development of the flood evacuation routes presented in Table 5.1. The table identifies the largest design flood event where the road remains trafficable based on the town flood model results.

Most of the evacuation routes are available up to the 5% AEP design flood event before being cut. The time available for evacuation can be calculated using the rate of rise from a trigger level or from a BOM forecast time to the level that cutes access.

The evacuation time calculations in the Operational Sub Plan assume each town is evacuated in its entirety. Using the flood modelling results, a revised set of evacuation travel times should be calculated for flood risk based on the estimated number of vulnerable people and the route distance.

A particular danger for residents along Baileys Lane is that there is a low risk of flooding from Washpool Gully up to the 2% AEP event, and then the hazard escalates quickly.

Table 5.1 Evacuation Route Assessment

Town	Locality	Evacuation Route Name	Distance (km)	Immunity
Baralaba	Agricultural	Alberta Road	6	< 5% AEP
Biloela	Baileys Lane & Hills Ave	Valentine Plains Road	8	5% AEP
Biloela	Callide	Burnett Highway	18	< 10% AEP
Biloela	Tognolini Baldwin Rd	Tognolini Baldwin Road	3.5	5% AEP
Biloela	Muirs Road	Muirs Road	10	5% AEP
Jambin	Jambin	Burnett Highway	3	5% AEP
Moura	Saleyards Road	River Road	12	5% AEP
Moura	Saleyards Road	Dawson Highway	5	5% AEP
Theodore	Town & surrounds	Eidsvold - Theodore Road to airfield	8	10% AEP
Theodore	Town & surrounds	Leichhardt Highway to Moura	60	10% AEP
Theodore	Western agricultural	Gibber Gunyah Connection Road to airfield	18.5	< 10% AEP

Table 5.2 presents the transport links connecting those towns at risk of isolation by flooding. The table identifies the main transport routes out of each town and the largest design flood event where the road remains trafficable. It should be noted that this analysis is based on the town flood model results. There may be other crossings outside the modelled areas where access may be cut before reaching the next regional town or community. Theodore and Jambin are not included in this table since the

evacuation route assessment includes the transport links that would be used for resupply.

The duration of isolation varies for each town depending on the size of the upstream catchment. For towns along the Dawson River, flood levels can be elevated for days and even weeks. These towns may require resupply by air during the period of isolation. For the towns in the Callide Valley and Dee River, the duration of flooding is much shorter, ranging from a few hours to a few days depending on the town and nature of the storm event. The duration that people are willing to shelter in place will vary depending on their circumstances.

Table 5.2 Town Isolation & Resupply Access

Town	Route	Destination	Direction	Distance (km)	Immunity
Baralaba	Balalaba Woorabina Road	Woorabinda	West	40	< 5% AEP
Baralaba	Moura Baralaba Rd	Moura	East	70	Not modelled
Biloela	Dawson highway	Gladstone	East	120	5% AEP
Biloela	Dawson highway	Banana	West	50	< 10% AEP
Biloela	Burnett Highway	Rockhampton	North	150	< 10% AEP
Biloela	Burnett Highway	Monto	South	100	~10% AEP
Dululu	Burnett Highway	Biloela	South	80	< 10% AEP
Dululu	Leighhardt Highway	Rockhampton	North	100	Not modelled
Goovigen	Jambin Goovigen Road	Biloela	South	50	< 10% AEP
Moura	Dawson highway	Rolleston	West	150	< 5% AEP
Moura	Dawson highway	Biloela	East	70	Not modelled
Taroom	Leighhardt Highway	Theodore	North	100	< 5% AEP
Taroom	Leighhardt Highway	Wandoan	South	60	Not modelled
Thangool	Burnett Highway	Biloela	North	13	~10% AEP

Review of Flood Classifications

As part of the Bureau's Flood Warning Service Program it uses a three tiered classification scheme that defines flooding as minor, moderate or major based upon the effect of flooding for some distance upstream and downstream of a station. This is defined by standard descriptions of the flood effects and an understanding of water level in the town. Accurate flood classifications form part of an effective flood forecasting and warning service.

Table 5.3 presents the available information for steam gauging stations located within some of the towns modelled for this study. The target lead warning time for each trigger height to be exceeded (CoA, 2013b) is also provided for gauges on the Dawson River. Flood warnings are issued when the trigger heights defined at forecast locations are expected to be exceeded.

The classifications can be revised based on historic data and local information, as well as flood studies. Estimates of flood levels from the flood study have been used to determine which areas are likely to be flooded from the predicted river height. The end result is a series of recommended updates to the classifications which are provided in dark red text.

These should be reviewed and endorsement by the local community and relevant stakeholders prior to passing the recommendations to the Bureau for inclusion in forecast and warning procedures. Consideration also needs to be given to the local information contained in 'Annexure C - Trigger Points' of the Banana Shire Local Disaster Management Plan – Evacuation Operational Plan.

During model calibration there was uncertainty in the gauge measurements at Moura and Baralaba which should be resolved before any recommendations are made to the Bureau. The trigger heights for flood warnings should also be reviewed in light of this.

Table 5.3 Flood classifications

Station No	35282	39315	39296	39143	539219
Station Name	Taroom TM	Theodore	Moura	Baralaba	Dululu TM
First Report		7	6	3	
Minor Flood Height	4.5	8	6	4	
	4.4	12.4	13.0	14.1	10.2
Crops Grazing	3	10	11		
Moderate Flood Height	6	11	11	7.5	
	6.4	12.9	13.3	15.3	12.5
Towns Flood Ht.	7.6	12.2			
Major Flood Height	7	12	12	9	
	7.8	13.5	13.6	15.9	12.9
Crossing Height	6.7	5.9	12.5	8.8	
	6.7	14.0	13.0	10.9	4.4
Crossing Name	Leichhardt Highway	Leichhardt Highway	Dawson Highway	Baralaba Woorabinda Road	Burnett Highway
Owner	DNRM	BOM	BOM	BOM	DNRM
Target Warning Lead Time (hrs)	12	24	24	24	
Trigger height (m)	> 6.0	> 10.0	> 10.0	> 9.0	
Feb 1954	8.2	13.6	-	15.5	
Feb/Mar 2010	7.3	13.5	12.2	12.5	
Dec 2010/Jan 2011	10.4	14.7	12.7*	15.3*	
Feb-15					13.8
5% AEP	8.4	13.5	13.2	14.9	11.4
2% AEP	9.2	14.4	13.5	15.6	13.1
DFE	10.4	15.7	13.8	16.6	14.0

** uncertainty in gauge measurements*

6 Floodplain management plan

The FPMP outlined in this report comprise a series of actions recommended for the BSC area as a whole and the individual townships within Banana Shire that require structural and non-structural mitigation measures. The lists of actions may be collated in a database and additional fields added to reflect cost, responsibility assignment, planned commencement and completion date, etc.

It is strongly recommended that these actions be dealt with as a program to be managed over the next five years or so depending on the availability of funding. Sourcing funds is a key element to the success of implementing the structural measures.

Each table has the following headings and meanings:

- Classification: which allows reference to a discussion paper or report
- Actions for the relevant area
- Priority: priority will be dependent on the individual risk ratings and SMAUG assessments
- Timing: a preferred timing is suggested but actual timings will depend on BSC resources, funding and lead times to implement the recommended actions.

SMAUG criteria: an acronym for seriousness, manageability, acceptability, urgency, growth by which priorities can be assigned for each action was applied to the tables.

Table 6.1 provides a description of the terminology used in the floodplain management tables included in this section. SMAUG assessments however have been excluded from Tables 6.2 to 6.9 for presentation purposes.

Table 6.1 Description of Floodplain Management Plan terminology

Descriptor	Seriousness	Manageability	Acceptability	Urgency	Growth
Low	Not very serious	Very easy to manage	Generally acceptable	Not urgent	Low growth
Moderate	Serious	Easy to manage	Acceptable	Average urgency	Average growth
High	Very serious	Not easy to manage	Generally not acceptable	Very urgent	High growth

The FPMPs indicate a priority and a suggested timing of actions, and relate to the implementation of treatment options and plans to mitigate residual risk. Cost and budget considerations are excluded and are for further discussion and completion by BSC.

The FPMP needs to be updated on a regular basis for which three years is considered a maximum. The plans also need to be updated whenever there is a substantial change in circumstances (e.g. whenever a particular mitigation measure has been completed (in which case a new recommended review period is set), or if the risk is reassessed for any reason such as might occur if there is a large flood and models are recalibrated).

Other circumstances that might require a review of the FPMP include changed priorities, new data or the commencement of new legislation.

The Plans also recommend extending their scope to include management of local catchment flooding. Ideas put forward during the conduct of the FPMS have been captured and encapsulated into the FPMP.

The FPMP is contingent upon the regular updating of the hydrologic and hydraulic models, which in turn will inform the need to update the FPMS. This aspect is discussed in Section 5.3 of this Report.

6.1 FLOODPLAIN MANAGEMENT PLAN – BSC AREA

The actions listed below apply to the whole of the BSC area. Specific tables are provided for the towns at risk of flooding where structural and non-structural measures are deemed to provide a measurable reduction in exposure to flood hazard and the reduction of flood risk.

While reducing the flood risk to rural areas is unlikely within floodplains, there are opportunities to improve warning systems, reduce the risk of flooding along major traffic routes, improve community resilience and assist isolated residences to lessen the impact of a flood event.

Table 6.2 Floodplain management plan – BSC area

Number	Classification	Actions for the BSC area	Priority	Timing (years)
1	Community resilience	All communities are provided with information about their flood risk, measures available that will assist them to respond in the advent of a flood emergency and actions they need to take to respond effectively and safely. This includes the reports and maps produced as part of the Banana Shire Flood Study. This includes providing communities with access to the following flood warning information pertinent to their individual situations: • links to relevant (Bureau of Meteorology) BOM weather forecasts, flood warnings and forecast water levels at gauges • links to relevant BOM flood warning gauges (rainfall and river sites) • links to SunWater website and Facebook page for dam levels, alerts, and flood warnings • Road closures. • Banana Shire Disaster Management Information Facebook Page • News websites • SES Domestic & Business Disaster Plans • Queensland Government Disasters & Alerts Some of this information is already available at the Banana Shire Council Disaster Management webpage.	High	1

Number	Classification	Actions for the BSC area	Priority	Timing (years)
2	Community engagement	Develop a community engagement plan to advise local residents of the non-structural measures that have and are being developed for each town/area.	High	2
3	Emergency management	Emergency management activities include the following strategies: • reduce the magnitude of the hazard (e.g. constructing physical barriers) • reduce the exposure to the hazard (e.g. changing land uses in susceptible areas) • reduce the impact upon those who will be exposed to the hazard, (e.g. by developing and implementing the evacuation strategy).	High	1–5
4	Emergency management	Engage the community in emergency management planning. An important part of flood management is a prepared community that can respond well to information and the directions given. This can be achieved through awareness and participation programs to ensure the community is informed and educated so they can understand warning messages and act responsibly, quickly and efficiently. This in turn will assist into minimising overall losses to achieve a reduction in the vulnerability of a flood hazard.	High	1
5	Emergency management	BOM is unable to include Jambin as a forecast location in its Service Level Specification. Consider the development of a live hydrologic modelling flood forecasting system for the Callide Valley. Current technology allows model outputs from the flood study (hydraulic modelling results, digital elevation models, property GIS datasets, and critical infrastructure GIS datasets) to provide an indication of likely flood behaviour based on forecast rainfall. A flood surface for the predicted flows can be generated rapidly to support emergency management efforts. An initial step is to use the models built for this study to generate simple rainfall lookup tables (intensity-flow-duration curves) for the Callide Valley, Dee River and Castle Creek catchments where flash flooding is a higher risk.	High	2
6	Emergency management	Constantly refine flood warning triggers as an essential part of flood readiness, which can be enhanced through engagement with BOM flood warning officers.	High	3
7	Emergency management	Undertake annual reviews of the robustness of communication systems including provision of power, communication links, potential loads and connectivity.	High	Ongoing
8	Emergency management	Consider the development of a decision support system to aid evacuation planning and execution to provide structure to consider the detail, to apply assumptions and provide a process for understanding the current threats, risk and how to manage these as quickly as possible to maximise the time available for other parts of the evacuation process.	Moderate	2
9	Land use planning	BSC adopt a DFE that includes an allowance for increasing run-off over time due to climate change.	High	< 1
10	Land use planning	That the proposed Banana Shire Planning Scheme contains provisions that control development in floodplains having regard to safety, flood hazard exposure, risk mitigation, disaster response, community infrastructure, evacuation and emergency management, chemical and biological hazard, adverse impacts and future hazard.	High	Recommended
11	Land use planning	That the proposed Banana Shire Planning Scheme contains a flood hazard overlay code with associated assessment code for the local government area.	High	Recommended
12	Land use planning	Flood hazard maps are incorporated into the proposed Banana Shire Planning Scheme map overlay series to assist application of the Building Code of Australia.	High	Recommended

Number	Classification	Actions for the BSC area	Priority	Timing (years)
13	Land use planning	The flood hazard overly code has regard to the impacts of flooding, appropriate hazard ratings, flood immunity, freeboard and safe access requirements for each land use type including provisions for essential services and critical infrastructure.	High	Recommended
14	Land use planning	The proposed Banana Shire Planning Scheme contains a Works, Services and Infrastructure Code that will ensure the ecological, drainage, structural integrity of new and existing assets.	High	Recommended
15	Land use planning	Proposed developments are assessed on potential for flood impacts including whether it will be a burden to require evacuation during a flood emergency and the proposed management planning to be implemented to reduce this impact.	Medium	Recommended
16	Land use planning	Ensure that land use planning includes provisions that prevent an intensification of development behind levees (if built) as this will increase residual risk.	High	Recommended
17	Development control measures	Include a series of development control measures/acceptance criteria for flooding when considering hydraulic reports submitted in support of development applications in the proposed Banana Shire Planning Scheme, Planning Scheme Policies or referenced as a guideline of the planning scheme.	High	Recommended
18	Development control measures	Proposed developments within the flood hazard overly must demonstrate the works will not result in: • an increase flood risk to people, property or reduce existing drainage capacity of adjacent properties. • detrimental impacts to flood evacuation efficacy as a result of the development. • an increase in emergency management burden or worsen post-flood recovery as a result of the development. • worse flooding on adjacent buildings or roads and the works do not prejudice development of any adjacent lots..	High	Recommended
19	Development control measures	Development assessment processes are applied consistently but measurement tolerances are sufficiently flexible to accommodate differing flood characteristics between urban and rural areas.	High	Recommended
20	Development control measures	Critical infrastructure and facilities defined as 'lifelines' during a flood emergency should be identified and its approach routes should wherever possible be protected from flooding. New development should be aimed: • to not increase, and preferably reduce any expectation of flood risk, flood damage and flood hazard to existing properties • to not place their occupants or users at undue risk of flood damage or hazard • to not adversely affect flooding so as to reduce the development potential of other landowners within the floodplain • to not impose any additional burden on, and if possible improve, a local authority's counter disaster response efforts during a flood emergency.	High	Recommended

Number	Classification	Actions for the BSC area	Priority	Timing (years)
21	Development control measures	Development control measures adopted assist the proposed Banana Shire Planning Scheme to ensure: • development is safely located with respect to flood hazard • extensions to new dwellings within H4 to H6 flood hazard areas are prevented • people are not put at risk from flooding • damage is minimised (avoidance preferred) • the environment is not adversely affected if development is flooded • new lots are outside the flood hazard overlay area and provided with direct and simple egress routes signed to indicate safe egress route(s) • development is to be resilient to flood events • development avoids any increase in water flow, velocity or flood level and does not increase the potential for damage • reductions in flood storage is minimised to acceptable thresholds (care needed as proposed solutions may not be hydraulically sound) • no unacceptable changes to flow paths, no acceleration or retardation of flows or reductions in flood warning times upstream or downstream of the development unless part of a flood mitigation measure • changes to waterways are avoided unless part of mitigation measures • development avoids the release of hazardous materials during a flood • buildings are fabricated from resilient building materials • manufacturing equipment is sited to enhance flood immunity • community infrastructure can function effectively during and immediately following a flood event.	High	Recommended
22	Development control	BSC prepares guidance documents for landowners on how applications for owner-developed flood mitigation projects can be developed.	Moderate	2
23	Development control	BSC prepares guidance documents for landowners on the level of information required by BSC for local flood mitigation projects in rural areas and the tests that might be required by BSC for approval. This includes regulating new levee proposals and modifications to existing levees.	Moderate	2
24	Development control	Survey the extent of private flood mitigation works that currently exist, particularly in the Callide Valley.	Moderate	5
25	Flood mitigation	BSC, through discussion with Councillors and the community, select the preferred structural and/or non-structural measures for each town outlined in the FPMP.	High	2
26	Flood mitigation	BSC submit business cases to secure funding for the further investigation of preferred structural measures (if any) to 'proof of concept' level.	High	3
27	Flood mitigation	BSC collates the actions contained in the various floodplain management plans into a database, additional fields are inserted to assign cost estimates, track costs, assign responsibilities, timing, funding and other resourcing provisions.	High	1
28	Flood mitigation	Investigate options for government assistance for house raising for residences where structurally possible in H1 to H3 flood hazard areas.	High	3

Number	Classification	Actions for the BSC area	Priority	Timing (years)
29	Flood mitigation	Investigate options for government assistance in regard to land swap for residence in H4 to H6 flood hazard areas. In rural areas owners may have sufficient land available for onsite relocation with assistance.	High	3
30	Flood mitigation	Investigation options for government assistance for land swap or raising buildings for commercial properties in H4 to H6 flood hazard areas.	High	3
31	Flood resilience	BSC undertakes a review of existing plans and procedures included in the Disaster Management Plan (such as Part IV - Capacity Building, Part V – Response Strategy, Part VI – Recovery Strategy) to provide essential services during a flood emergency and restore critical functions as quickly as possible. Consideration should be given financial recovery, data recovery, human and physical resource recovery, and for local authorities, recovery planning for their communities..	High	2
32	Stormwater Management Plans	Stormwater Management Plans are prepared for each town so that the data that quantifies local flood events can augment regional/riverine flood management information	Moderate	3
33	Transport	Develop priority list of essential stream crossings that BSC considers should be upgraded, interacting with DTMR as appropriate.	Moderate	1
34	General	The FPMP is updated regularly as more accurate data becomes available, as circumstances change and at no longer than three yearly intervals.	Low	3
35	Risk registers	Maintain and updates risk registers as recommended above	Moderate	3
36	General	The hydrologic and hydraulic models developed are part of the project and need to be maintained and updated on a regular basis	Moderate	Ongoing

6.2 FLOODPLAIN MANAGEMENT PLAN – THEODORE

Theodore has been assigned a High Risk rating and is susceptible to flooding of the Dawson River but is also likely to be affected to some extent by local flooding from Castle Creek, particularly if there is coincident flooding.

Evacuation from the town is only possible via the Leichhardt Highway (north to Moura and west to Taroom) for Dawson River events less than 5% AEP and Castle Creek events less than 10% AEP. Evacuation south to the aerodrome is only possible via the Eidsvold Theodore Road in Dawson River events less than 10% AEP.

This creates a risk at Theodore for the town to become isolated in relatively small flood events. However, there is higher ground at the southern end of town where residents can take refuge as occurred in the 2010/11 flood. For larger floods, the entire town is inundated. A decision to evacuate must be made with sufficient time to coordinate the departure before existing evacuation routes are cut in the rising stages of the flood otherwise rescue operations will be necessary.

In the BOM Service Level Specification (SLS) for Flood Forecasting and Warning Services for Queensland, the minimum lead time that will be provided before the onset of a flood is 24 hours. This is a reasonable warning time which, through coordinated emergency management, can allow residents in the affected part of town to prepare for the flood or evacuate as directed.

Building floor levels in Theodore are not available but it is presumed that the Hospital, Ambulance and aged care facilities in town don't meet recommended flood immunity standard. This is defined as the 0.2% AEP flood event for health and aged care facilities. However, there is no flood free land in town during the 0.2% AEP flood event so there would be little benefit protecting or raising these buildings. Given the long duration of flooding from the Dawson River and the warning times available, evacuation is the best option for Theodore.

As flooding is so widespread, a flood mitigation program is considered necessary and structural elements would form a major part. The structural measures outlined below are directed to the protection of evacuation routes, erection of flood levees to extend the available evacuation time and to protect properties. While flood levees have merit, it may be more economical to raise a number of dwellings that are at risk rather than to construct and subsequently maintain flood levees.

The incremental hydraulic benefit does not provide sufficient justification for any of the flood mitigation costs alone. However, this is typical for flood mitigation works.

The preferred selection of mitigation options for Theodore has yet to be determined by BSC and further investigation may be required to optimise the various components to the 'proof of concept' stage.

Table 6.3 Floodplain management plan – Theodore

Number	Classification	Additional actions for Theodore	Priority	Timing (years)
1	Evacuation planning	Currently, all possible evacuation routes to the south, west and north are flooded early in a major flood reducing evacuation time. BSC further investigates the need to upgrade or select additional evacuations routes for Theodore.	High	1
2	Evacuation planning	The number of people and their animals likely to be evacuated in a significant flood is determined and contingency plans developed for their hosting and transport beyond Theodore.	High	1
3	Evacuation planning	Review the total evacuation time required for flood affected population based on the evacuation route assessment. This will help prioritise decisions and resources based on the most vulnerable people and the safety of evacuation	High	1
4	Emergency management	Discuss the revised flood classifications at the Theodore river gauge (39315) with the community and refine flood warning triggers through engagement with BOM flood warning officers.	High	1
5	Emergency management	Investigate simple rainfall lookup tables (intensity-flow-duration curves) for the Castle Creek catchment where there is a risk of flash flooding.	Medium	2
6	Structural measures	Consider a shorter evacuation route to the Theodore airstrip via Gibbs Road. It is proposed that Gibbs Road be raised over 1.3 km to the 20% AEP Dawson River flood level. Also a connecting local levee to protect houses around the engineering works and timber mill up to the DFE. (Option THE-01)	High	2
7	Structural measures	Consider a local levee to protect residents in town up to the 2% AEP event. Also raise suitable houses outside the levee that are below the 2% AEP event. (Option THE-Combination1)	High	2
8	Structural measures	Consider house raising as a sustainable alternative to levees. Raise suitable houses in town that are below the 2% AEP event. (Option THE-05)	High	2

Number	Classification	Additional actions for Theodore	Priority	Timing (years)
9	Structural measures	Some levees may become more feasible with alignment and functional refinements to reduce construction costs. Therefore BSC should consider further investigating the optimum levee configuration, design and level of flood immunity to be provided. .	High	2
10	Community Engagement	Develop a community engagement plan that presents the most important elements of possible flood mitigation measures for Theodore. The Theodore Local Emergency Coordination Committee should be included in forming the engagement plan.	High	2
11	Community resilience	Investigate the flood immunity of the following key buildings and facilities: • Fuel stations on Fifth Avenue and Ninth Avenue • Theodore Primary school • Theodore Hospital and Ambulance • The Police and Fire stations • Theodore RSL Hall, Hotel and Library • Early Learning Centre and Council of the Ageing • Supermarkets near Fifth Avenue. KBR understands that following the 2010/11 flood, modifications were made to mechanical and electrical plant and equipment of the Water Treatment Plant and Sewage Treatment Plant to provide better flood immunity.	High	1-5

6.3 FLOODPLAIN MANAGEMENT PLAN – BILOELA

Biloela has been assigned a High Risk rating and is susceptible to flooding from Callide Creek and Kroombit Creek, which can be particularly severe if there is coincident flooding.

Warning time can be very short during intense rainfall events along the Calliope Range. For properties along Washpool gully and Browns gully this is particularly problematic where water levels can rise rapidly once Kroombit Creek breaks out of channel. Similarly, for properties at the end of Muirs Road the flood risk escalates rapidly once the creek bank is overtopped.

SunWater has released factsheets for Callide Dam and Kroombit Dam showing flood impact mapping for different outflows depicted as blue, yellow or red zones. Complementary to the notifications and warnings from BSC and the Local Disaster Management Group (LDMG), if flooding is occurring or likely near the Callide and/or Kroombit Dams, SunWater will notify registered EAP residents of the flood zone that is closest to the expected flood extent.

Biloela can be isolated for up to 24 hours when flooding occurs in both Callide Creek and Kroombit Creek, or longer depending on damage to roads sustained by flooding. Both the Dawson and Burnett Highways are overtopped in relatively frequent flood events (~10% AEP).

Much of Biloela is located on high ground that is free from flooding. As such, there is opportunity for people to retreat to refuge on higher ground above the flood and therefore the risk to life is limited. Resupply of lifelines (food, water, shelter) and medical evacuation can occur during a flood if required.

Key buildings and facilities that may be susceptible to overfloor flooding in the DFE are the Council Shire Chambers and Wahroonga Retirement Village. Floor levels for these buildings are currently not available but should be surveyed to confirm the available flood immunity.

A flood mitigation program is considered necessary and would comprise structural and non-structural elements. The structural measures outlined below are directed to the protection of evacuation routes and properties. While flood levees have merit, it may be more economical to raise a number of dwellings (where structurally possible) that are at risk rather than to construct and subsequently maintain flood levees. The non-structural measures include possible buy-back and rezoning of high risk flood areas.

The incremental hydraulic benefit does not provide sufficient justification for any of the flood mitigation costs alone. However, this is typical for flood mitigation works. The preferred selection of mitigation options for Biloela has yet to be determined by BSC and further investigation may be required to optimise the various components to the 'proof of concept' stage.

The need to enhance the flood monitoring network in the Callide Valley to allow meaningful and timely flood warnings as detailed in Recommendation 6 of the review (IGEM, 2015) has been reflected in the actions management plan for Biloela.

Table 6.4 Floodplain management plan – Biloela

Number	Classification	Additional actions for Biloela	Priority	Timing (years)
1	Emergency Evacuation	Review the total evacuation time required for flood affected population based on the evacuation route assessment. This will help prioritise decisions and resources based on the most vulnerable people and the safety of evacuation	High	1
2	Community resilience	Building floor level survey for the Council Shire Chambers and Wahroonga Retirement Village and determine the susceptibility to flooding.	High	1
3	Emergency Management	Review accessibility of the Local Disaster Coordination Centre during major flood events in Kroombit Creek. Review how and when the centre may be activated during a Kroombit Creek flood such that the Local Disaster Management Group can access the centre.	High	1
4	Non-Structural measures	Supplement the existing flood monitoring network with additional rainfall stations along the top of the Calliope Range. This provides improved storm monitoring in the upper catchments of the Don River, Bell Creek and Callide Creek.	High	3
5	Non-Structural measures	Consider upgrading the existing rainfall and steamflow stations within the Callide Valley to include ALERT communications capability.	High	3
6	Structural measures	Consider several short levees to protect vulnerable properties and evacuation routes impacted by breakout flows from Kroombit Creek up to the DFE. (Option BIL-Combination1)	High	1
7	Structural measures	Consider raising Muirs Road to extend the time available for evacuation of the residential properties. (Option BIL-04)	High	1
8	Structural measures	Consider voluntary house purchase and removal of vulnerable homes at the end of Muirs Road. (Option BIL-08)	High	1

Number	Classification	Additional actions for Biloela	Priority	Timing (years)
9	Structural measures	Some levees may become more feasible with alignment and functional refinements to reduce construction costs. Therefore BSC should consider further investigating the optimum levee configuration, design and level of flood immunity to be provided.	High	2
10	Community Engagement	Develop a community engagement plan that outlines the most important elements of possible flood mitigation measures for Biloela.	High	2

6.4 FLOODPLAIN MANAGEMENT PLAN – TAROOM

Taroom has been assigned a Medium Risk rating and is susceptible to flooding of the Dawson River. Taroom is located significantly higher than the surrounding Dawson River floodplain to the west of the town. Flooding at Taroom is affected by the Leichhardt Highway crossing of the Dawson River.

The majority of Taroom remains flood free up to the PMF. A small number of properties within the lowest lying areas located on the western side of Taroom (around Lion's Park and some lower areas to the west of Dawson Street) are inundated in the 5% AEP flood event. In large to extreme food events, a small number of these properties may need to be evacuated. Key buildings and facilities susceptible to overfloor flooding in the DFE are the fuel station and local IGA supermarket.

The Leichhardt Highway north from Taroom is significantly inundated in the 5% AEP flood event. During large flood events, access to the north would be cut for several days.

Table 6.5 Floodplain management plan – Taroom

Number	Classification	Additional actions for Taroom	Priority	Timing (years)
1	Emergency management	Discuss the revised flood classifications at the Taroom river gauge (35282) with the community and refine flood warning triggers through engagement with BOM flood warning officers.	High	1
2	Structural measures	Consider house lifting for suitable houses in town that are below the DFE. (Option TAR-02)	High	1
3	Community resilience	Investigate, and if required improve, the flood immunity and potential environmental risks of the Fuel station on Dawson Street. This could include relocation to a flood free site.	High	3

6.5 FLOODPLAIN MANAGEMENT PLAN – JAMBIN

Jambin has been assigned a Medium Risk rating and is susceptible to flooding from Callide Creek and Kroombit Creek. The available warning time is around 16-18 hours from the upstream gauges and dams. Although flooding is not particularly deep it is widespread and buildings can suffer overfloor flooding. As flooding is so widespread a structural flood mitigation program is considered necessary.

In Jambin, the Hotel and surrounding properties are located on slightly higher terrain than the general floodplain. However this area is between the Callide Creek main channel and an eastern secondary channel that overtops local roads and can cut access.

There is a portion of Jambin that is inundated in the 10% AEP flood event and the entire town is completely inundated in a 2% AEP flood event. Most properties are raised on low stumps and some have been raised higher since the past flood events. For homes with sufficient clearance sheltering in place is a reasonable option, particularly if raised above the DFE. Other residents will need to take refuge at the Jambin State School.

The Burnett Highway (south), Jambin Dakenba Road and Biloela Duaringa Road are all cut during a 10% AEP event. Jambin becomes completely isolated during a 5% AEP flood event as the Burnett Highway in both directions is cut by flood waters. During large flood events, access to Jambin could be cut for several days.

Table 6.6 Floodplain management plan – Jambin

Number	Classification	Additional actions for Jambin	Priority	Timing (years)
1	Emergency Evacuation	Review the total evacuation time required for flood affected population based on the evacuation route assessment. This will help prioritise decisions and resources based on the most vulnerable people and the safety of evacuation	High	1
2	Structural measures	Consider a small levee to protect the Jambin Hotel combined with house lifting up to the DFE. (Option JAM-Combination1)	High	1
3	Community Engagement	Develop a community engagement plan in consultation with the Local Emergency Coordination Committee that outlines the most important elements of possible flood mitigation measures for Jambin.	High	2

6.6 FLOODPLAIN MANAGEMENT PLAN – MOURA

Moura has been assigned a Medium Risk rating although the town itself is not vulnerable to flooding from the Dawson River. It is located approximately 7 km from the main channel and 30 m above the floodplain. However, a group of rural residential properties on Saleyards and River Road are flood affected in a 1% AEP flood event. Floor level survey of the residential properties is not available, but there may be opportunity to lift the most vulnerable homes. However, with the flood warning times available residents in this area may be able to raise contents off the floor to reduce damages and then evacuate early.

Access on the Dawson Highway to the west of Moura is cut in a 5% AEP flood event. During large flood events, access to the south would be cut for several days or weeks depending on damage to roads sustained by flooding.

Table 6.7 Floodplain management plan – Moura

Number	Classification	Additional actions for Moura	Priority	Timing (years)
1	Evacuation planning	The number of people and their animals likely to be evacuated in a significant flood is determined and contingency plans developed for their hosting in town.	High	1
2	Evacuation planning	Review the total evacuation time required for flood affected population based on the evacuation route assessment. This will help prioritise decisions and resources based on the most vulnerable people and the safety of evacuation	High	1

Number	Classification	Additional actions for Moura	Priority	Timing (years)
3	Emergency management	Discuss the revised flood classifications at the Moura river gauge (39296) with the community and refine flood warning triggers through engagement with BOM flood warning officers.	High	1
4	Structural measures	While flood levees have merit, BSC should consider progressively lifting vulnerable homes along River Road and Saleyards Road that are below the DFE. (Option MOU-02)	High	1

6.7 FLOODPLAIN MANAGEMENT PLAN – BARALABA

Baralaba has been assigned a Medium Risk rating and is susceptible to flooding of the Dawson River. The majority of Baralaba is located above the floodplain and is not directly impacted by floodwater. Access to the west across the floodplain can be cut for several days or weeks during large flood events.

The key building and facility susceptible to overfloor flooding in the DFE is the lower part of Baralaba State School. Floor levels are not available but the school buildings do not appear to be impacted. A few farm houses are located in the western floodplain and may need to be evacuated during large flood events. The access route back into town is along Alberta Road which has a low point that is severed by floodwaters in minor flood events.

Table 6.8 Floodplain management plan – Baralaba

Number	Classification	Additional actions for Baralaba	Priority	Timing (years)
1	Evacuation planning	Review the total evacuation time required for flood affected population based on the evacuation route assessment. This will help prioritise decisions and resources based on the most vulnerable people and the safety of evacuation	High	1
2	Emergency management	Discuss the revised flood classifications at the Baralaba river gauge (39143) with the community and refine flood warning triggers through engagement with BOM flood warning officers.	High	1

6.8 FLOODPLAIN MANAGEMENT PLAN – OTHER TOWNS

The towns of Thangool, Goovigen, Dululu and Wowan have been assigned a Minor Risk rating and floodplain management activities for other towns are generally directed to improving flood resilience.

Flooding at Thangool is primarily governed by breakout flows from Kariboe Creek. The majority of Thangool itself is located outside of the Kariboe Creek floodplain and remains flood free for more frequent flood events. However, due to its location, it can become isolated as roads become flooded. Thangool becomes completely isolated during a 2% AEP flood event as the Burnett Highway in both directions is cut by flood water. At the same time some properties adjacent to Kariboe Creek are inundated, including the Primary School and the majority of Thangool runway.

At Goovigen, large flood events in Callide Valley mostly cut access to the town and resilience programs should be directed to ensure sufficient supplies of water, food and fuel are available for the duration of a flood event or when resupply is possible.

Flooding in Dululu is primarily governed by breakout flows from the Dee River. A small gully runs through Dululu, conveying breakout flows through town to the downstream floodplain. The town is flood affected in a 2% AEP flood event, which impacts the majority of the buildings in Dululu. Floor levels are not available at the Dululu Community Hall but it is likely to have overfloor flooding in the DFE.

The majority of Wowan is located outside of the Dee River's floodplain and is not vulnerable to regional flooding in most storm events. However local flooding from Pocket Creek should be investigated further as this may present a more significant flood risk to the town.

Table 6.9 Floodplain management plan – Other towns

Number	Classification	Additional actions	Priority	Timing (years)
1	Emergency management	Discuss the revised flood classifications at the Dululu river gauge (539219) with the community and refine flood warning triggers.	High	1
2	Flood Study	Before a decision is made regarding mitigation measures for Wowan, an investigation into flooding from Pocket Creek is completed.	High	3
3	Structural measures	While flood levees have merit, BSC should consider progressively lifting vulnerable homes in Dululu and Thangool that are below the DFE allowing residents to take refuge in place. (Options DUL-02 and THA-03).	High	1
4	Structural measures	Consult with the Department of Housing and Public Works to discuss the feasibility of relocating Thangool Primary School.	Medium	1
5	Emergency management	Use the hydrology models to generate simple rainfall lookup tables (intensity-flow-duration curves) for the catchments upstream of Thangool, Dululu and Wowan where there is a risk of flash flooding.	High	2
6	Flood resilience	The Wowan Caravan Park is vulnerable to flash flooding from Pocket Creek and subject to hazard which is unsafe for all vehicles and people. Consider relocating the Caravan Park as people are vulnerable to flash flooding.	High	1

7 Conclusions and recommendations

Over the past six years Banana Shire has suffered some of its worst flooding on record with many homes and businesses flooded, people displaced and agriculture devastated. Flooding has caused great distress and long-lasting impacts leaving some residents living in fear of a repeat event. Global warming could make heavy summer downpours more likely by the end of the century. But the changing climate is not the only concern. The way we transform the environment and develop the floodplain can leave us more exposed to flood risk.

The development of this BSC Floodplain Management Plan is the culmination of a two year floodplain management study, during which the flood risk to the BSC area was analysed with particular reference to 10 major towns.

For the purposes of floodplain management in the BSC area the Plan recommends a range of land use planning, development control, community awareness, community consultation, disaster planning and preparation activities, liaison with other levels and agencies of government, and a series of structural measures intended to change the way flood water behaves.

While this report provides recommended actions and timelines, the assignment of priorities and detailed sequencing and timing of structural measures requires input and review by BSC and will depend largely on available funding and other Council resources.

The timeframes suggested in the Plans are indicative only and should be reviewed both individually and in relation to other activities. The shorter timeframes reflect either the urgent need for implementation or in some cases the fact that as individual actions which although comprehensive are on their own relatively easy to achieve.

Specific recommendations additional to those actions contained in the various Plans include:

- BSC implement of as many of the actions contained in the respective Floodplain Management Plans as possible within the timeframes nominated in the Plans.
- BSC and the Local Emergency Coordination Committees are given opportunity to comment on the Draft Plan.
- The Draft Plan is made publically available for comment and the community is consulted on the recommended actions.
- That approaches are made to source funds as soon as practicable with the final amount to be confirmed at the completion of the relevant optimisation studies.

- The list of actions recommended in the Floodplain Management Plan be collated into a database and additional fields added to reflect cost, responsibility assignment, planned commencement and completion date, etc.
- The recommended actions are dealt with as a program to be managed over the next five years, depending on the availability of funding.

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Appendix A

GLOSSARY

Appendix A

Glossary

The following terms used in the report are taken from the Australian Emergency Management Manual 3 Glossary (EMA 1998).

Acceptable risk:

That level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable.

ALARP :

An acronym concerning risk management for 'as low as reasonably practicable'.

Annual exceedance probability (AEP)

The probability of a specified magnitude of a natural event being exceeded in any year. A measure of the likelihood (expressed as a probability) of a flood reaching or exceeding a particular magnitude. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year. See also average recurrence interval.

Average annual damage (AAD)

The average damage per year that would occur in a nominated development situation from flooding over a very long period of time. AAD provides a basis for comparing the economic effectiveness of different management measures against floods of all sizes, i.e. their ability to reduce the AAD.

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, eg. floods with a discharge as great as or greater than the 20 year ARI flood event 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.

Community

A social group which has a number of things in common, such s shared experience, locality, culture, heritage, language, ethnicity, pastimes, occupation, workplace, etc.

Consequence

The outcome of an event or situation expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. The outcome of an event or situation expressed qualitatively or quantitatively. In the emergency risk management context, consequences are generally described as the effects on persons, society, the environment and the economy.

Continuing flood hazard

The hazard a community is exposed to after floodplain management measures have been put in place. For a town protected by levees, the continuing flood hazard is the consequences of the levees being overtopped. For an area without any floodplain management measures, the continuing flood hazard is simply the existence of flood liability. See also flood hazard.

Counter disaster

A term based on the letters 'CD', for civil defence, invented in Australia to describe the area now known as emergency management.

Design flood

The flood, either observed or synthetic, which is chosen as a basis for the design of a hydraulic structure. See also probable maximum flood.

Design storm

Rainstorm, either observed or synthetic, which is chosen as the basis for the design of a hydraulic structure. Rainfall amount and distribution adopted for a given drainage area, used in determining the design flood.

Disaster

A serious disruption to community life which threatens or causes death or injury in that community and/or damage to property which is beyond the day-to-day capacity of the prescribed statutory authorities and which requires special mobilisation and organisation of resources other than those normally available to those authorities.

Discharge

The rate of flow of water measured in terms of volume per unit time, e.g. cubic metres per second. Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving, e.g. metres per second.

Economic risk

That risk which, if realised, would result in dollar losses.

Effective warning time

The time available after receiving advice of an impending flood and before the floodwaters disable damage reduction activities. The effective warning time is typically used to move farm equipment, raise furniture and evacuate people.

Emergency

An event, actual or imminent, which endangers or threatens to endanger life, property or the environment, and which requires a significant and coordinated response.

Emergency management

A range of measures to manage risks to communities and the environment.

Emergency Management Australia (EMA)

The Commonwealth Government agency within the Department of Defence with the responsibility of reducing the impact of natural and man-made disasters on the Australian community.

Emergency risk management

A systematic process that produces a range of measures which contribute to the well-being of communities and the environment.

Evacuation

The planned relocation of persons from dangerous or potentially dangerous areas to safer areas and eventual return

Exceedance probability

The probability that an event of a given magnitude, or any greater magnitude, will occur. Exceedance probability relates to a given time period, commonly one year. See also annual exceedance probability.

Extreme flood

A rare and usually very severe flood, greater in magnitude than the 1% annual exceedance probability event and possibly approaching the magnitude of a probable maximum flood

Flood

The overflowing by water of the normal confines of a stream or other body of water, or the accumulation of water by drainage over areas which are not normally submerged.

Flood awareness

An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures. In communities with a high degree of flood awareness, the response to flood warnings is prompt and efficient. In communities with a low degree of flood awareness, flood warnings are liable to be ignored or misunderstood, and residents are often confused about what they should do, when to evacuate, what to take and where it should be taken.

Flood damage

The tangible and intangible costs of flooding. Tangible costs can be quantified in monetary terms, e.g. damage to goods and possessions, loss of income or services during the flood aftermath, etc. Intangible damages represent the increased levels of physical, emotional and psychological illness in flood affected people attributed to a flooding episode and are less easy to quantify in monetary terms.

Flood forecast

Prediction of the stage, discharge, beginning and duration of a flood, especially of the peak discharge at a specific point on a stream.

Flood fringe areas

The remaining area of flood prone land after floodway and flood storage areas have been defined

Flood hazard

The potential loss of life, property and services which can be directly attributed to a flood.

Floodplain

The land which may be covered by water when the river overflows its banks during floods. The extent of a floodplain will normally be greater than the area covered in a 1% flood

Floodplain management measures

The full range of techniques available to reduce flood damage and disruption, as canvassed in floodplain management studies

Flood proofing

A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.

Flood risk

The probability of losses occurring due to flooding.

Flood warning

A statement by the Bureau of Meteorology including all or part of the following items for particular catchments:

- a summary of the current meteorological situation and expected developments;
- a summary of the rainfall which has occurred or is expected;
- river heights at key locations;
- the class of flooding that is expected; and/or
- river heights.

Freeboard

A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as a height above a flood planning level and/or the adopted flood mitigation standard. Freeboard provides a factor of safety to compensate for wave action, localised hydraulic behaviour, settlement and other effects such as 'greenhouse' and climate change.

Hazard

A source of potential harm or a situation with a potential to cause loss. A potential or existing condition that may cause harm to people or damage to property or the environment

Hazard mapping

The process of establishing geographically where and to what extent particular phenomena are likely to pose a threat to people, property, infrastructure, and economic activities. Hazard mapping represents the result of hazard assessment on a map, showing the frequency/probability of occurrences of various magnitudes or durations.

Hydraulics

The study of water flow in a river and across a floodplain and the evaluation of the flow characteristics such as height and velocity. This may include assessments of the effects of obstructions such as bridges and buildings on water flow, and changes in the slope of the water surface during the flood.

Hydrograph

A graph which shows how the discharge or stage/flood level at any particular location changes with time during a flood.

Hydrology

The study of the rainfall runoff process as it relates to the development of flooding and the derivation of hydrographs at different locations in a river system for given floods.

Lifelines

The public facilities and systems that provide basic life support services such as water, energy, sanitation, communications and transportation.

Systems or networks that provide services on which the well-being of the community depends.

Likelihood

A qualitative description of probability and frequency.

Low hazard

In relation to flooding, should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty in wading to safety.

Major flooding

Flooding where appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

Minor flooding

Flooding that 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 townspeople begin to be flooded.

Moderate flooding

Flooding where low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic bridges may be covered

Non-structural flood mitigation

System for reduction of the effects of floods using non-structural means, eg. land-use planning, advance warning systems, flood insurance.

Peak discharge

The maximum discharge occurring during a flood event

Perceived risk

The level of risk that is thought to exist by an individual or group of individuals.

PMF

See probable maximum flood.

PPRR

An abbreviation for prevention, preparedness, response and recovery.

Preliminary flood warning

A warning issued by the Bureau of Meteorology when flood-producing rains are occurring or are expected over particular river catchments. The warning is normally of a general nature and is issued to the public. It includes advice on the current meteorological situation and expected developments, together with an assessment of the class of flooding that can be expected in a particular river basin.

Preparedness

Arrangements to ensure that, should an emergency occur, all those resources and services which are needed to cope with the effects can be efficiently mobilised and deployed.

– Measures to ensure that, should an emergency occur, communities, resources and services are capable of coping with the effects.

Prevention

Regulatory and physical measures to ensure that emergencies are prevented, or their effects mitigated.

Probability

The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome and 1 indicating an outcome is certain.

Probable maximum flood (PMF)

The flood resulting from the probable maximum precipitation coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions.

Public awareness

The process of informing the community as to the nature of the hazard and actions needed to save lives and property prior to and in the event of disaster

Recovery

The coordinated process of supporting emergency-affected communities in reconstruction of the physical infrastructure and restoration of emotional, social, economic and physical wellbeing

Recurrence interval

The average time interval at which events equal to or greater than a certain magnitude would recur if existing natural regimes continued without change. Recurrence interval is a function of exceedance probability.

Relief

The provision of immediate shelter, life support and human needs of persons affected by, or responding to, an emergency. It includes the establishment, management and provision of services to emergency relief centres.

Residual risk

The remaining level of risk after risk treatment measures have been taken.

Resilience

A measure of how quickly a system recovers from failures

Response

Actions taken in anticipation of, during, and immediately after an emergency to ensure that its effects are minimised, and that people affected are given immediate relief and support.

Risk

(EMA Glossary) A concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, communities and the environment.

– The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.

– A measure of harm, taking into account the consequences of an event and its likelihood. For example, it may be expressed as the likelihood of death to an exposed individual over a given period.

– Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability.

Risk

(ISO31000:2009) *the effect of uncertainty on objectives*

Risk assessment

The process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria

Risk management

The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, evaluating, treating and monitoring risk

Risk reduction

A selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence or its consequences, or both.

Risk retention

Intentionally or unintentionally retaining the responsibility for loss, or financial burden of loss within the organisation.

Risk transfer

Shifting the responsibility or burden for loss to another party through legislation, contract, insurance or other means. Risk transfer can also refer to shifting a physical risk or part thereof elsewhere.

Risk treatment

Selection and implementation of appropriate options for dealing with risk

Societal risk

The risk of a number of fatalities occurring. The societal risk concept is based on the premise that society is more concerned with incidents which kill a larger number of people than incidents which kill fewer numbers.

Standard operating procedure (SOP)

A set of directions detailing what actions could be taken, as well as how, when, by whom and why, for specific events or tasks.

Structural flood mitigation

Structural system for reduction of the effects of floods using physical solutions, including reservoirs, levees, dredging, diversions, and flood proofing.

Sustainable development

Development in the present that does not destroy the resources needed for future development.

Threat

See hazard

Tolerable risk

A risk which the exposed people are expected to bear without undue concern, once all reasonable practicable reduction measures have been adopted. ‘Tolerable’ is sometimes used interchangeably with ‘acceptable’, but its more negative connotations make it more appropriate for risks which are reluctantly accepted.

Vulnerability

The degree of susceptibility and resilience of the community and environment to hazards

Vulnerable groups

Categories of displaced persons with special needs, variously defined to include: unaccompanied minors, the elderly, the mentally and physically disabled, victims of physical abuse or violence and pregnant, lactating or single women

Appendix B

DEFINING FLOOD RISK

Appendix B

Defining Existing Flood Risk

RISK ASSESSMENT METHODOLOGY

The risk management process that has been employed to justify the recommendations of this Plan is based on the National Emergency Risk Assessment Guidelines (GoA, 2010). It allows for adjustments via constant monitoring and review. Figure B1 is a flowchart of this process.

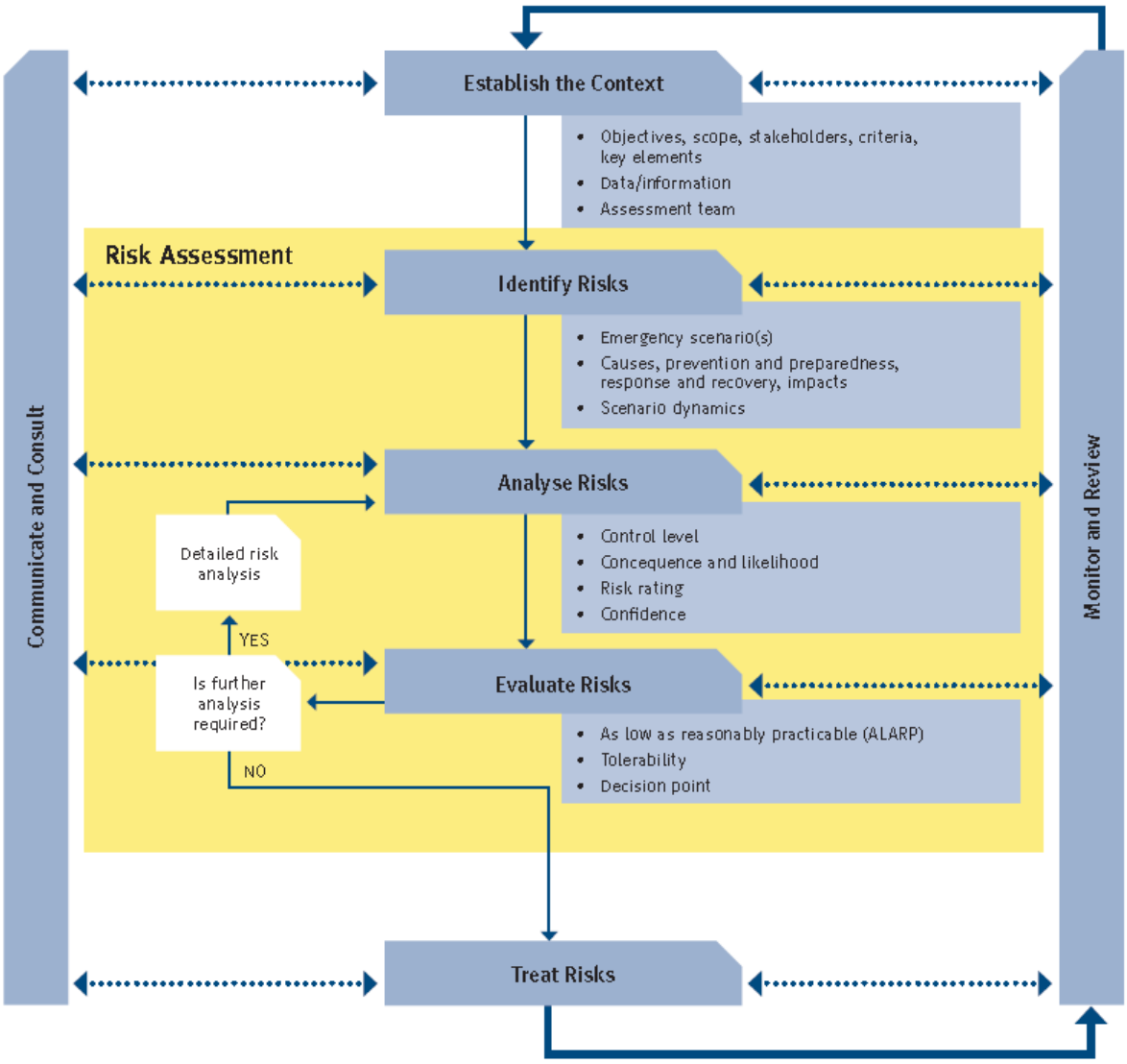

Figure B1
RISK MANAGEMENT FRAMEWORK (GoA, 2010)

The objective of the risk assessment process is to separate the minor acceptable risks from the major risks and to provide information to assist in the assessment and management of risks. Each element of risk needs to be considered and the following questions asked:

- what can happen?
- where can it happen?
- when can it happen?
- applying the potential event, why and how it can happen.

The use of the potential event is an adoption of the precautionary principle and provides conservative assessments.

The principal factors to assess credible risks are LIKELIHOOD and CONSEQUENCE. The risk assessment process compares the likelihood of a risk event occurring against the consequences of the event occurring.

Likelihood is a qualitative description of the probability of an event occurring based on estimated or calculated probability, history or experience. Where possible it is based on past records, relevant experience, industry practice, published literature or expert judgement. Consequence is a qualitative description of the effect of the event based on the interpretation of estimated or calculated impacts, history and experience. The process acts as a filter by applying a reasoned and consistent process.

The Likelihood (Table B1) and Consequence (Table B2) definitions used in the current risk assessment process are provided. These are reproduced from the National Emergency Assessment Guidelines (GoA, 2010) and generally conform to the draft Guideline for the State Planning Policy (SPPG, 2013). The recommended Defined Flood Event (equivalent to the 1% AEP flood magnitude in the year 2100) is in the likelihood range of 'Possible'. The 2010/11 flood in the Dawson River and the 2015 flood in the Dee-Don system are also in the likelihood range of 'Possible'.

Table B1 Likelihood table (reproduced from GoA, 2010)

Likelihood level	Frequency	Average Recurrence Interval	Annual Exceedance Probability
Almost certain	Once or more per year	< 3years	> 0.3
Likely	Once per 10 years	3 – 30 years	0.031 – 0.03
Possible	Once per 100 years	31 – 300 years	0.0031 – 0.03
Unlikely	Once per 1,000 years	301 – 3,000 years	0.00031 – 0.003
Rare	Once per 10,000 years	3,001 – 30,000 years	0.000031 – 0.0003
Very rare	Once per 100,000 years	30,001 – 300,000 years	0.0000031 – 0.00003
Almost incredible	Less than once per million years	300,000 years	< 0.0000031

The consequence table can be weighted to enable the categories of environment and heritage, safety and health, and operations to be ranked in accordance with BSC's perceived significance. The weighting factor allows sensitivity examinations: if for example, it is deemed that economic consequences are more detrimental to BSC business than say health and safety consequences. The factor can be selectively modified to a value between 0.0 and 1.0, with a higher value indicating greater significance. The factor is carried through the risk assessment process and will bias final risk ratings. For the purposes of this assessment, weighting has been set to 1.0 across the categories implying each is of equal significance.

Table B2 Consequence table (reproduced from GoA, 2010)

Consequence level	People	Environment	Economy	Public administration	Social setting	Infrastructure
Weight	1	1	1	1	1	1
Catastrophic	Widespread multiple loss of life (mortality > 1 in ten thousand), health system unable to cope, displacement of people beyond ability to cope	Widespread severe impairment or loss of ecosystem functions across species and landscapes, irrecoverable environmental damage	Unrecoverable financial loss > 3% of the government sector's revenues, asset destruction across industry sectors leading to widespread business failures and loss of employment	Governing body unable to manage the event, disordered public administration without effective functioning, public unrest, media coverage beyond region or jurisdiction	Community unable to support itself, widespread loss of objects of cultural significance, impacts beyond emotional and psychological capacity in all parts of the community	Long-term failure of significant infrastructure and service delivery affecting all parts of the community, ongoing external support at large scale required
Moderate	Isolated cases of loss of life (mortality > than one in one million), health system operating at maximum capacity, isolated cases of displacement of people (less than 24 hours)	Isolated but significant cases of impairment or loss of ecosystem functions, intensive efforts for recovery required	Financial loss 0.3-1% of the government sector's revenues requiring adjustments to business strategy to cover loss, disruptions to selected industry sectors leading to isolated cases of business failure and multiple loss of employment	Governing body manages the event with considerable diversion from policy, public administration functions limited by focus on critical services, widespread public protests, media coverage within region or jurisdiction	Ongoing reduced services within community, permanent damage to objects of cultural significance, impacts beyond emotional and psychological capacity in some parts of the community	Mid-term failure of (significant) infrastructure and service delivery affecting some parts of the community, widespread inconveniences
Minor	Isolated cases of serious injuries, health system operating within normal parameters	Isolated cases of environmental damage, one-off recovery efforts required	Financial loss 0.1-0.3% of the government sector's revenues requiring activation of reserves to cover loss, disruptions at business level leading to isolated cases of loss of employment	Governing body manages the event under emergency regime, public administration functions with some disturbances, isolated expressions of public concern, media coverage within region or jurisdiction	Isolated and temporary cases of reduced services within community, repairable damage to objects of cultural significance, impacts within emotional and psychological capacity of the community	Isolated cases of short- to mid-term failure of infrastructure and service delivery, localised inconveniences
Insignificant	Near misses or minor injuries, no reliance on health system	Near misses or incidents without environmental damage, no recovery efforts required	Financial loss < 0.1% of the government sector's revenues to be managed within standard financial provisions, inconsequential disruptions at business level	Governing body manages the event within normal parameters, public administration functions without disturbances, public confidence in governance, no media attention	Inconsequential short-term reduction of services, no damages to objects of cultural significance, no adverse emotional and psychological impacts	Inconsequential short-term failure of infrastructure and service delivery, no disruption to the public services

The relationship between likelihood and consequence factors determines the final risk rating, as shown by Table B3. This table is based on Table 4 (p.36) of National Risk Assessment Guidelines and is applied in Section 3 of the main report.

Table B3 Risk rating

	Consequence level				
Likelihood level	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very rare	Low	Low	Low	Low	Medium
Almost incredible	Low	Low	Low	Low	Low

Table B4 below is based on the As Low As Reasonably Possible (ALARP) principle requirement for prioritising action based on the acceptability of the risk. The risk rating is used to determine the immediacy of risk treatments. Risk treatments can range from immediate corrective action (such as stop work or prevent use of the asset) for 'Extreme' risks to manage by routine procedures for 'Low' risks. An event with a 'High Risk' rating will require 'Prioritised action'.

Table B4 ALARP actions

Extreme risk	Intolerable/immediate corrective action
High risk	Prioritised action
Medium risk	Tolerable subject to ALARP
Low risk	Broadly acceptable

The degree to which risk is accepted or tolerated is very much dependant on the frequency, magnitude and controllability of the hazards involved. It is also influenced by the length of time that has elapsed since the last significant hazard impact (the more recent the event, the lower the threshold of acceptance or tolerance) and the perceived significance by the community.

Control measures

Controls such as land use management, building codes and regulations, legislation, structural flood mitigation measures, and Occupational Health and Safety (OH&S) audits, may contribute to minimising the likelihood and consequence of a hazard occurring. Minor risks can be eliminated through the consideration of existing controls, while residual risk may be of such significance as to require the development of specific risk treatment options and plans. Once the various forms of control measures have been defined, the residual risk ratings can be documented in a Risk Register.

Control measures are generally directed to changing human or physical behaviour through a variety of mechanisms as outlined in Table B5 (reprinted from GoA, 2010). The table presents three levels of controls, which can inform the emergency management planning and response.

Level 3 ratings for emergency management are generally expected for behavioural and procedural controls. Communities expect the physical controls to be at Level 3 but this is not always financially achievable. Whatever structural measures program is finally adopted, the implications of the intended level of control should be explained to the impacted community and strengthened over time wherever possible or appropriate.

Table B5 Control table

Level of control	Behavioural controls Reliance on human action initiated by individuals or groups based on their experience.	Procedural controls Reliance on human action in accordance with prescribed approaches within a management system.	Physical controls Passive/fixed controls or automatic execution of controls within a management system and without requiring human action.
1	Immature organisation High turnover of staff High proportion of new population within community History of control failure	Documented procedure (no document control) One-off competency assessment against procedure One-off conformance and outcome evaluation	Designed to specific performance criteria (availability, reliability) Implemented to design criteria
2	Organisation with well-understood roles and responsibilities Skilled and trained staff Community with communication and interaction between all population groups History for minor control failures Staff have holistic understanding of the impact of one control's failure on another	Document control system Periodic competency assessment against the procedure Defined performance outcomes Periodic conformance auditing including management reporting of audit outcomes	Designed in relation to the element at risk to be protected Managed as part of a preventative maintenance system System-generated notification in the event of activation and failure
3	Mature organisation with clear and documented roles and responsibilities Experienced and skilled staff Well-established community with high level of awareness and/or education involving all population groups No history of any control failures and demonstrated ability to learn from the past	Management system includes rules and protocols (access, authority levels, expected control range) Continuous performance checks Management reporting of conformance Documented management follow-up of deficiencies Management system subject to external accreditation and auditing	Control covered by a rigorous change management regime Deliberate actions required for disabling control Failures managed as part of maintenance system and given higher priority for resolution Maintenance system differentiates between critical and non-critical tasks Documented management follow-up of system deficiencies

Appendix C

CRITICAL INFRASTRUCTURE

Appendix C
Critical Infrastructure

The register helps to identify the buildings most vulnerable to flood risk across Banana Shire Council area. The historic and design flood levels presented in this table are representative of flooding for the critical infrastructure listed. Floor level information is not available and there may be higher flood levels at each property depending on the direction of flow. This information is provided as a guide to the flood immunity of critical infrastructure. If floor level data becomes available this table should be updated.

Table C.1 Critical Infrastructure – BSC area

Classification	Type	Town	Name	Historic Flood Level (mAHD)			Design Event (AEP) Flood Level (mAHD)				
				2010	2013	2015	10%	5%	2%	1%	1%CC
None	Administration	Biloela	Council Shire Chambers			176.32			176.00	176.31	176.69
None	Administration	Moura	Government Agency (QGAP)								
None	Administration	Taroom	Council Administration Office								
None	Public buildings, spaces	Biloela	Biloela Shoppingworld								
None	Public buildings, spaces	Biloela	IGA SUPA Biloela								
None	Public buildings, spaces	Biloela	Library								
None	Public buildings, spaces	Moura	Library								
None	Public buildings, spaces	Moura	IGA Moura								
None	Public buildings, spaces	Taroom	IGA Taroom								191.76
None	Public buildings, spaces	Taroom	Library								
None	Public buildings, spaces	Theodore	Library	142.47					142.16	142.59	143.27
None	Public buildings, spaces	Theodore	Supermarket	142.51					142.21	142.61	143.23
None	Public buildings, spaces	Theodore	Supermarket	142.42					142.17	142.52	143.17
Evacuation Centres	Public buildings, spaces	Biloela	Biloela Civic Centre								
Evacuation Centres	Public buildings, spaces	Moura	Moura Kianga Hall								

Classification	Type	Town	Name	Historic Flood Level (mAHD)			Design Event (AEP) Flood Level (mAHD)				
				2010	2013	2015	10%	5%	2%	1%	1%CC
Evacuation Centres	Public buildings, spaces	Taroom	Taroom Showgrounds								
Place of Refuge	Public buildings, spaces	Banana	Banana Sutherland Hall								
Place of Refuge	Public buildings, spaces	Baralaba	Baralaba Hall								
Place of Refuge	Public buildings, spaces	Dululu	Dululu Community Hall		127.51	127.58			127.47	127.57	127.79
Place of Refuge	Public buildings, spaces	Goovigen	Goovigen Hall								
Place of Refuge	Public buildings, spaces	Jambin	Jambin Hotel	133.09	133.58	133.60	132.77	132.87	133.44	133.77	134.10
Place of Refuge	Public buildings, spaces	Jambin	Jambin State School								
Place of Refuge	Public buildings, spaces	Jambin	Jambin Hall	133.33	133.79	133.81		132.93	133.66	133.98	134.29
Place of Refuge	Public buildings, spaces	Theodore	Theodore RSL Hall	142.67					142.32	142.76	143.36
Place of Refuge	Public buildings, spaces	Wowan	Wowan Multi Purpose Centre		115.26						115.24
Vulnerable	Early Education	Biloela	Biloela Community Kindergarten								
Critical Infrastructure	Early Education	Biloela	C&K Biloela Kindergarten								
Vulnerable	Early education	Biloela	Early Learning Centre & Child Care								
Vulnerable	Early education	Moura	C&K Community Kindergarten								
Vulnerable	Early education	Theodore	Theodore Early Learning Centre	142.82				141.67	142.41	142.93	143.54
Vulnerable	School	Baralaba	Baralaba State School	87.49						87.41	87.92
Vulnerable	School	Biloela	Redeemer Lutheran College								
Vulnerable	School	Biloela	Prospect Creek State School								
Vulnerable	School	Biloela	Biloela State High School								
Vulnerable	School	Biloela	Biloela State School								
Vulnerable	School	Biloela	St Joseph's Catholic Primary School								
Vulnerable	School	Jambin	Jambin State School								
Vulnerable	School	Moura	Moura State High School								
Vulnerable	School	Moura	Moura State School								
Vulnerable	School	Taroom	Taroom State School								
Vulnerable	School	Thangool	Thangool Primary School		192.50	193.16		192.46	192.82	193.17	193.45
Vulnerable	School	Theodore	School	142.23					141.70	142.36	143.08

Classification	Type	Town	Name	Historic Flood Level (mAHD)			Design Event (AEP) Flood Level (mAHD)				
				2010	2013	2015	10%	5%	2%	1%	1%CC
Vulnerable	School	Theodore	School	142.22					141.73	142.35	143.06
Vulnerable	School	Wowan	Wowan State School		115.49				115.49	115.49	115.49
Critical Infrastructure	Aerodromes	Moura	Moura Aerodrome								
Critical Infrastructure	Aerodromes	Taroom	Taroom Aerodrome								
Critical Infrastructure	Aerodromes	Thangool	Thangool Aerodrome			193.28				193.29	193.57
Critical Infrastructure	Aerodromes	Theodore	Theodore Airport								
Critical Infrastructure	Aged Care	Baralaba	Community Aged Care Association								
Critical Infrastructure	Aged Care	Biloela	Wahroonga Retirement Village		175.00	175.46			175.20	175.41	175.94
Critical Infrastructure	Aged Care	Biloela	Reserve for Health								
Critical Infrastructure	Aged Care	Biloela	Qld Country Women's Assoc.								
Critical Infrastructure	Aged Care	Biloela	Queensland Housing Commission								
Critical Infrastructure	Aged Care	Moura	Retirement Village Committee Inc.								
Critical Infrastructure	Aged Care	Taroom	Leichhardt Villa								
Critical Infrastructure	Aged Care	Theodore	Theodore Council of the Ageing	142.32						142.45	143.17
Critical Infrastructure	Aged Care	Wowan	Dundee Retirement Units								
Critical Infrastructure	Emergency Services	Baralaba	Ambulance								
Critical Infrastructure	Emergency Services	Biloela	Ambulance								
Critical Infrastructure	Emergency Services	Moura	Ambulance								
Critical Infrastructure	Emergency Services	Taroom	Ambulance								
Critical Infrastructure	Emergency Services	Theodore	Ambulance	142.22					141.73	142.35	143.06
Critical Infrastructure	Emergency Services	Wowan	Ambulance								
Critical Infrastructure	Emergency Services	Baralaba	Fire Station								
Critical Infrastructure	Emergency Services	Biloela	Fire Station								
Critical Infrastructure	Emergency Services	Moura	Fire Station								
Critical Infrastructure	Emergency Services	Thangool	Fire Station								
Critical Infrastructure	Emergency Services	Theodore	Fire Station	142.56					142.25	142.65	143.26
Critical Infrastructure	Emergency Services	Baralaba	Police								

Classification	Type	Town	Name	Historic Flood Level (mAHD)			Design Event (AEP) Flood Level (mAHD)				
				2010	2013	2015	10%	5%	2%	1%	1%CC
Critical Infrastructure	Emergency Services	Biloela	Police								
Critical Infrastructure	Emergency Services	Goovigen	Police								
Critical Infrastructure	Emergency Services	Moura	Police								
Critical Infrastructure	Emergency Services	Taroom	Police								
Critical Infrastructure	Emergency Services	Theodore	Police	142.56					142.20	142.66	143.29
Critical Infrastructure	Emergency Services	Wowan	Police								
Critical Infrastructure	Energy	Biloela	Callide Power Station								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Biloela	Retail fuel outlet								
Critical Infrastructure	Energy	Moura	Retail fuel outlet								
Critical Infrastructure	Energy	Moura	Retail fuel outlet								
Critical Infrastructure	Energy	Taroom	Retail fuel outlet	191.45				189.61	190.44	191.06	191.77
Critical Infrastructure	Energy	Taroom	Retail fuel outlet								
Critical Infrastructure	Energy	Thangool	Retail fuel outlet								
Critical Infrastructure	Energy	Theodore	Retail fuel outlet	142.34					141.96	142.46	143.16
Critical Infrastructure	Energy	Theodore	Retail fuel outlet	142.20					141.68	142.33	143.04
Critical Infrastructure	Energy	Wowan	Retail fuel outlet		114.81				114.82	114.81	114.81
Critical Infrastructure	Health Centre	Biloela	Biloela Community Health Service								
Critical Infrastructure	Health Centre	Taroom	Taroom Health Services								
Critical Infrastructure	Hospital	Baralaba	Baralaba Hospital								
Critical Infrastructure	Hospital	Biloela	Biloela Hospital								
Critical Infrastructure	Hospital	Moura	Moura Hospital								
Critical Infrastructure	Hospital	Taroom	Taroom Hospital								

Classification	Type	Town	Name	Historic Flood Level (mAHD)			Design Event (AEP) Flood Level (mAHD)				
				2010	2013	2015	10%	5%	2%	1%	1%CC
Critical Infrastructure	Hospital	Theodore	Theodore Hospital	142.20					141.69	142.32	143.04
Critical Infrastructure	Water & sewerage	Baralaba	Water Treatment Plant								
Critical Infrastructure	Water & sewerage	Biloela	Sewage Treatment Plant								
Critical Infrastructure	Water & sewerage	Biloela	Water Treatment Plant								
Critical Infrastructure	Water & sewerage	Moura	Sewage Treatment Plant								
Critical Infrastructure	Water & sewerage	Moura	Water Treatment Plant								
Critical Infrastructure	Water & sewerage	Taroom	Water Treatment Plant								
Critical Infrastructure	Water & sewerage	Taroom	Sewage Treatment Plant								
Critical Infrastructure	Water & sewerage	Theodore	Water Treatment Plant	142.74				141.66	142.37	142.84	143.46