Blackall-Tambo
Regional Council

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PRELIMINARY

BLACKALL FLOOD RISK MANAGEMENT PLAN

Prepared for Blackall -Tambo Regional Council
By DC Solutions and Yarramine Environmental

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Preliminary

Blackall Flood Risk Management Plan

Blackall-Tambo Regional Council

The Preliminary Blackall Flood Risk Management Plan is a joint initiative of the Blackall-Tambo Regional Council and the Queensland Government.

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LIMITATION STATEMENT

The recommendations contained with this Plan are based on the Scope of Work described in the preceding Blackall Flood Risk Management Study prepared by DC Solutions and Yarramine Consulting Pty Ltd, trading as Yarramine Environmental (Yarramine). DC Solutions and Yarramine performed the services in a manner consistent with the level of care and expertise exercised by members of the environmental profession.

In conducting the Study and preparing this Plan, DC Solutions and Yarramine have relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report as ‘the data’.

Except as otherwise stated in the Study or Plan, DC Solutions and Yarramine have not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this report (‘conclusions’) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. DC Solutions and Yarramine will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to DC Solutions and Yarramine.

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DC Solutions and Yarramine have prepared flood damage estimates and preliminary cost estimates in this report using information reasonably available to the Yarramine employee(s) who prepared this report; and based on assumptions and judgments made by Yarramine.

The damages and cost estimates have been prepared for the purpose of preliminary pricing for a high-level evaluation of options and must not be used for any other purpose. Cost estimates are a preliminary estimate only.

Actual prices, costs and other variables may be different to those used to prepare the cost estimates and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this Plan. DC Solutions and Yarramine does not represent, warrant or guarantee that works progressed can or will be undertaken at a cost that is the same or less than the cost estimates.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

Other parties should not rely upon the report or the accuracy or completeness of any conclusions, and should make their own inquiries and obtain independent advice in relation to such matters.

To the best of DC Solutions and Yarramine’s knowledge, the study presented and the facts and matters described in this report as at the time of the study, and from information provided by the Client, are current. Any changes to this information of which DC Solutions and Yarramine are not aware, and have not had the opportunity to evaluate cannot, therefore, be considered in this report.

DC Solutions and Yarramine will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

DC Solutions and Yarramine will retain any documents or files in its possession relating to the Scope of Work for a period of 7 years from the date of this report.

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Contents

1 Introduction 1
1.1 The Study Area 1
1.2 Objectives of the Flood Risk Management Study & Plan 1
2 Assessment of Recommended Potential Measures 2
2.1 Introduction 2
2.2 Multi-criteria analysis 3
2.3 Levees, Flood Gates & Pumps 6
2.3.1 Project 1 - Option A: Permanent Township Levee 6
2.3.2 Project 1 - Option B: Permanent CBD Levee 9
2.3.3 Project 1 - Option D: CBD Mobile Flood Barrier 10
2.4 Emergency Planning & Management 13
2.4.1 Project 2: Blackall Flood Emergency Sub Plan 13
2.5 Flood Warning & Intelligence 14
2.5.1 Project 3: Flood Warning & Intelligence Improvement Project 14
2.6 Public Information & Flood Awareness 15
2.6.1 Project 4: Flooding Awareness Campaign 15
2.6.2 Project 5: Business FloodSafe Toolkit & Plan 16
2.7 Voluntary Protection Retrofitting 17
2.7.1 Project 6: Homeowners Guide to Retrofitting Your House 17
2.8 Consideration of Planning & Development Controls 18
2.8.1 The Planning & Development Assessment Framework 18
2.8.2 The Blackall Tambo Regional Planning Scheme 18
2.9 Consideration of Neighbouring Council Flood Mitigation Approaches 22
3 Final Recommended Management Options 23
4 Funding & Implementation 26
4.1 Funding Sources 26
4.2 Establishment of Steering, Working and Advisory Groups 26
4.3 The Next Steps 26
4.4 Ongoing Review of Plan 27

Figures

Figure 1: Indicative alignment of the permanent township levee 6
Figure 2: The BAUER-IBS DEMFLOOD System used to bridge levee gaps across roads 7
Figure 3: Indicative alignment of permanent CBD levee 9
Figure 4: Indicative alignment of CBD mobile flood barrier 10
Figure 5: The foldable AquaFence partition 11
Figure 6: Deployment of AquaFence during a flood in Thailand 12
Figure 7: BEAVER® element ready for deployment 12
Figure 8: Example of twin BEAVER® elements deployed 13

Tables

Table 1: Potential flood management measures recommended in the Study 2
Table 2: Assessment issues for management measures 3
Table 3: Multi criteria assessment of each option 4
Table 4: Scope of cost estimates for levee construction 8
Table 5: Flood risk land use responses and the new BTRC Planning Scheme 20
Table 6: Summary of final recommended flood management measures for implementation 24

Appendices

Appendix A FLOOD DAMAGES ASSESSMENT
Appendix B INDICATIVE ALIGNMENT OF LEVEE & BARRIER OPTIONS
Appendix C OPPORTUNITIES & DRAWBACKS OF MOBILE FLOOD BARRIER SYSTEMS
Appendix D AQUAFENCE (FOLDOUT FENCE) MOBILE FLOOD BARRIER SYSTEM
Appendix E BEAVER® (TUBES) MOBILE FLOOD BARRIER SYSTEM
Appendix F EXAMPLE BLACKALL FLOOD EMERGENCY SUB PLAN TABLE OF CONTENTS
Appendix G EXAMPLE HOMEOWNERS GUDIE TO RETROFITTING TABLE OF CONTENTS
Appendix H REVIEW OF NEIGHBOURING COUNCIL'S FLOOD MITIGATION APPROACHES

Glossary & Abbreviations

AAD (Average Annual Damage)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
AEP (Annual Exceedance Probability)	The likelihood of a flood of a given size (or larger) in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 cubic meters per second has an AEP of 5%, it means that there is a 5% risk (i.e. a probability of 0.05 or a likelihood of 1 in 20) of a peak flood discharge of 500 cubic meters per second or larger occurring in any one year. The AEP of a flood event gives no indication of when a flood of that size will occur next.
ARI (Average Recurrence Interval)	ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, an ARI 1 in 100 flood is a flood that occurs or is exceeded, on average, once every 100 years.

1 Introduction

Natural hazards, including floods, have the potential to threaten life and property. They impose social and economic costs on governments and the community. Indeed, flooding is recognised as the costliest natural disaster in Australia.

Historically, floodplains have always attracted settlement. Posing risks to the township of Blackall, riverine flooding from the Barcoo River tends not to follow a predictable pattern, occurring at any time of year and at irregular intervals. Flood risk management is a compromise that trades off the benefits of human occupation of the floodplain against the risk of flooding. The risk includes the flood hazard, social, economic and environmental costs and adverse consequences of flooding.

This Preliminary Flood Risk Management Plan for Blackall has been prepared by DC Solutions and Yarramine Environmental, and follows on from the development of the Blackall Flood Risk Management Study.

The Blackall Flood Risk Management Study drew on the results of the Queensland Reconstruction Authority (QldRA) flood investigation for the township of Blackall, as part of the Queensland Flood Mapping Program.

The Study and Plan have been produced as separate documents. This plan should be read in conjunction with the Blackall Flood Risk Management Study report.

1.1 The Study Area

The Study and this subsequent Plan focuses on mitigating the effects of riverine flooding on the township of Blackall from the Barcoo River.

1.2 Objectives of the Flood Risk Management Study & Plan

- To ensure that all levels of government and the local community accept their responsibilities for managing flood risk in Blackall.
- To ensure that flood risk and flood behaviour is understood and considered in a strategic manner in the decision-making process.
- To ensure land use planning and development controls minimise both the exposure of people to flood hazard and damage costs to property, new developments and infrastructure.
- To ensure a broad range of flood risk management measures are considered, and flood mitigation measures appropriate to the location and acceptable to the local community are used to manage flood risk where economically, socially and environmentally acceptable.
- To provide flood forecasting and warning systems and emergency response arrangements that cope with the impacts of flooding on the community in light of the available flood intelligence.
- To aid the community in recovering from the devastating impacts of flooding.
- To identify the range of best flood risk management measures to be implemented based on consideration of environmental, social, economic and engineering issues.

2 Assessment of Recommended Potential Measures

2.1 Introduction

A number of potential risk management measures were considered in the Blackall Flood Risk Management Study. Community members, through the community Focus Group exercise held, and the project team's Specialist Panel assembled for the project, suggested many of these measures.

The measures considered, and recommendations from the Study, are summarised in Table 1 below. Further information concerning the basis of these recommendations can be found in the Blackall Flood Risk Management Study.

Further details concerning implementation of the recommended potential measures are provided in the remainder of this Plan.

Table 1: Potential flood management measures recommended in the Study

RISK MANAGEMENT MEASURE	COMMENT	RECOMMENDED FOR PLAN
Flood Modification Measures		
Flood Mitigation Dams	Not considered	No
Levees, Flood Gates & Pumps	May be viable; need to carefully consider height and extent - i.e. all areas subject to inundation or just parts (e.g. CBD). Both a permanent and temporary levee (mobile barrier) will be examined.	Yes
Detention Basins / Retarding Basins	Not a suitable measure for Barcoo River	No
Channel Modifications	Changing channel geometry not viable; addressing floodplain and riverine vegetation will have no significant impact on flooding characteristics	No
Bypass Floodways	Perhaps, but ultimately considered not economically feasible	No
Response Modification Measures		
Emergency Planning & Management	Urgent: LDMP requires expansion with a focus on activity triggers (e.g. evacuation, safe havens and general protocols and procedures re flood emergency)	Yes
Flood Warning	Essential part of overall flood management plan; recently expanded network will help immensely; opportune time to review information systems etc. and how this links with flood intelligence	Yes
Flood Intelligence	Identified as a shortcoming; haphazard at best, at the moment; requires systematic management; can be a very simple but quite powerful tool	Yes
Public Information & Flood Awareness	Identified as a shortcoming; many possibilities that could be progressed; emphasis on information messages and awareness	Yes
Property Modification Measures		
Voluntary Building Purchase Scheme	Not considered feasible	No
Voluntary Building Raising	Not considered feasible	No
Voluntary Protection Retrofitting	Residents and business owners would need guidance and support; may not gather traction if not subsidised	Yes

2.2 Multi-criteria analysis

The assessment of options recommended for further investigation was undertaken using a multi-criteria procedure that considers relevant issues for the study area. Table 2 lists the issues considered.

Table 2: Assessment issues for management measures

CATGEORY	ISSUES
Social	Does the measure reduce trauma to individuals during floods?
	Does the measure increase or decrease the disruption/access in and around the town during a flood?
	Does the measure have an impact on community growth?
	Does the measure affect property values?
	Does the measure have a visual impact?
Economic	Cost of mitigation measures?
	Savings in potential flood damages?
	Can the project be funded?
Environmental	Will the measure result in increased erosion of river banks?
	Does the measure maintain or improve riverine habitat that encourages diversity of species?
	Does the measure enhance or degrade water quality?
	Does the measure improve habitat and vegetation of the floodplain environs?
Flooding Behaviour	Does the measure increase or reduce the hazard to the community?
	Does the measure reduce the potential for inundation in the town?
	Does the measure improve or worsen the impacts of a flood event larger than the design flood?
	Does the measure change velocities or water levels downstream?
	Does the measure change water levels and extent of inundation upstream?

Each measure was assessed against these issues using a five point system:

1 – major negative impact

2 – minor negative impact

3 – no impact / negligible

4 – minor positive impact

5 – major positive impact

The social and environmental assessment is qualitative only, while the economic assessments are arrived at based on flood damage estimates (refer to the Appendix A - the total AAD for the existing Blackall township is estimated to be $324,000 (in round terms)) and benefit and cost estimates, where available.

Flood behaviour assessments is also qualitative only as the hydraulic detail required is not available. Hydraulic modelling should be undertaken in order to inform further investigation and design of permanent levees should these be considered by BRTC.

Each of the recommended measures listed in Table 1, further broken down into a viable Management Option were assessed. Table 3 below details the score of each item.

Table 3: Multi criteria assessment of each option

OPTION	MANAGEMENT OPTION	SCORE	COMMENTS
Flood Modification Measures			
Levees, Flood Gates & Pumps			
1	Permanent Township Levee	48	High capital cost Poor socially due to visual amenity and access to Barcoo River for recreation Problems with false sense of security
2	Permanent CBD Levee	52	High capital cost Problems with false sense of security
3	CBD Mobile Flood Barrier	58	More ‘upfront’ affordable alternative Portable alignment can be adjusted Potential issues with marinating sufficient ground connection
Response Modification Measures			
Emergency Planning & Management			
4	Blackall Flood Emergency Sub-Plan	61	Standard measure and highly desirable
Flood Warning			
5	Flood Warning & Intelligence Improvement Project	57	Desirable Could be costly and drawn out depending on scope
Flood Intelligence			
-	As above		
Public Information & Flood Awareness			
6	Flooding Awareness Campaign	54	Limited audience Requires other options to be pursued to be of most benefit Generic information en masse is likely to have little impact on levels of awareness
7	Business FloodSafe Toolkit & Plan	54	Limited audience
Property Modification Measures			
Voluntary Protection Retrofitting			
8	Homeowners Guide to Retrofitting Your House	54	Limited audience Relies on homeowners to fund and make retrofits

Based on Table 3 the ranking is:

High Scores (54 or greater):

Option 4: Blackall Flood Emergency Sub-Plan

Option 3: CBD Mobile Flood Barrier

Option 5: Flood Warning & Intelligence Improvement Project

Option 6: Flooding Awareness Campaign

Option 7: Business FloodSafe Toolkit & Plan

Option 8: Homeowners Guide to Retrofitting Your House

Medium Score (between 46 and 54):

Option 2: Permanent CBD Levee

Option 1: Permanent Township Levee

Low Score (45 or less):

None

Detailed investigation of each of the options is discussed below.

Where possible for each item a benefit cost ratio was calculated. A benefit cost ratio greater than one (1) indicates that the benefits outweigh the costs. A benefit cost ratio below one (1) indicates that costs outweigh benefits. In the latter case, the option becomes difficult to justify. The ratio provides a means by which the options can be ranked on economic grounds.

For the economic analysis, a 30-year project life and 6% discount rate was assumed. The steps taken in computing benefit cost ratio are:

Where **B** = Average annual benefit ($) **(AAB)**

AAB = Average annual damage for existing situation – average annual damage for a given mitigation option.

N = Net annual benefit ($) **(NAB)**

NAB = *B* – annual maintenance cost for a given mitigation option.

P = present value of benefits ($). This is a capitalised value computed by discounting **N** over the life of the works (***y*** years) at a discount rate of **i**, such that:

$$\mathbf{P} = \mathbf{N}\left(\frac{(\mathbf{1}+\mathbf{i})^{\mathbf{y}}-\mathbf{1}}{\mathbf{i}(\mathbf{1}+\mathbf{i})^{\mathbf{y}}}\right)$$

$$\mathbf{P} = \mathbf{N} \times \mathbf{13.7468}$$

Benefit cost ratio = *P/C*

It is important to note that Cost (C) refers to costs associated with the planning and further investigation works required (i.e. feasibility studies etc.) along with the costs associated construction for flood modification measures and implementation for response and property modification projects. Further, it is also important to note that “Project Duration” refers to the time required for planning/investigation and construction/implementation.

The cost estimates for the construction of the Permanent Township Levee (Project 1 - Option 1) and Permanent CBD Levee (Project 1 - Option 2), were derived from a high-level cost review of the recently constructed levee at Jericho based on the calculation of a linear km rate inclusive of associated tasks performed (as outlined in Table 4) by the project teams’ specialist engineer. The project teams’ engineer was involved with the construction of this levee.

The cost estimate for the CBD Mobile Flood Barrier (Project 1 - Option 3) was derived from discussions and calculations prepared by a supplier of mobile flood barriers, and the cost estimates for the remaining options were derived from the project team members experience designing and implementing community education campaigns and projects.

2.3 Levees, Flood Gates & Pumps

2.3.1 Project 1 - Option 1: Permanent Township Levee

Priority: Medium
Estimated Cost: Feasibility Study $300K + $3M - Subject to Results of Feasibility Study
Maintenance Cost: $12K (Annual) - Subject to Results of Feasibility Study
Project Duration: Subject to Results of Feasibility Study

As noted in the preceding Study, it may be possible to construct a permanent levee, approximately 3.5km along the northern bank of the Barcoo River to a maximum probable flood level along an alignment indicated in Figure 1 below and further enlarged in Map 18 included in Appendix B.

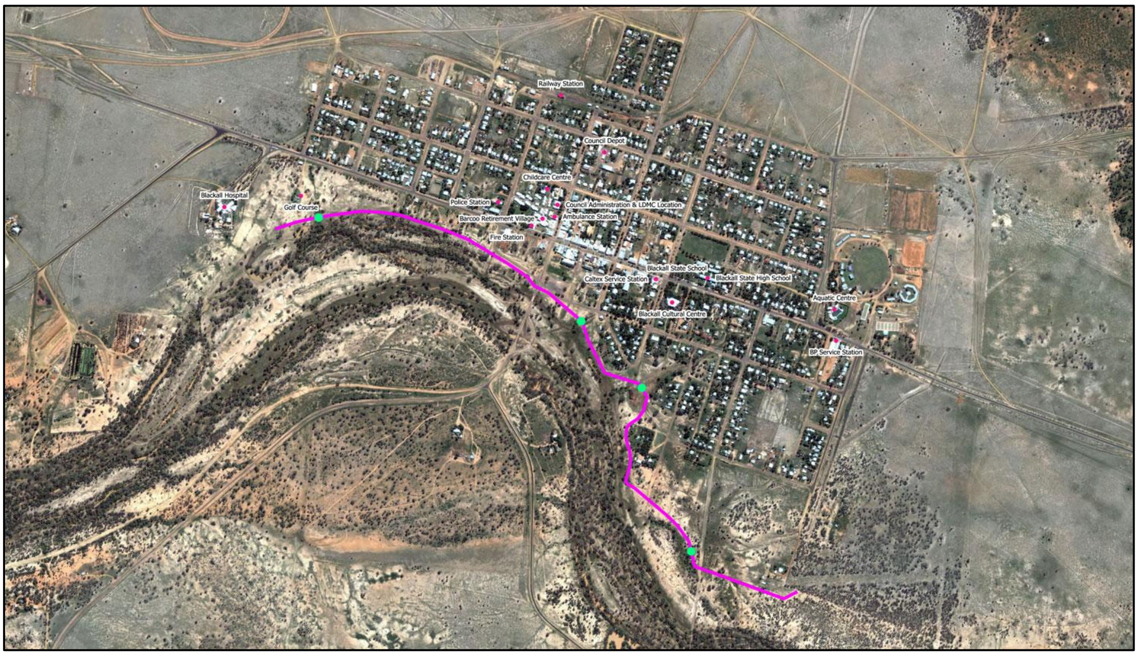

Figure 1: Indicative alignment of the permanent township levee

A levee built to maximum probable flood level would almost eliminate the risk of overtopping and consequential outcomes from such an event. However, it may not be physically possible to build the levee to such a height on land available between the commercial section of town and the river.

Alternatively, a levee built to withstand a lesser event may also be considered (such as ARI 1 in 50 - 7.5m at @ BOM GAUGE #036155). Note the April 1990 flood is considered equivalent to an ARI 1 in 25 year flood event.

A levee would also have the potential to increase water levels for properties that remain outside the levee including the potential for properties not traditionally flooded to be inundated (i.e. upstream but also notably for downstream properties and properties on the opposite side of the river) and as such all damage cannot be fully prevented.

Other important considerations in pursuing a permanent township levee include sourcing the material required to construct the levee and local stormwater implications.

In terms of the material used to construct such a levee, it is likely suitable sources of material will be available in the vicinity of the proposed levee. It is known that loam exists along the riverbanks of the Barcoo River close to the town of Blackall. This loam is not generally considered to be suitable, however, a blend of loam and black soil may be suitable. However, blending material together and carting from borrow pits to the preferred levee alignment may be financially prohibitive, particularly for a levee built to a maximum probable flood level.

Floodgates would be required to release water from the Ticklebelly Gully back into the river as well a number of other smaller gates draining other tributaries, however, a rainfall and runoff analysis would need to be undertaken to establish the height of the water stored outside against the levee. The results of this rainfall and runoff analysis may mean that a few properties are affected by the level of water within the protective area of the levee from local runoff. Stormwater backflow devices may also be required to stop water backing up the stormwater drainage line leading from Banks Park and the southern end of Clematis Street south of Shamrock Street.

Other considerations would be any land acquisition requirements, road crossings that could be left as breaks with a mobile barrier put in place in the lead up to an event (Figure 2), and the downstream impact, particular on the Hospital and airport, which may also need levees.

Figure 2: The BAUER-IBS DEMFLOOD System used to bridge levee gaps across roads

Before committing to a permanent township levee, a feasibility study would be required, at an estimated cost of $300K, to determine the technical design and financial details of such a levee.

Key actions in conducting a Blackall Flood Levee Feasibility Study would include:

- Undertaking of hydrology and hydraulic modelling including stormwater runoff analysis;
- Determination of level of protection (i.e. built for probable maximum flood, freeboard options 300mm/600mm);
- Identification of preferred alignment and subsequent land acquisition (if any);
- Identification of and location of suitable fill material for construction;
- Identification of environmental values that need further consideration or approvals;
- Survey of preferred alignment;
- Preparation of concept design;
- Economic analysis and preparation of cost estimates; and
- Community consultation.

Expected costs estimates would need to include items such as those summarised in Table 4 overleaf.

Table 4: Scope of cost estimates for levee construction

WORKS REQUIRED	DESCRIPTION
Preliminaries	Land Acquisition
	Cultural Heritage and Environmental Management
	Mobilisation
	Site Establishment
	Site Maintenance
	Project Management
	Construction Surveys
	Testing
	Approvals
Levee construction	Borrow pit establishment
	Screening & blending of earthen material
	Haulage
	Clearing, remove and stockpile topsoil
	Earth placement, compacting and trimming of embankment
	End and break capping
	Hyrdomulching crest and batters and landscaping
	Alterations to existing utility services
	Recreation embellishments such as footpaths, signage etc.
Associated bridgeworks and road works	Mobile barriers for road crossings
	Asphalt works
Associated stormwater works	Flood gates
	Stormwater backflow
	Culverts etc.
Overheads	Contingency (30% of direct costs)
	Engineering (7.5% of direct costs)
	Contract Administration & Construction Supervision (7.5% of direct costs)

Based on a high level costing exercise, the indicative cost estimate to undertake the feasibility study and construction of the levee was $3.3 million, which included site clearance, importing fill, construction of retaining wall, finishing, landscaping and capping.

This estimate assumed locally available material with little haulage required.

As discussed in Appendix A the total AAD estimated for the existing Blackall township is estimated to be $324,000 (in round terms).

The average annual damage (AAD) was reassessed with the mitigation option in place. With the town protected against a 1 in 50 year event the AAD is reduced to $27,000 (in round terms) a reduction of $297,000.

This AAD primarily represents the value of damage sustained to properties outside the levee, and it is assumed that there is no change to the damages for any event greater than the 50-year ARI event.

Based on the modelled damages from a 50-year ARI event, the high-level cost estimate of planning and construction and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 1 - Option 1 was calculated as 1.19.

2.3.2 Project 1 - Option 2: Permanent CBD Levee

Priority: Medium
Estimated Cost: Feasibility Study $150K + $1.4M - Subject to Results of Feasibility Study
Maintenance Cost: $5K - Subject to Results of Feasibility Study
Project Duration: Subject to Results of Feasibility Study

A variation of the permanent township levee would be a shorter version (approximately 1.6km) designed to protect the CBD of Blackall along an alignment indicated in Figure 3 below and further enlarged in Map 16 included in Appendix B.

Figure 3: Indicative alignment of permanent CBD levee

This levee could commence part way upstream along Ticklebelly Gully before joining the indicative alignment for a permanent levee at the junction of Aqua and Hawthorn Streets, following this but stopping short of the western end at the boundary of the golf club.

This option would not require as many flood gates and less road crossings, but would likely exacerbate flooding issues experienced by residents on the eastern side of Tickleberry Gully on its lower reaches. In addition, like Option 1, this option would also have the potential to increase water levels for properties that remain outside including the potential for properties not traditionally flooded to be inundated (i.e. upstream but also notably for downstream properties and properties on the opposite side of the river).

A feasibility study would also be required covering the same scope of works as outlined above. It is possible that such a feasibility study could cover both the permanent options put forward for around the same cost given the alignments are shared for a large part of their lengths.

Based on a high level costing exercise, the indicative cost estimate to undertake the feasibility study and construction of the levee was $1.55 million, which included site clearance, importing fill, construction of retaining wall, finishing, landscaping and capping.

This estimate assumed locally available material with little haulage required.

As discussed in Appendix A the total AAD estimated for the existing Blackall township is estimated to be $324,000 (in round terms).

The AAD was reassessed with the mitigation option in place. With the CBD protected against a 1 in 50 year event the AAD is reduced to $116,000 (in round terms) a reduction of $208,000.

This AAD primarily represents the value of damage sustained to properties outside the levee, and it is assumed that there is no change to the damages for any event greater than the 50-year ARI event.

Based on the modelled damages from a 50-year ARI event, the high-level cost estimate of planning and construction and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 1 - Option 2 was calculated as 1.19.

2.3.3 Project 1 - Option 3: CBD Mobile Flood Barrier

Priority: High
Estimated Cost: $200K Preliminaries, Purchase, Storage, Cartage & Use Training
Maintenance Cost: $15K (Annual)
Project Duration: 12 months - subject to funding program constraints and incorporating placement analysis

A less costly and more limited in protection option that could be progressed, would be the use of mobile flood barrier solutions to protect key buildings located in the CBD from inundation.

Three separate mobile barriers could be located along an alignment indicated in Figure 4 below and further enlarged in Map 17 included in Appendix B.

Figure 4: Indicative alignment of CBD mobile flood barrier

Mobile flood barrier systems differ in material, construction, permanent fittings and fixtures, and available protection height, and consideration of the types of commercially available systems would need to be undertaken to determine which type or types would be most suitable.

Appendix C presents a brief assessment of the opportunities and drawbacks of mobile flood protection systems to assist BTRC investigate available options.

Two such mobile barrier options (both with their opportunities and drawbacks) that could be examined more closely are the AquaFence and BEAVER® Flood Barrier systems. These systems are available in Australia.

AquaFence (Figure 5 and Figure 6) is a commercially available mobile flood barrier system that consists of fences composed of a number of inter-linked, foldable elements. The fences consist of two lengths of boarding rigidly locked together by a system of brackets, and are formed in such a way that the application of floodwater pressure consolidates and strengthens the fencing rather than weakening it.

For further information about the AquaFence mobile barrier system, refer to Appendix D.

Figure 5: The foldable AquaFence partition

Figure 6: Deployment of AquaFence during a flood in Thailand

The BEAVER® Flood Barrier is a product that consists of two flexible PVC tubes laid side by side, permanently joined to form a twin element with high static stability. The re-usable elements are available in different lengths and heights. Initially inflated with air, twin-elements can be pre-deployed awaiting confirmation of the final position. When in the required position, they are then filled with water.

BEAVER® elements can also be stacked. This allows the user to standardise on a small or medium size product and yet have the flexibility to cater for deeper or deepening floodwaters if required.

Supported by a 4,000 L/min pump, a 1m high and 10m long BEAVER® twin-element can, reportedly, be deployed in less than 15 minutes.

Figure 7: BEAVER® element ready for deployment

Figure 8: Example of twin BEAVER® elements deployed

For further information about the BEAVER® Flood Barrier system, refer to Appendix E.

Based on a high level costing exercise, the indicative cost estimate to purchase a mobile flood barrier system was $200,000, which included things like storage, training and transport.

As discussed in Appendix A the total AAD for the existing Blackall township is estimated to be $324,000 (in round terms).

The AAD were reassessed with the mitigation option in place. With the CBD protected with a mobile flood barrier system against a 1 in 50 year event the AAD is reduced to $129,000 (in round terms) a reduction of $195,000.

This AAD primarily represents the value of damage sustained to properties (residential and some commercial) outside the areas protected by the mobile barriers, and it is assumed that there is no change to the damages for any event greater than the 50-year ARI event.

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 2 was calculated as 12.38.

2.4 Emergency Planning & Management

2.4.1 Project 2: Blackall Flood Emergency Sub Plan

Priority: High
Estimated Cost: Council Staff Costs ($60K)
Maintenance Cost: Council Staff Costs ($5K)
Project Duration: 12 months

As noted in the Flood Risk Management Study, there is a need for more in-depth planning resources to support emergency management activities.

It is suggested that in parallel with the pursuit of a levee or barrier option, Council also undertake an exercise to improve its Blackall Tambo Local Disaster Management Plan 2009-2014 (due for review this year) to include a Blackall Flood Emergency Sub Plan.

This plan would have clearly detailed preparedness measures, and provide a sound basis for the conduct of flood operations and the establishment of coordination for recovery measures to deal with floods in Blackall and the broader Blackall / Tambo region.

An example Table of Contents for Council to consider is provided in Appendix F.

Such a project should also be undertaken under the auspices of a Blackall Flood Working Group, which is also recommended to be established and described further on in this Plan.

The impact of the implementation of the Sub Plan project, through revision of the Average Annual Damage estimates for commercial and residential properties, is difficult to capture in purely monetary terms.

It is reasonable to suggest that benefits arising, due to a significant reduction in the social impacts on the community, could be expected to amount to some $35,000 annually. Resulting improvements in preparedness and recovery, in particular, could yield a 10% reduction in damages sustained. Thus, the benefit of the project is estimated at $67,400.

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 2 was calculated as 14.3.

2.5 Flood Warning & Intelligence

2.5.1 Project 3: Flood Warning & Intelligence Improvement Project

Priority: High
Estimated Cost: $200K
Maintenance Cost: $30K
Project Duration: 24 months

Flood intelligence refers to a broad collection of flood related information that is used to prepare, plan for, and respond to floods.

The key thrust of this project would be to improve and expand upon the existing flood intelligence systems currently in place. Focus here would be on developing data collection, storage and analysis processes and systems to improve decision-making. This information can be used predicatively in later flood episodes to inform response decisions, and to provide higher-quality warnings to the community than have traditionally been possible.

The building up over a period of a dossier of information on flood behaviour constitutes a valuable resource to guide later efforts.

Its aim would be to create an enhanced flood intelligence system that would improve local understanding of flood behaviour and response to warnings.

The backbone of the system would make use of Geographic Information System (GIS) technology to store, map and allow for spatial integration of flood related data, such as floor heights, inundation levels, evacuation centres and routes, risk profiles etc.

To support the flood intelligence system, community education resources should also be developed (refer to next options) to improve responses to flood warnings.

As discussed in the Flood Risk Management Study, warning messages could be developed as part of the Sub Plan and disseminated when pre-defined flood level heights, informed by the information contained in the flood intelligence system, are reached.

The impact of the implementation of Flood Warning & Intelligence Improvement, through revision of the Average Annual Damage estimates for commercial and residential properties, is difficult to capture in purely monetary terms.

It is reasonable to suggest that benefits arising due to a significant reduction in the social impacts on the community, improved decision-making, expedited preparedness and more timely and relevant warnings could be expected to amount to some $60,000 annually. Resulting improvements in preparedness and recovery, in particular, could yield a 15% reduction in damages sustained. Thus, the benefit of the project is calculated as $108,600.

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 3 was calculated as 5.4.

2.6 Public Information & Flood Awareness

2.6.1 Project 4: Flooding Awareness Campaign

Priority: High
Estimated Cost: $100K
Maintenance Cost: $10K
Project Duration: 12 months

This project would focus on developing new and/or 'localising' a range of resources based on the collective knowledge and experiences of the Blackall community to raise the level of awareness of flooding and flooding issues.

As noted in the Flood Risk Management Study, the majority of Blackall residents have a medium level of flood awareness and, to a lesser degree, preparedness.

Any flood awareness projects or programs that are implemented will need to be developed by Council, taking into account the views of the local community, funding considerations and other awareness programs. The details of the exact measures would need to be developed in consultation with affected residents and businesses.

Any such formulated projects would also need to be very targeted. The provision of information en masse has generally not been found to be effective at increasing level of floods awareness elsewhere.

General methods of communication that would underpin the project could consist of the following; however, it is important that such methods employed be used in a targeted fashion:

- Informative flyer with utility bill / rates notice (can be general or targeted to flooding in specific areas);
- Flood information pack - including background information on flooding in Blackall, an example emergency flood plan or template, action guides and information regarding Council flood mitigation plan and program of activities;
- Briefings at social and civic clubs, e.g. Rotary, Lions;
- Expert panels (flooding, emergency and planning experts);
- Newspaper feature story on general flooding issues or historical (flood commemorations);
- Information booth at community festivals, shows etc.;
- Information repository at libraries, Council office etc.;
- Newspaper insert (fact-sheet style);
- Flood information website or section on existing website;
- Signposting of evacuation routes;
- Noticeboards in public areas to signpost floodways, structures etc.

- School projects on floods and floodplain management;
- Historical flood markers;
- Flood certificates; and
- Email newsletters.

Other more novel project concepts could attract alternative funding sources not traditionally used to fund flooding awareness activities. For example, staging a flood photo exhibition at the local art gallery, the preparation and publishing of a local flood history book, or an oral history project.

A more intensive project would involve in-home consultations with the most affected residents and businesses, coupled with property inspections. While such a project would be limited in terms of the number of people who could be reached, by focusing on those most vulnerable, (in terms of the flood risk) the impact of a major flood could be significantly moderated. Such an approach would also have a major advantage of being able to tailor effort to the specific needs and interests of the individual residents and businesses.

The impact of the implementation of a Flooding Awareness Campaign, through revision of the Average Annual Damage estimates for commercial and residential properties, is difficult to capture in purely monetary terms.

It is reasonable to suggest that benefits arising due to a significant reduction in the social impacts on the community could be expected to amount to some $60,000 annually, and resulting improvements in preparedness and recovery in particular could yield a 25% reduction in damage sustained to residential and commercial properties. Thus, the benefit of the project is calculated as $140,000.

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 2 was calculated as 17.87.

If a Flooding Awareness Campaign is established as a priority, it is recommended that the SES be closely involved with the project, as there is a significant body of material associated with their FloodSafe program that could be drawn upon.

Furthermore, it is suggested that the project be rolled out under the auspices of a Blackall Flood Working Group, recommended to be established further on in this Plan.

2.6.2 Project 5: Business FloodSafe Toolkit & Plan

Priority: High
Estimated Cost: $75K
Maintenance Cost: $5K
Project Duration: 12 months

This project would focus on ‘localising’ or making available, via a small series of workshops, a Business FloodSafe Toolkit & Plan (such as the NSW SES toolkit[1]) to assist local businesses manage the potential impact of floods.

It is acknowledged that the interest and use of such a toolkit in Blackall only would be limited, which is why it is suggested that this project, should it be established as a priority, be progressed with a number of nearby Councils and their towns, to both widen its audience and share its development and roll out costs.

The impact of such a project, through revision of the Average Annual Damage estimates for commercial properties, is difficult to capture in purely monetary terms.

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[1] Available at http://www.ses.nsw.gov.au/content/documents/pdf/floodsafe/45122/riverine_business_floodsafe_toolkit

It is reasonable to suggest that benefits arising, due to a significant reduction in the social impacts on the community and improved decision-making by businesses, could be expected to amount to some $75,000 annually. Resulting improvements in preparedness and recovery, in particular, could yield a 20% reduction in damages sustained to the commercial sector. Thus, the benefit of the project is calculated as $124,560.

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 2 was calculated as 21.91.

Should the concept of a joint project be progressed with a number of nearby councils, the cost of the project could be shared amongst participants; however, this is ultimately dependent on the idea being well received and their level of involvement and expected return.

2.7 Voluntary Protection Retrofitting

2.7.1 Project 6: Homeowners Guide to Retrofitting Your House

Priority: High
Estimated Cost: $50K
Maintenance Cost: $5K
Project Duration: 12 months

In some cases, retrofitting homes or regrading properties (with consideration of effects on neighbours) can help reduce the potential for flood damage to structures and their contents.

Retrofitting techniques include elevating buildings above flood levels, and wet or dry flood proofing.

This small project would see the production of a *Homeowners Guide to Retrofitting Your House* specifically developed to provide advice to homeowners who want to know how to protect their homes from flooding, and would focus on providing straightforward guidance on what methods are available, how they work, how much they may cost, and whether they will meet specific needs of the homeowner.

It is acknowledged that the use of such a guide in Blackall only would be limited, which is why it is suggested that this project, like Project 5, should it be established as a priority, be progressed with a number of nearby councils and their towns to both widen its audience and share its development costs.

An example Table of Contents is provided in Appendix G, which gives an idea of how such a guide could be put together.

The impact of developing and disseminating a guide (assumed a soft copy) through revision of the Average Annual Damage estimates, is difficult to capture in purely computed monetary terms.

It is reasonable to suggest that benefits arising due to a reduction in dwelling damages could be expected to amount to some $30,000 annually (i.e. 1/2 reduction in AAD for residential).

Based on the modelled damages from a 50-year ARI event, the high-level cost and maintenance estimates and the modelled reduction in AAD, with the adopted underlying assumptions the Benefit/Cost Ratio for Project 2 was calculated as 6.87.

Should the concept of a joint project be progressed with a number of nearby councils, the cost of the project could be shared amongst participants; however, this is ultimately dependent on the idea being well received, and their level of involvement and expected return.

2.8 Consideration of Planning & Development Controls

Although development in Blackall does not experience the pressures of larger towns and cities, this Preliminary Flood Risk Management Plan and its linkages with the Blackall Tambo Regional Planning Scheme can lay a strong foundation for responding to flood hazards and to identifying issues to consider in developing appropriate land use responses for the township of Blackall.

2.8.1 The Planning & Development Assessment Framework

Queensland's planning and development assessment framework is currently going through a significant reform process, due for completion by the end of 2014, to deliver streamlined assessment and approval processes, remove unnecessary red tape and re-empower local governments to plan for their communities.

To date, three key reform initiatives have been delivered as part of amendments to the *Sustainable Planning Act 2009* (SPA), which came into effect on 22 November 2012:

- The establishment of the State Assessment and Referral Agency (SARA) on 1 July 2013 as a single point of lodgement and assessment for all development applications where the state has a jurisdiction under the Sustainable Planning Act 2009 (SPA);
- The establishment of the State Planning Policy (SPP) in December 2013 to simplify and clarify matters of state interest in land use planning and development. Importantly, the SPP replaced multiple planning policies including SPP 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide 1.0; and
- The introduction of a more balanced infrastructure-charging framework that is equitable, transparent and certain.

In addition, the Queensland Government is currently reviewing planning legislation in an attempt to create the best planning and development assessment system in Australia. Captured in the proposed Planning for Prosperity Bill that is currently being drafted, it will create a more efficient, effective, integrated, transparent and accountable system.

This Bill has the potential to dramatically alter how Queensland approaches plan making, plan implementation and development assessment and will have a new purpose, new terminology and new processes.

When it comes to flood risk management the SPP sets out the interests and policy requirements that Blackall Tambo Regional Council must take into account when preparing or amending their local planning schemes or assessing certain types of development applications. Flood hazard is one such state interest. Local government planning schemes must integrate relevant state interests and provide local context to those interests.

As with previous state planning polices, the SPP applies to development assessment by local government, only to the extent that the SPP has not already been appropriately integrated in a local planning instrument.

In the first instance, development applications in flood prone areas in Blackall must be guided by, and assessed against, the local plan, this being the Blackall Tambo Regional Planning Scheme, provided the State Government has deemed it to sufficiently address its state interests.

2.8.2 The Blackall Tambo Regional Planning Scheme

The Blackall Tambo Regional Planning Scheme (a QPP3-compliant scheme is currently under consideration by the State Government) considers both current levels of development and potential development scenarios should mineral exploration in the area increase the development level of the town.

An analysis of the Planning Scheme shows that when it comes to flood hazards, its strategic intent, zoning and assessment provisions have provided a balance between community expectations, financial considerations (regarding potential for compensation from back zoning) and the precautionary principle to be risk averse in decision-making.

The Planning Scheme defines a flood event level based on the 1990 flood height of 7.3 metres and secures a policy position to reduce development yields in flood prone areas by both land use and fiscal constraints.

Any new development in flood prone areas cannot increase development yields, and requires increased costs in development contributions, construction and assessment costs. Whilst not preventing development from occurring in flood prone areas it does make it unattractive for development to occur.

Table 5 overleaf summarises an assessment of the Blackall Tambo Planning Scheme carried out during the preparation of the accompanying Blackall Flood Risk Management Study prior to its submission by Council to the Queensland Government for its consideration.

This assessment shows the way in which the scheme has been formulated to address development and flood hazard in Blackall, which given the township does not experience significant development is relatively straightforward.

Accordingly, this Preliminary Blackall Flood Risk Management Plan does not include any recommendations that would alter the strategic intent or development controls established in the Planning Scheme currently under consideration by the State. Rather, the Plan seeks to establish a range of parallel mitigation measures to compliment the local planning framework.

Table 5: Flood risk land use responses and the new BTRC Planning Scheme

Land Use Response	Land Use Strategy	New Planning Scheme Framework
Maintain the status quo		
Make no changes to existing land uses as risk is minimal	- None required	
Adapt existing urban areas		
Support built form change over time	- Improve built form outcomes through urban design and building code controls	- Floor height limits are incorporated into the scheme
	- Promote traditional Queensland building designs & construction methods	- The floor height limit means that a slab on ground house cannot be constructed in the flood prone areas
	- Set habitable floor levels	- Floor height limits are incorporated into the scheme
	- Build with resilient materials	- The scheme does not do this but the floor height limit gives a high level of immunity
	- Maintain/rehabilitate natural waterways and flow paths	- While floor height limits incorporated in the scheme plus other controls allow this, no specific provisions have been incorporated due to the reduced impact of flood water velocity
	- Avoid filling to minimise cumulative impacts on floodplain	- Operational works provisions in flood prone areas have been strengthened in the scheme over those available in the current scheme
Limit certain land uses that are not appropriate for the hazard	- Adjust current zonings to reflect appropriate land uses	- While the current zoning extents have not been adjusted the provisions within the scheme have been to strengthen flood resilience
	- Create flood-constrained precincts within zones, which may limit certain land use types or density increases.	- Such provisions have been incorporated into the draft planning scheme
Retreat from specific existing urban areas		
Remove existing vulnerable land uses from areas of highest risk	- Actively transition existing at-risk land uses	- This is a policy matter for the council i.e. outside the draft planning scheme
	- Back-zone areas of highest concern	- Not incorporated in the draft planning scheme to avoid compensation claims

Land Use Response	Land Use Strategy	New Planning Scheme Framework
	- Investigate planned retreat programmes such as voluntary purchase, land swaps, compulsory acquisition to complement scheme response	- Not incorporated into the scheme as a direct zoning. - Existing residential zones in flood prone areas has little subdivision potential. Back-zoning would still allow for a house to be applied for. Planning controls over back zoning achieves resilience without the angst of back-zoning.
Expand into new areas suitable for urban development		
Allocate future urban areas in areas of lowest or no risk	- Avoid zoning areas of medium or highest concern for future urban purposes.	- The scheme achieves this.
	- Site-based investigations during application stage may identify additional areas of concern. Avoid inappropriate land uses in these areas.	- Floor height limits incorporated in the scheme as well as other provisions that are designed to seek assessment of risk.
Maintain agricultural and rural landscape values		
Support flood-appropriate land uses in non-urban areas	- Tailor rural land uses appropriate to the areas of concern.	- The scheme adequately deals with the rural land uses within its jurisdiction.
Treat risks to linkages and isolated places		
Ensure transport and infrastructure routes are resilient to the hazard, and address isolation risks created through interruptions to such linkages	- Avoid creating additional risks by not placing key transport/infrastructure linkages in floodable areas, or by ensuring their resilience to those events.	- The scheme does not promote any Greenfield development in areas of high flood risk and would avoid placing any new linkages in areas subject to flooding

2.9 Consideration of Neighbouring Council Flood Mitigation Approaches

As part of the Study and Plan, a review of the flood mitigation approaches of shires that abut Blackall Tambo Regional Council (BTRC) was undertaken.

This desktop review of publicly available documents found all but one of the five neighbouring local governments have sought to address flood risk to varying degrees.

In brief, specific mitigation measures such as the construction of flood levees and associated works, for example Murweh Shire Council (recent levee supplementary works were completed in early 2014) and Barcaldine Regional Council (Jericho constructed in 2011) have been advanced. Others, such as Quilpie Shire Council, have referred to flooding so as far as it is isolation risk for Quilpie, while Longreach Regional Council has only expressed an indication of intent to address flooding in Longreach.

Appendix H details further information regarding the results of the review undertaken.

What is clear from this review is that each local government area has adopted responses commensurate with the risk posed, and impact of past flooding on their communities, and the availability of funding to progress mitigation measures.

The mixture of measures (or lack thereof) progressed indicates that community responses to the issue of flooding and the adopted mitigation measures is very much dependant on local flooding circumstances, community desires and tolerability, and availability of funding.

3 Final Recommended Management Options

The final recommended measures for the preliminary flood management plan are summarised in Table 6 below.

As discussed in Appendix A, a detailed flood damages analysis was made for the residential, commercial and industrial areas of Blackall that may be flood prone. The analysis established that the Average Annual Damage (AAD) in Blackall is $324,000 (in round terms).

A benefit cost analysis was then performed for each recommended management option by applying it to the property database to calculate a revised AAD estimate. Here it is important to note that this benefit cost analysis was performed for each individual option in isolation from one another, rather than in a cumulative fashion as each option would have overlapping benefits.

For the levee and barrier options assessed, a conservative approach was taken. It was assumed that these measures only protected the town to the point they were designed for and that not all damage could be eliminated.

As shown in Table 6 overleaf, the implementation of certain measures will result in a significant reduction in the Average Annual Damage for properties in Blackall.

It is important to note that often, no single flood risk management measure or specific option will suffice by itself. The determination of the optimum mix of measures involved, the careful balancing of social, economic and environmental issues, as well as flooding issues.

Table 6: Summary of final recommended flood management measures for implementation

MANAGEMENT OPTION	OBJECTIVE	AAD REDUCTED TO	ESTIMATED COST	BENEFIT COST RATIO	RECOMMENDED FOR IMPLMENTATION	COMMENTS
Flood Modification Measures						
Permanent Township Levee	To protect town	$27,000	$3,300,000	1.19	Yes (1st)	Subject to favourable Feasibility Study and sourcing of high capital outlay required Would result in greatest amount of protection but not eliminate damage entirely In lieu of other flood modification options
Permanent CBD Levee	To protect CBD	$116,000	$1,550,000	1.80	No	Subject to favourable Feasibility Study and sourcing of high capital outlay required Would result in next greatest amount of protection but not eliminate damage entirely In lieu of mobile flood barrier option
CBD Mobile Flood Barrier	To protect the most at risk parts of CBD	$129,000	$200,000	12.38	Yes (2nd)	In lieu of a permanent levee options Less capital outlay required but not as great longer term benefit in comparison to permanent levee options
Response Modification Measures						
Blackall Flood Emergency Sub-Plan	Provide a sound basis for planning, preparation, response and recovery activities.	$256,700	$60,000	14.30	Yes	Highly desirable
Flood Warning & Intelligence Improvement Project	Enable and persuade the community to take the appropriate actions to increase safety and reduce the damages associated with flooding Improve decision making capability	$215,500	$200,000	5.40	Yes	Scope of the project would need to be tightly defined and given recent projects associated with flood warning favour intelligence focus. Would require access to GIS skills. It is understood that Council's existing planning consultants have such skills.
Flooding Awareness Campaign	Ensure that the community is fully aware that floods are likely to interfere with their normal activities	$184,100	$100,000	17.87	Yes	Scope of activity would need to be tightly defined Development would need to involve community Need to be very targeted.
Business FloodSafe Toolkit & Plan	Provide information and planning tools to plan and prepare for floods, encourage retrofit activities, increase safety and resilience and to reduce damages associated with flooding	$199,540	$75,000	21.91	Yes	Only if a regional collective of council participation can be garnered.

Property Modification Measures						
Homeowners Guide to Retrofitting Your House	Provide information to encourage retrofit activities by residents to reduce damages associated with flooding	$294,100	$50,000	6.87	Yes	Its effectiveness will be limited without access to funding incentives to encourage implementation of works by homeowners. Only if a regional collective of council participation can be garnered.

4 Funding & Implementation

4.1 Funding Sources

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

- State and Commonwealth funding for flood risk management measures through the Department of Local Government, Community Recovery and Resilience's disaster mitigation and resilience funding[2];
- Council funds;
- funds from other organisations (e.g. SES) and private owners; and
- Volunteer labour (e.g. Community Groups or School Groups that may be able to assist in maintenance of the creek corridors or other flood awareness initiatives).

Council can expect to receive the majority of financial assistance through the Department of Local Government, Community Recovery and Resilience. These funds are available to implement measures that contribute to reducing existing flood problems.

Although much of the Plan may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding of investigation and design activities as well as any works and ongoing programs is normally available. Maintenance, however, is normally the responsibility of Council.

It should also be noted that the Plan involves feasibility assessments and investigations of various work options (notably permanent levee design and construction) which, when included, will significantly increase the cost of the adopted work program by BTRC.

4.2 Establishment of Steering, Working and Advisory Groups

In addition to the final recommended management options, it is suggested that Council also examine planning, management and consultative arrangements associated with the implementation and review of the plan (Steering Committee), progressing specific options and works (Working Group(s)) and channelling community input and engagement (Advisory Group).

4.3 The Next Steps

The steps in progressing the flood risk management process are as follows:

- BTRC determines a program of works, based on overall priority, available Council funds and any other constraints);
- BTRC submits an application(s) for funding assistance to the Department of Local Government, Community Recovery and Resilience and negotiates other sources of funding;
- Updating of the Plan to reflect chosen strategic directions, established priorities and initially funded activity; and
- Implementation of a formally adopted Plan proceeds, as funds become available and in accordance with the established priorities.

[2] Disaster mitigation and resilience funding is currently available through a joint package arrangement administered by the Department which draws upon the Royalties for the Regions (Qld), Local Government Floods Response Subsidy (Qld) and Natural Disaster Resilience Program (joint Qld & Commonwealth) programs. The 2014-15 joint application package closed to applications on 12 May 2014. See: - http://www.dsdip.qld.gov.au/grants-and-subsidies-programs/queensland-disaster-mitigation-and-resilience-funding.html

The timing of the proposed works will depend on BTRC's overall budgetary commitments and the availability of funds from other sources (e.g. State and Commonwealth flood mitigation funding).

4.4 Ongoing Review of Plan

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the local planning framework.

In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

Appendix A

FLOOD DAMAGES ASSESSMENT

Flood Damages Assessment

Flood damage assessments aim to establish the 'baseline' socio-economic costs of flooding (i.e. based on current conditions) which can then be used to help quantify the benefits of potential mitigation measures.

A flood has a variety of effects on the lives and livelihoods of people whose possessions and places of residence or of employment are inundated. Because of this, the types and costs of flood damage can be categorised in a number of ways.

At the broadest level, flood damages are either financial or social in nature and are often respectively referred to as the tangible and intangible costs of flooding. The total financial "damage" caused by a flood can be separated into two major components, the cost of the direct damage to inundated property and the cost of the indirect damage associated with the disruption of social, community and business relationships during the aftermath of a flood.

It is important to note that the assessment of flood damages is never referred to as the calculation of flood damages, but rather the estimation of flood damages. The distinction is important. Estimating flood damages is not an exact science as methodologies and data used in the valuation process vary. Certain assumptions within the process can have a noticeable impact on damage estimations.

Financial Damages

The direct costs of flooding can be subdivided into the cost of damage to the actual structure of an inundated building, the cost of damage to its contents, and the cost of the immediate post flood clean-up operations. These costs are referred to as "structural", "contents" and "clean up" costs.

The type of structural damage sustained by a building depends upon both the materials and manner of its construction and the depth of inundation and velocity of the floodwaters. Inundation by deep, fast-flowing floodwaters may actually wash a building away, whereas shallow, slow moving water may cause relatively minor structural damage.

The damage to the contents of residential dwellings and out buildings includes the cost of cleaning, repairing or replacing flood-damaged furnishings (carpets, furniture, etc.), appliances, services (electricity, telephone, water supply and sewerage) and clothing. Flood damage to cars and other equipment stored on the property is also included in the contents category. Contents damage to commercial property includes damage to raw materials, plant and equipment, stock, and "incidentals". The last category includes damage to office furnishings, employees' possessions, and services.

After a flood has subsided, there is a concentrated clean-up period. It is common for community minded people and organisations to rally as volunteers to help in the clean-up of flooded houses.

Walls require washing down, both inside and out, in an attempt to reduce silt staining, silt is removed from the houses and irreparably damaged items are taken away for disposal. Similarly, volunteers and employees help in the clean-up operations at commercial establishments affected by the flooding.

The cost of immediate post flood clean-up operations is essentially the value of the time of those engaged in the clean-up process plus the cost of removing and dumping flood damaged materials, together with loss of business for commercial establishments.

Indirect Damage

A flood can severely disrupt the goods and services provided by commercial establishments in the community (this includes industrial and rural ventures). It may take many weeks for a community to regain their pre-flood levels of productivity. The indirect flood damages to the community include the loss of production, revenue and wages, which occurs during the flood and the post-flood recuperative phase. Indirect damages also arise in a number of other ways. For example, the disruption and diversion of traffic, both during and immediately after a flood, represents another indirect loss.

Indirect residential damages may include clean-up costs, loss of wage or salary, cost of removal, accommodation, inconvenience, and loss of amenity. Inconvenience and loss of amenity includes such factors as possible loss of schooling, the loss of personal mementoes, cancellation of social events and the like, many of which are intangible losses which are very difficult to quantify.

Indirect commercial damage may include costs of removal and storage, loss of business confidence and loss of trading profit. Smith's study of Lismore (1980) found that indirect costs were 18.5% of direct damage suffered by the commercial sector and 35% in the industrial sector. It is normal to include clean-up costs as a direct damage. If it is incorporated into the equation as a percentage of indirect costs, then the indirect costs can be up to 25% of the total direct costs (Smith 1980).

Actual & Potential Damages

Damage estimates based on the costs arising from an actual flood event are referred to as actual flood damages. Actual damages are often less than potential damages due to actions taken to reduce flooding after flood warnings are issued. The data available for an actual damages study are in general more reliable than those used in a potential damages study. In the actual damage situation the areas, depths and duration of flooding and the number of properties inundated can usually be estimated reliably.

Financial costs are more accurate when based on damage sustained during an actual event.

Commercial/Industrial

For the purposes of calculating the commercial/industrial damages, damages were estimated based on values provided by business operators from commercial surveys undertaken as part of previous floodplain management studies conducted primarily in NSW by professional services firm SMEC.

These include the Gunnedah Floodplain Management Study (SMEC 1999), Upper Nepean River Floodplain Management Study & Plan (SMEC 2001), the Wollondilly River and Mulwaree Chain of Ponds Floodplain Management Study and Plan (SMEC 2003) and the Cowra and Gooloogong Floodplain Management Studies (SMEC 2006).

The damage curves for each business were collated from data on the estimated value of damage sustained through the various components of a business. These components were:

- Stock;
- Fittings;
- Fixtures;
- Wiring;
- Equipment;
- Electrical; and
- Other.

Infrastructure / Public sector

A major component of infrastructure damage is concerned with transport - damages to roads, bridges and culverts and locally to rail and air connections where applicable. Other losses are to services such as water, sewage treatment plants, gas, electricity and telephones. The variability in terms of location, the period of inundation, problems of sedimentation and erosion are such that no standard technique is possible. Australian and international literature suggests that infrastructure damage is normally within the range of 7% to 20% of that to the private sector (DI Smith et al 1986).

In this study, specific data on previous flood damage to roads at Blackall was not available so the Rapid Appraisal Method for Floodplain Management (2000) was adopted for damage to roads. The Rapid Appraisal Method (RAM) uses a total cost per kilometre for a major, minor and unsealed road:

- Major sealed roads $32,000 per km
- Minor sealed roads $10,000 per km
- Unsealed roads $4,500 per km

This single estimate of cost per kilometre of road inundated includes:

- Initial repair to roads;
- Subsequent additional maintenance to roads;
- Initial repairs to bridges; and
- Subsequent additional maintenance to bridges.

The costs listed in the RAM report are based on the 1993 flood in North Eastern Victoria and the 1998 floods in East Gippsland.

Residential

For the residential properties, it was necessary to derive estimates of potential flood damage for a range of flood magnitudes. In addition, it was necessary to take account of community "flood awareness" and their experiences in coping with floods, that is, the higher the awareness and experience, the lower the ratio of potential damages to actual damages will be. Preparedness of a community is a function of both the turnover of the population and the time since the last flood. The higher the awareness and experience, the lower the ratio of potential damages to actual damages will be. A reduction factor is applied to reflect community flood awareness and flood warning procedures.

In Blackall, there is generally a reasonable level of flood awareness in the community with the last major event occurring in 2012. However, the Rapid Appraisal Method (2000) defines an inexperienced community as one that has not experienced a flood for five (5) years. Also historically, the community has had approximately 12 hours warning before the flood peak arrives in town. In reflection of this, the flood-warning ratio was assumed to be 0.7 based on a greater than 12 hour warning time with an inexperience community.

Flood Damage Estimates Derived

This study estimates the flood damage for a 2% AEP flood event (the closest exceeding AEP from the highest known flood April 1990 for Blackall) likely to occur in Blackall for the following two major damage categories:

- the **direct financial costs** of damage to property; and
- the **indirect financial costs** associated with the disruption of social, community, industrial and commercial relationships during the post-flood period. Indirect commercial damage may include costs of removal and storage, loss of business confidence and loss of trading profit.

For residential properties, direct damage estimates represent the sum of the structural, contents and clean-up cost components. The indirect damage estimates derived in this study are calculated as a percentage of the direct damages. The estimates also include consideration of the flood warning system presently in place and the reduction in potential flood damages that may be achieved with the warning system adhered to and adequate emergency procedures in place. The current residential indirect damages were estimated at 30% of the direct damages.

In evaluating property damage for residential the following equations were used:

For Depth of over floor flooding < 1 m

$$\boldsymbol{D = D_2\left(0.06 + 1.42H - 0.61H^2\right) R(1 + ID) + D_{CLEAN}}$$

For Depth of over floor flooding >1 m

$$D = D_2(0.75 + 1.12H)\ R(1 + ID) + D_{CLEAN}$$

Where **D** = Value of damage to property ($).

D_2 = Assessed value of residential property damage at 2 m depth of flooding (H) ($).

H = Depth of over floor flooding (m).

R = Reduction factor by virtue of a flood warning provision. 0.7 was adopted in this study.

ID = Indirect damage factor. 0.25 was adopted for the Blackall study.

D_{CLEAN} = Clean-up cost ($).

The values adopted are given below in Table 1:

Table 1: Adopted internal, external and structural residential property damages values

RESIDENTIAL PROPERTY TYPE	INTERNAL	EXTERNAL	STRUCTUAL
Low value property	$9,698	$1,062	$4,892
Medium low value property	$11,625	$1,275	$6,330
Medium value property	$14,535	$1,575	$8,445
Medium high value property	$16,860	$1,845	$10,575
High value property	$20,055	$2,205	$13,725

Only occupied properties (i.e. with dwellings) were considered, and for lots inundated but the dwelling not inundated only the external damage value was considered.

The aged care facility was considered as a commercial property despite it performing a residential function.

To make an allowance for the difference in comparable "size" between houses, flats and units, the following formulation was derived:

$$D_2 = X\ (Int + Ext) + (Y\ \times Struct)$$

Where **D2** = Annual assessed value of residential property at 2 m depth of flooding (H) or size (S) ($).

X = Total number of units/flats located on title block.

Y = Total number of buildings which contain X.

Int = Internal property value ($).

Ext = External property value ($).

Struct = Structural property value ($).

To calculate the potential clean-up costs for residential properties, a clean-up equation was adopted as used in the 1999 SMEC study, River Torrens, Adelaide and adjusted to suit Blackall conditions:

$$D_{CLEAN} = \text{Daily Rate} \times \text{Z} \times \text{In}\ \left(\frac{H}{0.023}\right)$$

Where **D_{CLEAN}** = Potential clean-up costs ($).

Daily Rate = Earnings per day of one worker ($/day).

H = Depth of over floor flooding (m).

Z = Factor accounting for sediment load and deposition.

After consideration of other SMEC studies, Tamworth (PPK Consultants, 1993) and River Torrens (SMEC, 1999), a value of Z = 7 was adopted to account for sediment load and deposition and a daily rate of $70/day. This gave:

$$D_{CLEAN} = 490 \text{ In } \left(\frac{H}{0.023}\right)$$

Due to the inclusion of the natural logarithm function ln(A) in all equations used to evaluate damages, a value of 'A'< 1 would result in negative values creating instances of negative damages for small depths of over floor flooding ranges. Considering $\mathbf{D_{CLEAN}}$, if $\mathbf{D_{CLEAN}}$ is to be greater than zero, **H** must be greater than 0.023 m.

Accordingly, for depths of flooding between zero and (0.023 + 0.01) m (=0.033 m), $\mathbf{D_{CLEAN}}$ was estimated as if the depth, **H**, was in fact 0.033 m:

$$D_{CLEAN} = 490 \text{ In } \left(\frac{0.033}{0.023}\right) = \$176.90$$

For commercial and infrastructure calculations, an allowance for clean-up costs has been included in the indirect component. The direct damages were estimated based on curves relating flood height to level of damage sustained, then factored up by 25% for indirect damages. It is possible that the factors used in the estimation of indirect damages underestimate the true value of these damages.

The current estimates are based on previous studies and experience, as the true value could only be determined by a detailed survey of business owners to determine the actual costs incurred to their business during the 2012 flood.

Estimation of Flood Damage

A variety of factors affect the flood damage caused to a particular piece of property. For the purposes of this Study and Plan, the following three factors have been used to predict direct potential flood damages:

- the use to which the land is put (hereinafter referred to as land use);
- the "size" of the buildings and other improvements associated with the land use; and
- the depth of flooding.

Land in Blackall is used for a variety of purposes, such as residential, commercial, industrial and recreation. Flood damage varies with land use.

The amount of damage that occurs on a particular piece of land tends to increase with the "size" or "scale" of the operations undertaken with, other factors remaining constant. Measures of property size can include annual assessed value ($) as the measure of size for residential and recreational property and floor area (m^2) for all other types of property.

For this study, damages for commercial properties were based on an extensive database of actual and potential damages from previous studies undertaken (Upper Nepean, SMEC 2001; Gunnedah, SMEC 1999, Wollondilly River SMEC 2003). This information was analysed and estimates of damage for various components of each business was made e.g. stock, fittings, fixed or moveable machinery, etc. for a 2% AEP flood event.

All commercial properties were divided according to a business category, and by summarising the above data, an estimate of average damage made for each category. Parkland and other public space with infrastructure was considered as commercial property (i.e. non-residential)

For this study, the damage estimates applicable to residential properties were based on published data relating to flood damages and a desktop survey of properties in Blackall undertaken by the project team. A damage curve was assigned to each residential property, which estimates the structural, contents and external costs. These curves were taken from the previous studies.

Dwellings on properties shown to be subject to inundation for a 2% AEP flood event were examined in the desktop exercise and data focussing on the following derived:

- type of property (house, unit, etc.);
- estimation of height of floor;
- construction type;
- estimated age of building;
- estimated size of building; and
- estimated value of building.

Average Annual Potential Damages

Average Annual Potential Damage (AAD) is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period and assumes that development is constant over the analysis period. It has been calculated using the total financial potential damages (direct and indirect costs). Effectively, AAD is the area under the curve when these two variables are graphed.

Flood damages for existing conditions in Blackall to residential properties are given in Table 2, damages to commercial/industrial properties are given in Table 3 and damages to infrastructure are given in Table 4. A summary of the AAD for each sector is given in Table 5.

Based on these calculations, the total AAD for the existing Blackall township is estimated to be $324,000 (in round terms).

Table 2: Estimated potential flood damages - Existing - Residential

AEP	CHANCE OF OCCURRENCE IN ANY 1 YEAR PERIOD	DAMAGE ($)	NUMBER OF PROPERTIES AFFECTED	NUMBER OF HOUSES AFFECTED
5%	1 in 20	$859,900	80	31
2%	1 in 50	$1,247,900	93	43
AVERAGE ANNUAL DAMAGE		**$67,900**		

Table 3: Estimated potential flood damages - Existing - Commercial/Industrial

AEP	CHANCE OF OCCURRENCE IN ANY 1 YEAR PERIOD	DAMAGE ($)	NUMBER OF PROPERTIES AFFECTED	NUMBER BUILDINGS AFFECTED
5%	1 in 20	$3,330,000	57	41
2%	1 in 50	$4,061,000	64	50
AVERAGE ANNUAL DAMAGE		**$247,800**		

Table 4: Estimated potential flood damages - Existing - Infrastructure

AEP	CHANCE OF OCCURRENCE IN ANY 1 YEAR PERIOD	DAMAGE ($)
5%	1 in 20	$112,100
2%	1 in 50	$138,500
AVERAGE ANNUAL DAMAGE		**$8,400**

Table 5: Average annual potential damages

SECTOR	AAD
Residential	$67,900.00
Commercial / Industrial	$247,800.00
Infrastructure	$8,400.00
TOTAL	**$324,100.00**

It should be noted that these estimates are potential damages and do not necessarily reflect actual damages that may occur during a flood. Community awareness and the actions of emergency services, the evacuation of residents and their property and, most especially, the evacuation of goods and equipment from commercial properties in the flood-affected areas will significantly reduce the level of flood damage.

Furthermore, such figures presented are considered very limited in their reliability due to the range of estimations and assumptions, for example regarding estimated values of buildings etc. and should be used with great caution. Improvement in reliability can be achieved with further work involving field (floor height, GFA measurement etc.), a financial valuation survey of inundated properties and properties and dwellings including and a business survey.

Appendix References

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SMEC (1999) River Torrens Flood Inundation Mapping Study, Prepared for the South Australia Flood Warning Consultative Committee

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SMEC (2003), Wollondilly River and Mulwaree Ponds Floodplain Risk Management Study and Plan, Prepared for Goulburn City Council.

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Smith, (1980) The Assessment of Urban Flood Damage in Australia: Methods, Problems and Recommendations, CRES, ANU, Australian Water Resources Council, Proceedings of the Floodplain Management Conference, Canberra, Australia, 7-10 May 1980.

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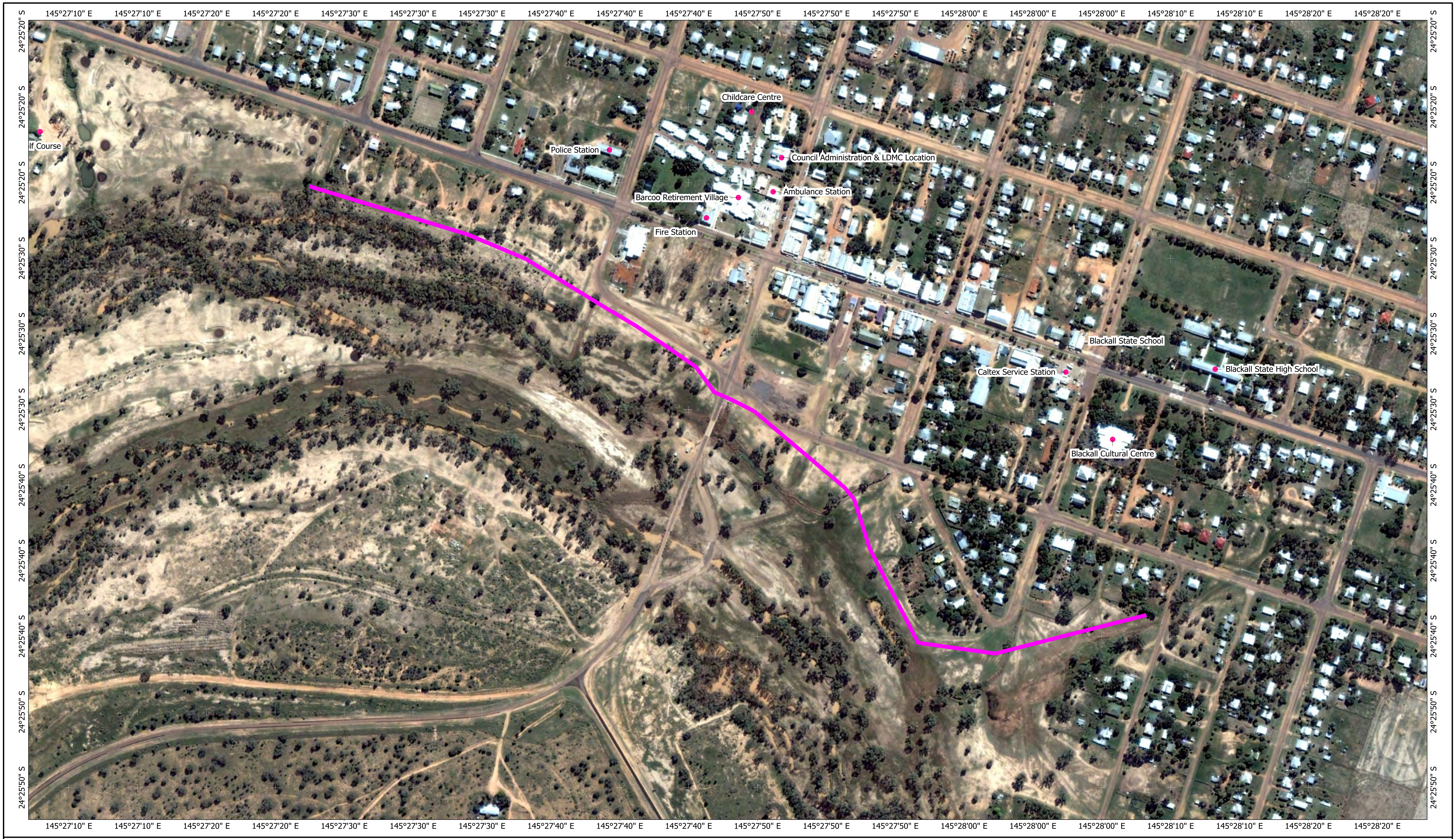
Appendix B

INDICATIVE ALIGNMENT OF LEVEE & BARRIER OPTIONS



Map 16: Indicative Alignment of Permanent CBD Levee

Job: J13_16_Blackall Flood Risk Management Study
Client: DC Solutions & Blackall Tambo Regional Council

Points of Interest

N

Datum: World Geodetic 1984 (WGS84) Auto
Coordinate System: Mercator
Scale: 1:6000 printed on A3

0 300 m

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Map 17: Indicative Alignment of CBD Mobile Flood Barrier

Job: J13_16_Blackall Flood Risk Management Study
Client: DC Solutions & Blackall Tambo Regional Council

● Points of Interest

N

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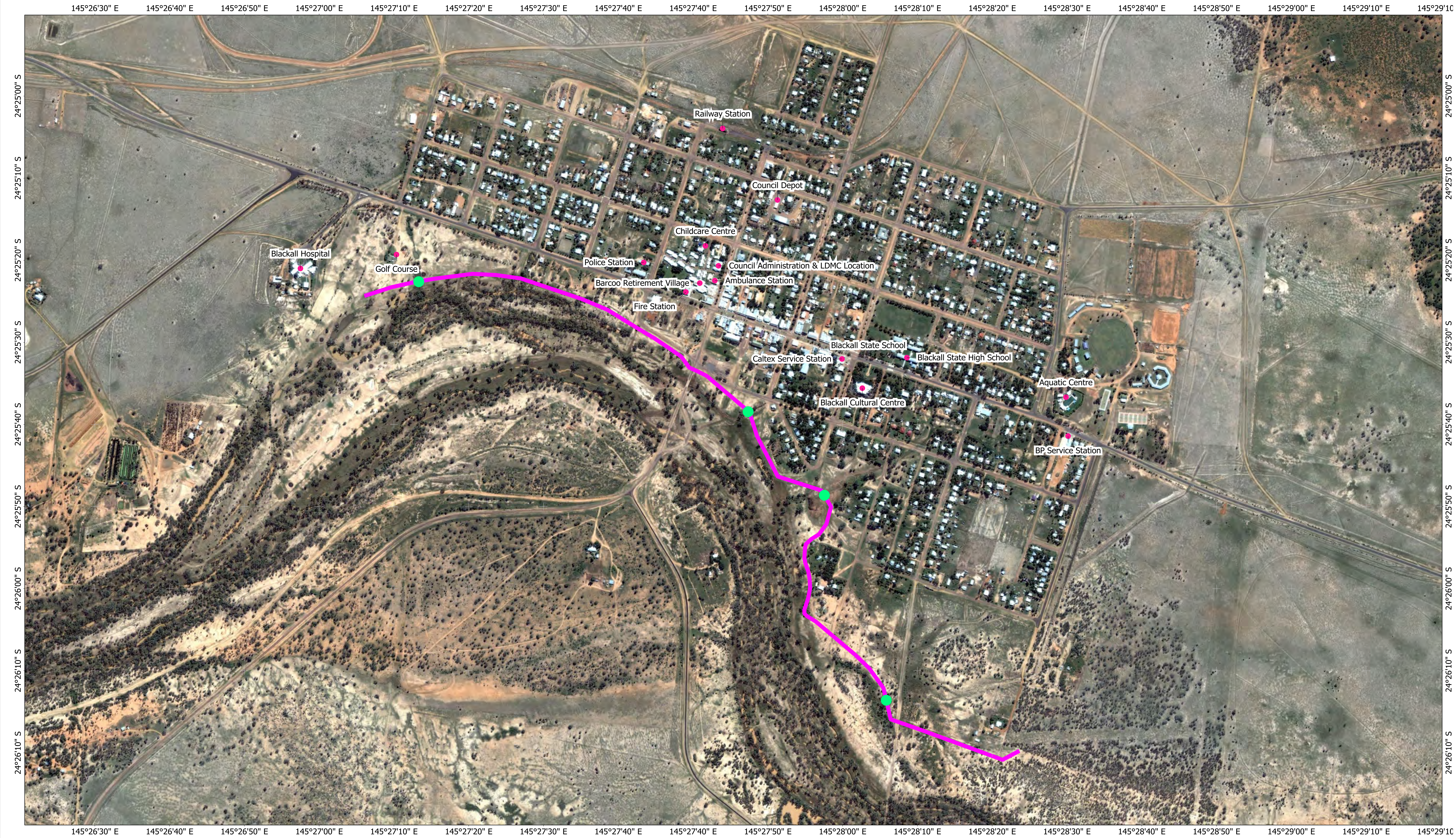
Coordinate System: Mercator
Scale: 1:1200 printed on A3

0 100 m



Map 18: Indicative Alignment of Permanent Township Levee

Job: J13_16_Blackall Flood Risk Management Study
Client: DC Solutions & Blackall Tambo Regional Council

- Points of Interest
- Flood Gate

N

Datum: World Geodetic 1984 (WGS84) Auto
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0 600 m

Date Produced: 17/06/2014 12:21:18 PM By: administrator WorkStation: CENTRALSERVER FilePath: Y:\YARRAMINE\JOBS\2013\J13_16 - Blackall Flood Mitigation Studies - DC Solutions\Mapping Files\GIS Data\Blackall.map Printer: Samsung CLX-6200 Series Contact Details: Yarramine Environmental PO Box 2588 TOOWOOMBA QLD 4350 (07) 46382442 www.yarramine.com.au

Appendix C

OPPORTUNITIES & DRAWBACKS OF MOBILE FLOOD BARRIER SYSTEMS

Opportunities and Drawbacks of Mobile Flood Protection Systems

Introduction

Mobile flood protection systems are one possible mitigation measure that could be employed by Blackall Tambo Regional Council for flood protection.

Such systems are especially useful in densely populated areas where no space for permanent structures is available. In addition, permanent structures may obstruct heavily the view onto the water body. In these cases, mobile flood protection measures may be a solution to fit both requirements: protection in case of flooding and open access to the floodplain over the remaining time.

Furthermore, mobile protective systems can be used as emergency tool against flooding in unprotected low-lying areas and for heightening of permanent flood protection structures in extreme events.

Mobile flood protection systems differ in material, construction, permanent facilities, and available protection height. This Appendix provides a brief description and assessment of different mobile protection systems.

Planning for Mobile Flood Protection

When considering the use of mobile flood protection systems, safety-related aspects, in particular need to be considered. The mode of operation, construction and the usable materials are dependent on available early warning time, static and dynamic loads from water level, waves and flotsam impact as well as physical stresses due to weathering effects and required protection height.

Beside the general stability with regard to static and geotechnical aspects, the risk of failure of mobile protection systems is mainly dependent on the possibility of a safe assembly of the system. Important parameters include early warning time, number of skilled helpers mobilised in a short time as well as manageability of protective components even under bad weather conditions.

A strict assembly schedule is mandatory based on locally defined threshold values of forecasted water levels defining action steps. The assembly schedule of mobile flood protection must not leave to the discretionary power of the decision maker.

Overall, a low failure risk of mobile flood protection can only be guaranteed if technical components as well as administrative conditions are suitably designed and followed.

Types of Application

Mobile flood protection systems can be designed in two ways: with or without permanent provisions.

Mobile systems equipped with permanent provisions are attached to a certain protection line, whereas the location for the installation of mobile systems without permanent provisions can be selected freely.

Nevertheless, it is also possible to install the latter on a predefined location similar to systems with permanent provisions.

In case of using stationary mobile systems with permanent provisions or mobile systems without permanent provisions but with a predefined location of installation, the alignment of the protection line is known in advance. In these circumstances, it is possible to gather information about conditions to guarantee a smooth installation and operation of the system.

For example, it is possible to ensure that buildings do not obstruct the protection line and the local topography and soil conditions allow the use of the protection system. Additionally, the planned deployment at a specific location enables the storage of system components close to the protection line and facilitates the provision of transport equipment adequate to the system as well as to the deployment area.

In case of emergency use of mobile systems without permanent provisions at locations not known in advance, none or only little information on local conditions is available. Important information includes details regarding soil conditions with respect to geotechnical load capacity and permeability (buoyant safety, hydraulic base failure, safety against erosion), topography, existing installations (pipe culverts, walls) as well as water bypaths (sewage systems, trenches).

In these circumstances, it is not possible to adapt the system as well as the location to the anticipated operating conditions prior to the flood event. Furthermore, the installation of the system has to be designed at short notice by the relevant officer-in-charge.

Deployment Time

The time-period for deployment of mobile flood protection includes:

- *Alarm time* – time between announcement of an alarm and operational readiness of the personnel;
- *Loading time* – time required for loading of the mobile system components and installation equipment on the means of transport;
- *Transport time* – driving time from the storage location to the protection line;
- *Safeguard / unloading time* – time for safeguarding the traffic lines and for unloading the means of transport at the protection line;
- *Installation time* – time for preparation of the surface at the protection line and for installation of the mobile system including time span to control the correctness of installation

The deployment time varies with type and length of mobile system, lengths and condition of transport ways as well as number and qualification of available personnel.

What also drives deployment time is early warning times (i.e. sufficient warning is required for sufficient deployment to occur). Generally early warning times of less than 12 hours would require usually a large number of at short notice available personnel, short transport ways, and a small numbers of components or a high pre-installation grade of the mobile system.

Financial Aspects

The costs of mobile flood protection are normally higher than permanent flood protection measures with comparable safety standard and protection line coverage, however flood protection systems are generally more affordable when considering initialisation costs and the time to be ‘flood ready’.

For mobile flood protection systems, the following cost types can be distinguished:

- *Planning costs* including examination of natural (frequency of flood water levels, loads) and social conditions (damage types and potential, deployment of personnel), objective definition (degree of protection), selection and assessment of appropriate system (analysis of system types), design and layout of selected system.
- *Purchase costs* including - if applicable - purchase and preparation of building ground (levelling, installation of permanent components), purchase of the system considering also weathering effects (lifetime), purchase of installation equipment (tools, means of transport, pumps, etc.).
- *Qualification costs* including theoretical and practical training of the personnel as well as information of the population
- *Allocation costs* including storage location and equipment.
- *Maintenance costs* including control and repair of the system.
- *Deployment costs* including personnel, transports, loss of components and equipment.

Personnel

Required training of the personnel is dependent on the type of protection system and the available installation equipment, should also include scenario and correct behaviour in case of overtopping, and anticipated system failure.

The number of required personnel is dependent on type and length of the protection system, available equipment, distance between storage and protection line, and duration of available early warning time.

Attention should be paid to the fact that the mobile system not only has to be installed but also observed and possibly repaired during the deployment.

After the end of the flooding event the mobile components have to be uninstalled, cleaned, and stored.

Failure Types

Generally, the failure of mobile flood protection systems can be distinguished into five types:

- Sliding (also rolling);
- Tilting;
- Failure of stability (due to poor layout, capacity overload, or vandalism);
- Leakage without overall failure; and
- Geotechnical failure.

If the static friction between system and the contact point on the ground is not sufficient due to minor friction coefficient or small normal force (buoying upwards of the system), the system may slide in case of acting lateral loads from water levels, waves, currents and wind. A special case of sliding is the lateral rolling of cylindrical systems.

Leakages can occur especially at contact point with the ground and lateral connection surfaces resulting from design aspects or incorrect installation.

Minor leakages are normally acceptable whereas larger leakages with higher current velocities may soak the underground leading to wash out of soil at ground contact and consequently lead to stability problems.

Geotechnical failure occurs if the system possesses no stable foundation, unstable slopes exist in the protection line or the safety against hydraulic base failure or erosion is not guaranteed.

Repair of Leakages During Deployment

Mobile flood protection systems should offer the opportunity of repair smaller damages during deployment.

For this, additional components or system adapted repair kits containing repair materials and tools must be available. Additionally, training of personnel for repair situations is necessary.

Inspection Rounds

Once installed, regular inspection rounds for monitoring the protection line are necessary to ensure an early recognition of leakages, damages, dislocations, and deformations.

System Height

Generally, mobile systems offer only limited protection heights. The highest possible heights can be achieved with stationary mobile systems with permanent anchorage.

Depending on the system’s capacity for stability and geotechnical conditions at the protection line, system heights of several meters are feasible. The deployment of such high mobile systems though generally requires comprehensive design calculations and the preparation of a detailed installation schedule.

Lower maximum heights are recommended for systems without permanent provisions. These systems used on predefined locations may reach protection heights of up to 1.2 m and used on non-predefined locations as an emergency system of up to 0.6 m.

The latter recommended minor protection height is because in case of an emergency use of a non-stationary mobile system an examination of subsoil conditions is usually not possible within the available early warning time. The risk of hydraulic base failure in case of higher hydraulic gradients is significant.

As flood water level prediction is afflicted with uncertainties, flood water levels may occur lower or higher than predicted. Therefore system behaviour in case of overtopping must be considered in the selection of system type and operational planning for mobile flood protection.

Unfortunately, many mobile systems show unfavourable behaviour like sudden failure in case of overtopping and exceeding load capacities.

Element Weight

In mobile flood protection, large component sizes rationalise the installation works but complicate the transport and handling of components. Dependent on the type of equipment for handling and installation the weight and dimension of the components have to be defined.

In case of non-stationary use of the system, the components must be designed in such way, that four persons at a maximum are able to carry the structure over a distance of at least 30 meters without severe exhaustion. A maximum weight can be defined to 100 kg per component provided that the structure is equipped with carry handles for four persons.

Larger unit weights are possible if the location of deployment is known and means of transport with lifting devices can be used.

Pull Down & Storage

For pull down and cleaning it is estimated that twice to four times the amount of installation time will be necessary.

The kind of storage and the selection of storage location are dependent on the type of system and the available early warning time.

If a mobile system is designed for a predefined urban area where only short early warning times are available the distance between storage location and protection line must be short and the components have to be stored within the city centre.

In case of longer early warning times, the storage may also be chosen in a peripheral location offering the possibility of lower storage costs.

Emergency systems for non-predefined locations have to be stored at a central place of the deployment area equipped with good road links.

All mobile components and required tools and equipment must be stored at a dry, aired, and accessible place. Prior to storage, corrosion protection of metal components must be ensured by cleaning and possibly refreshment of protective layers. Special attention must be given to contact erosion between e.g. aluminium and steel.

Storage in dedicated transport containers where all components and required tools and equipment as well as spare parts are assembled, is advantageous.

Maintenance works include inspection, test-installation, and repair of the system. For this, system related maintenance schedules have to be compiled. Attention must be paid not only to the stored mobile components but also any permanent components at the protection line.

Test-installations have to be done regularly, usually once a year, for inspection of the components and for training of the installation works.

Types of Mobile Flood Protection Systems

Available mobile flood protection systems differ in material, construction, permanent facilities, and available protection height, and can be divided in stationary and non-stationary mobile systems (refer to Figure 1).

Stationary mobile systems may be partly or completely preinstalled whereas non-stationary mobile systems may be sub-divided in container, mass, flap, and wall systems.

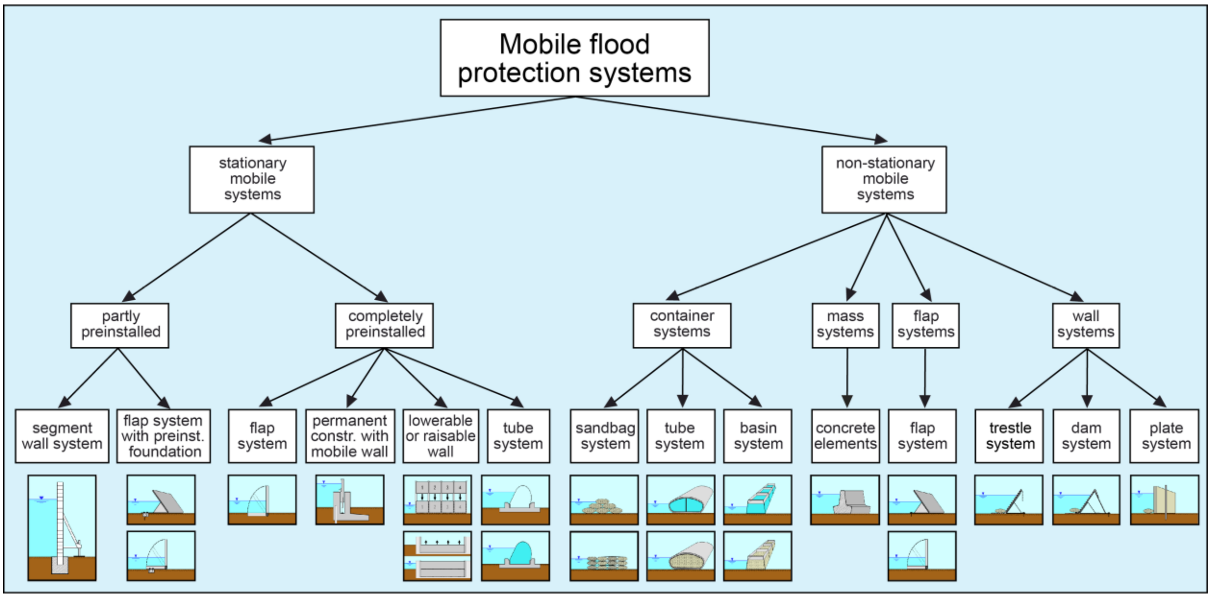

Figure 1: Classification of mobile flood protection systems

Completely Preinstalled Stationary Mobile Systems

Completely preinstalled stationary mobile systems are normally equipped with concrete foundations and mechanical systems to bring the mobile part of the system from the idle in the protection position. The investment costs are generally high for these systems.

Flap System

Completely preinstalled stationary mobile flap systems consist of a concrete foundation where pivoted flaps are stored at ground level that can be raised manually or mechanically in case of flooding (Figure 2).

Deep foundations offer better support and minimise water bypath. Therefore, the possible protection heights are larger in case of deep compared to shallow foundations. The latter offer advantages if pipelines or cables are crossing the protection line. The single concrete elements of the flap systems are 3 to 10 m long and up to 2.5 m high.

Figure 2: Completely preinstalled stationary flap system in Sinsheim near Heilbronn, Germany

Partly Mobile System

Partly mobile systems consist of permanent flood protection walls that can be raised by mobile segments that are stored inside the permanent construction during idle time (Figure 3).

The lateral loads have to be transferred completely by the bottom mounting or additional mobile lateral supports have to be installed. At any rate, the basic protection line must be strong enough to bear also the additional loads of the mobile section.

The combination of permanent and mobile flood protection elements offers the following advantages:

- Only minor obstruction of the view onto the water area during idle time;
- The protection line is fixed and reserved by the permanent basic protection (the alignment cannot be obstructed by parking cars etc.);
- Compared to fully mobile systems the available basic protection allows a later installation of the mobile system and therefore a better assessment of the flooding situation; and
- Compared to fully mobile systems fewer personnel are needed for the installation of the partly mobile system.

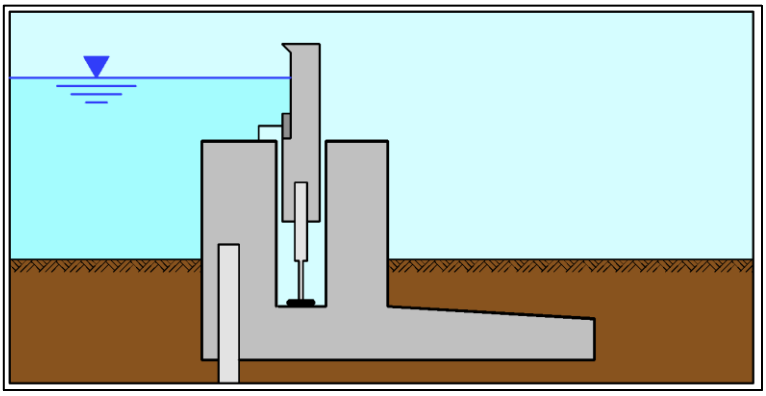

Figure 3: Examples sketch of a completely preinstalled stationary partly mobile system

Permanently Installed Lowerable Plat System

Permanently installed lowerable plat systems can be used to block road openings or doorways as well as to heighten permanent floodwalls. Depending on the type of application, the segments may be made of metal, glass or concrete.