Beaufort Floodplain Management Plan
Study Report

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GLOSSARY

Term	Description
Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded; it would be fairly rare but it would be relatively large.
ANUFLOOD	ANUFLOOD is an inter-active program designed to assess tangible urban flood damage. ANUFLOOD uses building descriptions (including location, ground and floor heights, construction material etc), stage-damage curves and flood level information to calculate flood damages. ANUFLOOD was developed during the 1980s and early 1990s at the Centre for Resource and Environmental Studies at The Australian National University.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	The average, or expected, value of the periods (in years) between exceedances of a given rainfall or flood event. It is implicit in this definition that the periods between exceedances are generally random. ARI is equivalent to 1/AEP and vice versa. i.e., a 100 Year ARI is equivalent to a 1% AEP, i.e., 100ARI = 1/0.01AEP
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. e.g. some roads may be designed to be overtopped in the 1 in 1 year or 1% AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse

	and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. The maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
GDA94	The Geocentric Datum of Australia (GDA) is the new Australian coordinate system, replacing the Australian Geodetic Datum (AGD).
High hazard	Possible danger to life and limb; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.

Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
IFD	Intensity Frequency Duration, method of determining design rainfalls according to procedures in Australian Rainfall and Runoff. This includes total rainfall for a given design (ARI) storm event and the pre-determined temporal pattern over which this rainfall is distributed.
LIDAR	**L**ight **D**etection **a**nd **R**anging is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal. Also known as Aerial Laser Scanning (ALS).
Low hazard	Should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Hydraulic model	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
RAM	**R**apid **A**ppraisal **M**ethod for Floodplain Management, is a guide for calculating flood damages based on broad criteria rather than specific property-based methods such as ANUFLOOD.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'.. Both are measured with reference to a specified datum

Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area

ABBREVIATIONS

AEP	Annual Exceedence Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
GHCMA	Glenelg Hopkins Catchment Management Authority
PSC	Pyrenees Shire Council
DSE	Department of Sustainability and Environment
EPA	Environment Protection Authority
NRE	(Department of) Natural Resources and Environment
SRWSC	State Rivers and Water Supply Commission
VicSES	Victorian State Emergency Service
RWC	Rural Water Commission

1. INTRODUCTION

This report outlines the investigations undertaken for the development of the Beaufort Floodplain Management Plan. This floodplain management plan will aid the Glenelg Hopkins Catchment Management Authority (GHCMA) and Pyrenees Shire Council (PSC) in fostering sustainable use and development of the Beaufort floodplain areas.

The Beaufort Floodplain Management Plan draws its' underlying principles from the Best Practice Principles for Floodplain Management in Australia (CSIRO 2000) and Victoria Flood Management Strategy (DNRE 1998). In particular the Victoria Flood Management Strategy (DNRE 1998) provides the following vision for the sustainable use of floodplain and the responsible management:

- Local communities participate in flood risk decisions
- Land use planning measures minimise future flood risk and damages
- Structural flood mitigation measures reduce flood risk and damages, and acceptable to the local community
- Flood warning and emergency planning measures minimise risk to health, life and safety of the community.

A study team lead by Water Technology was commissioned to undertake the Floodplain Management Plan for the PSC and GHCMA. The study team carried out the investigations in accordance with instructions from PSC. Michael Cawood and Associates prepared the flood response aspects and assisted in the flood warning aspects.

The structure of this report is as follows:

- Section 2 Study background – provides study context and background.
- Section 3 Current flood behaviour – outlines previous flood related investigations and the key flood behaviour characteristics.
- Section 4 Existing floodplain management arrangements- discusses the current floodplain planning framework, and flood warning and response arrangements.
- Section 5 Structural mitigation measure identification and detailed assessment – provides an initial assessment of potential structural flood mitigation measures and detailed assessment of feasible structural mitigation options
- Section 6 Non-structural mitigation measure identification and detailed assessment – identifies and assesses of non-structural flood mitigation measures.
- Section 7 Floodplain management plan – details the key elements of the Beaufort Floodplain Management Plan

2. STUDY BACKGROUND

The township of Beaufort has a population of approximately 1,500 (ABS, 2006 Census) and is situated some 45 km west of Ballarat on the Western Highway, midway between Ballarat and Ararat. It is situated within a circle of hills, at the confluence of Ding Dong, Cemetery, Cumberland and Yam Holes Creeks. Yam Holes Creek is the main waterway through the town and a major tributary of Mount Emu Creek. The confluence of Yam Holes Creek with Mount Emu Creek is approximately 10 km downstream of the Beaufort township. Mount Emu Creek is a major tributary of the Hopkins River which flows into the Southern Ocean just east of Warrnambool. Figure 2-1 displays the study area for the Beaufort Floodplain Management Plan.

The Beaufort township suffers significant inundation in moderate to major flood events. There is only limited information available for historic flood events in this area. The closest gauge is at Mena Park on Mount Emu Creek, approximately 17 km downstream of the confluence with Yam Holes Creek.

The Beaufort Flood Study (Water Technology 2008) was undertaken by the Glenelg Hopkins CMA in conjunction with the Pyrenees Shire Council. This study investigated the potential exposure of Beaufort to flood risks from Yam Holes, Ding Dong, Cemetery and Cumberland Creeks.

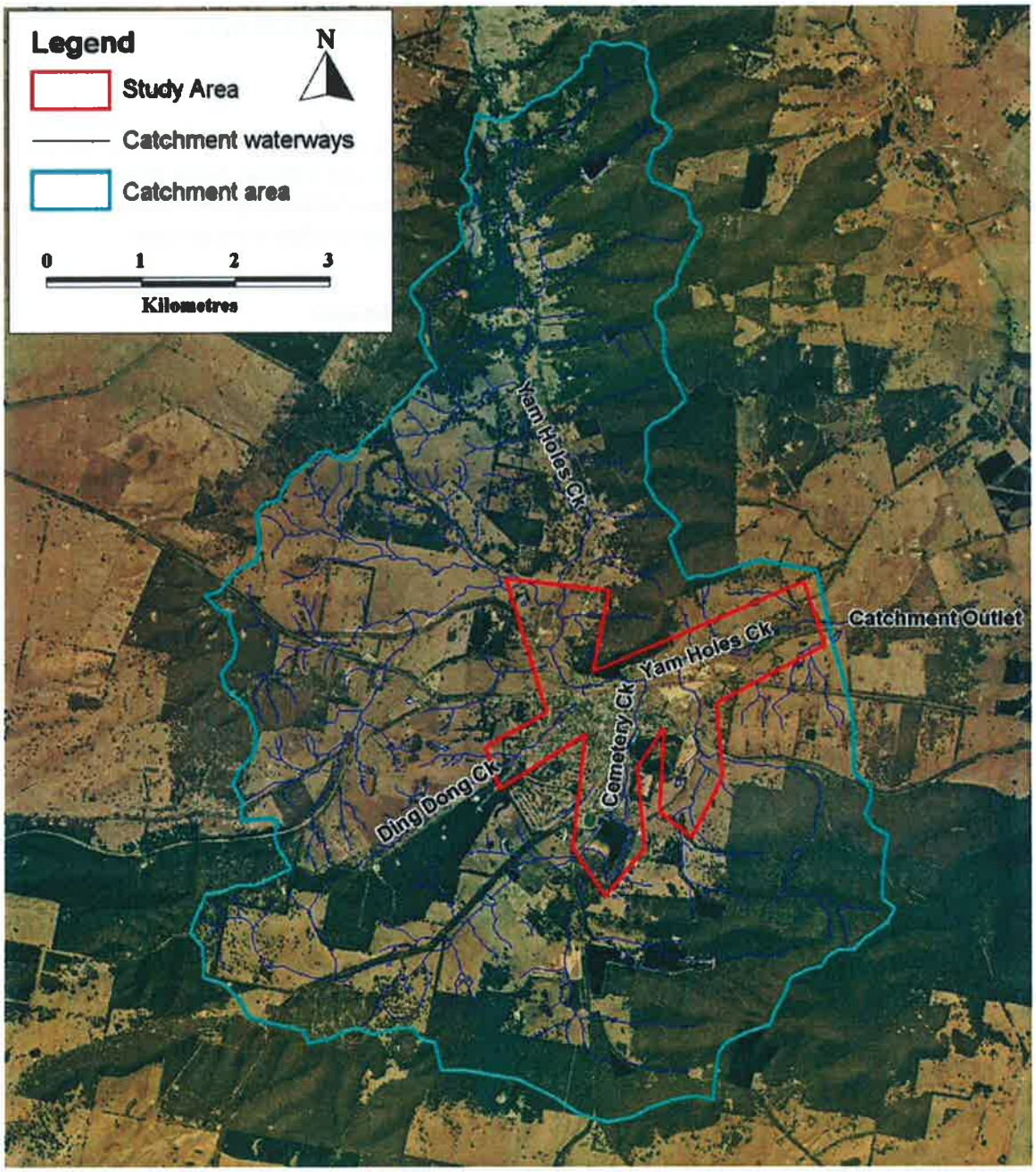


Figure 2-1 **Beaufort Floodplain Management Study area**

3. FLOODPLAIN MANAGEMENT ARRANGEMENTS

3.1 Overview

The Beaufort Floodplain Management Plan draws its' underlying principles from the Best Practice Principles for Floodplain Management in Australia (CSIRO 2000) and Victoria Flood Management Strategy (DNRE 1998). In particular the Victoria Flood Management Strategy (DNRE 1998) provides the following vision for the sustainable use of floodplain and the responsible management:

- Local communities participate in flood risk decisions
- Land use planning measures minimise future flood risk and damages
- Structural flood mitigation measures reduce flood risk and damages, and acceptable to the local community
- Flood warning and emergency planning measures minimise risk to health, life and safety of the community.

The plan has been developed in consultation with the study's reference committee and the broader community. The plan focuses on the reduction of future flood damages through appropriate land use and development controls. The plan provides for the construction and operation of structural mitigation measures where deemed appropriate. Also the plan acknowledges the roles and responsibilities of various agencies (PSC, Victoria Police and VicSES) in flood emergency response and seeks to minimise danger to the various agencies personnel through appropriate land use and development.

3.2 Floodplain planning framework

This section summarises the key elements in the current floodplain planning framework employed throughout Victoria and particularly for Beaufort.

The Victoria Flood Management Strategy (VFMS) (DNRE 1998 a) provides the principal framework for floodplain management in Victoria. The strategy outlines the roles of key agencies at a state, regional and local scale in floodplain management. In particular, the strategy defines the regional and local planning roles within the floodplain management framework.

At a ***state government*** level, the strategy identifies the relevant state legislation, policies and strategies as the underlying foundation for floodplain planning. In particular, state legislation provides statutory authority to regional and local authorities. The state agencies, principally the Department of Sustainability and Environment (DSE), co-ordinate and facilitate floodplain planning practice across the state. The following acts and strategies form the underlying legislative and policy framework for floodplain planning at a state level:

- *Catchment and Land Protection Act 1994 (CALP)* – Establishes the Glenelg Hopkins Catchment Management Authority as the responsible floodplain management authority
- *Water Act 1989* – Defines the Glenelg Hopkins Catchment Management Authority floodplain management functions
- *Planning and Environment (Planning Schemes) Act 1996* - Establishes two clear levels of planning policy within the overall state planning framework, State Planning Policy Framework (SPPF) and Local Planning Schemes. Also provides for specific flood management related planning zones and overlays in local planning schemes.
- *Victoria Flood Management Strategy (VFMS) 1998* – Establishes effective flood management by providing a consistent, state-wide framework for the management of flood related issues. Adopts a risk management approach to floodplain management where the likelihood and consequence of flooding are integral to defining appropriate actions and responses.

- *Victorian River Health Strategy 2002* - Provides an overall framework for the management of rivers within Victoria comprising of the strategic background, vision for management and river restoration, integrated management framework, specific management issues and management arrangements. Specifies how the various natural resource management agencies in Victoria should work in an integrated way to provide for the maintenance and improvement of river environments.
- *Victoria Planning Provisions* - Define the framework for local government planning schemes. Establishes provisions for the management of flood risk within the planning scheme
- *Victoria Planning Provisions:* Practice Notes Provide guidance to councils, referral authorities and applicants regarding the application of the flood related provisions. General set of development requirements for appropriate development is provided. However, it is noted that the further consideration of local flooding behaviour is required to establish appropriate local development controls. The Department of Infrastructure has prepared the following practice notes:
    1. Applying for a planning permit under the flood provisions: A guide for councils, referral authorities and applicants (DoI 2000a)
    2. Applying the flood provisions in planning schemes: A guide for councils (DoI 2000b)

At a ***regional scale***, the strategy identifies the regional catchment strategy and regional floodplain management strategy prepared by the catchment management authorities (Glenelg Hopkins CMA) as the principal regional planning instruments. These regional strategies provide strategic direction and governing philosophies for catchment and floodplain management. The following briefly outlines the key aspects of the regional catchment and floodplain management strategies:

- *Glenelg Hopkins CMA Regional Catchment Strategy 2003-2007* - Provides long-term direction for managing the future of land, water resources, and biodiversity of the Glenelg Hopkins catchments, and the foundation for investment decisions to ensure improved natural resource outcomes. The Regional Catchment Strategy (RCS) (GHCMA 2003) identified deficient floodplain management as a key catchment management issue. As part of the RCS, the CMA goals are to:
    - Involve the community in decisions relating to natural resource management.
    - Promote sustainable development of natural resource-based industries
    - Collaborate with industry and economic development organisations in achieving sustainable and profitable development of catchment communities
    - Maintain and improve the quality of water and condition of rivers
    - Prevent and where possible, reverse land degradation (including salinity control)
    - Minimise damage to natural ecosystems and natural resource-based industries caused by pest plant and animals
    - Minimise damage to public and private assets from flooding and erosion
- *Glenelg Hopkins CMA Regional Floodplain Management Strategy, 2003*- Provides the strategic direction for future floodplain management in the Glenelg Hopkins region. The strategy aims to minimise flood risk and promote sustainable use of the floodplains in the region through community involvement and best management. The objectives of the strategy are as follows:
    - To protect private and public assets from the impact of flooding, through management of mitigation assets
    - To protect public and private assets from flood damage through ensuring that all waterways have the 100 year ARI flood levels mapped and incorporated into planning schemes
    - To improve management of floodplains through the assessment of the social, economic, environmental benefits, and costs of floodplain land use and functionality

- To ensure sustainable development of floodplains through the development of decision tools to incorporate flood risk into development and land use Practices
- To protect public and private assets from flood damage through developing flood warning systems and processes

At a ***local scale***, the VFMS identifies the municipal strategic statement and the municipal planning scheme prepared by the municipal authority (Pyrenees Shire Council) as the local planning instrument. The following briefly outlines the key flood related aspects of the municipal strategic statement and the municipal planning scheme:

- *Pyrenees Shire Planning Scheme*: *State Planning Policy Framework*- defines underlying state-wide floodplain management principles and objectives
- *Pyrenees Shire: Municipal Strategic Statement*: concise statement of the key strategic planning, land use and development objectives for the municipality and the strategies and actions for achieving these objectives
- *Pyrenees Shire: Local Planning Policy Framework* – defines flooding risk through the delineation of Urban Floodway Zone (UFZ) Floodway Overly (FO) and Land subject to Inundation (LSIO). Specifies requirements for development/works within the UFZ, FO and LSIO.

3.3 Flood forecasting and warning arrangements

Flood warning systems are aimed at enabling and persuading people and organisations to take action to increase personal safety and reduce both the tangible and intangible damage caused by floods. They are an integral part of emergency and floodplain management (VFWCC 2005).

The total flood warning system concept has been developed to represent the many elements that need to come together to characterise an effective flood warning system (VFWCC 2005).

The effectiveness of a flood warning system can be measured by considering whether people (VFWCC 2005):

- Have received accurate and timely information;
- Have understood that information and appreciate what it means for them;
- Have been prompted to initiate suitable actions (eg, avoid flooded/closed roads, move property and/or livestock, evacuate to a suitable location, etc) within timeframes appropriate to the circumstances.

Emergency Management Australia (EMA, 1999b) considers there to be six building blocks within a flood warning system. These building blocks need to be appropriately developed and integrated to provide a successful and effective flood warning system. Such a system considers not only the production of an accurate and timely forecast but also the efficient dissemination of that forecast to response agencies and the threatened community in a manner that elicits an appropriate response. An informed and flood aware community is more likely to receive the full benefits of the warning system (VFWCC 2005).

Experience shows that in the past flood warning systems were not generally designed in an integrated manner and over-emphasised flood forecast production at the expense of attention to message construction, warning dissemination, local interpretation and community response (VFWCC 2005).

In the context of this Floodplain Management Plan, flood forecasting and warning arrangements are considered to encompass the data collection networks that support such arrangements as well as the prediction of flood peaks and timings, the interpretation of flood extents and related impacts, and the preparation of flood warning messages for dissemination to relevant agencies and the

community. Current flood forecasting and warning arrangements for Victoria are outlined in VFWCC (2001).

The Bureau of Meteorology does not provide a flood warning service for the creeks surrounding Beaufort.

Section 5.3 discusses potential improvement to the flood warning arrangements as part of the floodplain management plan.

3.4 Flood response arrangements

The Emergency Management Act (1986) requires local government to prepare and maintain a Municipal Emergency Management Plan (MEMP). The MEMP provides the overarching framework for emergency management at the local level. Local government is also required, through the Community Emergency Risk Management (CERM) process, to identify and plan for credible and location specific risks which have the potential to impact significantly on the local community. These particular risks are addressed via sub-plans within the MEMP.

Section 5.3 discusses possible improvements to existing flood response arrangements.

4. STRUCTURAL MITIGATION MEASURE IDENTIFICATION AND ASSESSMENT

4.1 Overview

Mitigation measures provide a means to reduce the existing flood risk (often measured in terms of tangible damages via the Average Annual Damage, AAD). Mitigation measures can reduce existing flood risk by lowering the likelihood of flooding and/or lowering the flood damages (consequences) for a given flood depth. Mitigation measures can be broken into:

- Structural – Physical barriers or works designed to prevent flooding up to a specific design flood standard. Structural measures aim to reduce existing flood risk flood by lowering flood likelihood at given locations. Structural works may include levees, floodways waterway works, improvements to hydraulic structures.
- Non-structural- Management and planning arrangements between relevant authorities designed to reduce related flood damages. Non-structural measures aim to reduce existing flood risk flood by lowering flood damage. Non-structural measures may include land use planning, flood warning and flood response

This section deals only with structural mitigation measures. Non-structural measures are discussed in Section 5.

4.2 Preliminary identification and assessment

4.2.1 Overview

A principal design consideration for structural mitigation measures is the level of flood protection (design standard) to be provided. As the elimination of all flood related damages is typically not feasible due to hydraulic, physical and cost constraints.

The Beaufort Flood Study (Water Technology 2008) identified the number of properties affected during flood events ranging in magnitudes from a 5 year to 100 year ARI, plus the Probable Maximum Flood (PMF). Table 4-1 shows the number of flood affected properties predicted.

Table 4-1 Flood affected properties

Item	Design Flood ARI (years)					
	5	10	20	50	100	PMF
Properties Flooded Above Floor	12	21	31	32	41	211
Properties Flooded Below Floor	169	176	178	179	173	50
Total Flooded Properties	**181**	**197**	**209**	**211**	**214**	**261**

Table 4-1 shows that the total number of properties affected in a 5 year event is 181 properties, compared to 214 properties in the 100 year event. The average annual damages were estimated at $383,000 (Water Technology 2008). The damages in the 5 and 10 year events contribute approximately $140,000 or 36% to the average annual damages.

Hence, targeting structural mitigation measure at minimising flood related damage for the 5 and 10 year events can have a significant contribution to the overall reduction of flood damages. The targeting of large flood events (20 year and greater) as the design standard is considered likely to prove impractical. This is due to adverse hydraulic impacts (considerable increase in flood levels or flows across private property), practical construction and implementation limitations (adverse impacts on property egress and street traffic-ability, impacts on underground services) and cost constraints.

This study has considered mitigation measures targeted on both frequent and large flood events.

4.2.2 Criteria applied to the preliminary feasibility assessment of structural flood mitigation measures

As part of Melbourne Water's redevelopment drainage services program, Melbourne Water has developed preliminary feasibility criteria for structural mitigation measures. This framework examines hydraulic, environmental, cultural and social aspects. This study has employed the Melbourne Water framework as a means of preliminary assessment. Key aspects include:

- Hydraulic performance (reduction in flood depths, peak flow, hazard)
- Public safety (flood depth and flow velocity)
- Community impact (recreational facilities, amenity, adjacent landholders, cultural)
- Environmental consideration (removal of vegetation, waterway habitat)

This preliminary assessment identified potential mitigation measures as feasible or non-feasible based on a broad assessment of hydraulic, economic, environmental and social aspects.

4.2.3 Preliminary measures considered

A range of structural mitigation measures were assessed for the various waterways against the above criteria. This preliminary assessment identified feasible measures, considered to warrant further investigation. The details of this preliminary assessment are listed in Table 4-2, and shown in Figure 4-1, Figure 4-2 and Figure 4-3.

From the feasible mitigation measures, six mitigation options were investigated, as detailed in Section 4.3.

Table 4-2 Structural mitigation measures – preliminary assessment

Measure	Preliminary assessment	Feasible measure
Ding Dong Creek		
Upstream retarding basin: Gregory Street, South Street & Riffle Butts Road	Hydraulic performance: - Requires ~ 26,000 m3 of storage to reduce 10 year peak to 5 year peak - Likely to yield only minor reduction in peak form large flood events (> 20 year) due to limited available land Public safety: - Designed to limit depth in the retarding basin - Outlet arrangements to be designed to minimise public safety Community impact - No public land available - Sited on private property - Inconvenience to affected landholder during flood events (i.e. inundated area within basin footprint) Environmental consideration - Sited to minimise/ eliminate vegetation removal	No: - Unlikely to have available land (storage) to enable reduction in significant reduction in peak flows
Channel enlargement: Gregory Street to Cummins Street:	Hydraulic performance: - Existing channel: ~ 3 m top width, ~ 0.5 m deep. Indicative capacity:~ 1.5 m3/s - Increase conveyance reduces local flood extent for frequent events (up to 10 years). - Limited benefit to larger flood events (20 year and greater). - Reduction in flood extent leads a reduction in flood storage and increases peak flows downstream. Likely increases to be limited to 10 % in 10 year event Public safety: - Designed to limit depth and velocity Community impact - Limited drainage reserve available (Generally 5 m in width) Environmental consideration - Removal of current riparian vegetation	**Yes:** - Widen channel base & remove vegetation Increase channel capacity

Measure	Preliminary assessment	Feasible measure
Retarding basin/wetland: South of Cummins Street).	Hydraulic performance: - Requires ~ 26,000 m3 of storage to reduce 10 year peak to 5 year peak - Available public land ~ 0.2 ha. Possible storage ~1000 m3. - Likely to yield only minor reduction in peak form large flood events (> 20 year) due to limited available land Public safety: - Designed to limit depth in the retarding basin - Outlet arrangements to be design to minimise public safety Community impact - Sited public land available - Inconvenience during flood events (i.e. inundated area within basin footprint) Environmental consideration Sited to minimise/ eliminate vegetation removal	No: - Unlikely to have available land (storage) to enable reduction in significant reduction in peak flows
Bund: – Downstream of Western Highway along open channel (south side), across Havelock Street to Railway station. – Downstream of Western Highway along open channel (north side), to Havelock Street then to corner of Burke and Havelock Streets. **Channel enlargement:** – Western Highway (Neil Street) to Havelock Street **Culvert upgrade:**	Hydraulic performance: - Limits flooding to between Pratt Street and railway - Reduces flooding across Burke Street - Increase flood levels within open channel and adjacent to Railway line bounded by rear of properties on Willoby Street and Havelock Street - Existing channel capacity: ~ 5.5. m top width, ~ 1 m deep. Indicative capacity:~ 5 m3/s - Existing culvert capacity under Havelock Street: Indicative capacity:~ 5 m3/s Public safety: - Designed to limit depth and velocity Community impact - Bunding along open channel (up to 0.6 m high) to contain 100 year without freeboard - Raised pavement at corner of Havelock and Willoby Street (up to 0.6 m high) to contain 100 year without freeboard - Bunding at rear of up 32,43,36 & 38 Willoby Street to 0.4 m high to contain 100 year	**Yes:** - Open channel: widen base & remove vegetation: - Bunding Culvert augmentation:

Measure	Preliminary assessment	Feasible measure
– Havelock Street **Storage:** – Excavate adjacent to railway line bounded by rear of properties on Willoby Street and Havelock Street to increase storage	without freeboard - Raised pavement at corner of Havelock and Willoby Street (up to 0.6 m high) to contain 100 year without freeboard - Raised pavement along centre median Burke Street to Havelock Street (up to 0.2 m high) to contain 100 year without freeboard Environmental consideration - Sited to minimise/ eliminate natural vegetation removal	
Cemetery Creek		
Bund: – Downstream of South Street along open channel (west side), across Leichardt Street, along western boundary of primary school to Western Highway – Downstream of Western Highway along Willoby and Beggs Street to Railway (west side of Cemetery Creek) – Downstream of Western Highway along eastern bank to Railway across High Street (west of properties at 2 Willoby Street and 1 High Street	Hydraulic performance: - Reduces flooding across residential area to west of Cumberland Creek between South Street and High Street - Reduces flooding across residential/industrial area to east of Cumberland Creek between Western Highway and High Street - Increase flood levels within open channel between bunds - Non-return values required on local drainage behind bund to limit backwater flooding - Removal of floodplain storage upstream of railway line may increase flows through railway culvert, and increase downstream water levels Public safety: - Designed to limit depth and velocity Community impact - Bunding along open channel (west side) between South Street to Western Highway (up to 1 m high generally 0.4 m -0.6 m) to contain 100 year without freeboard - Raised pavement section across Leichardt Street (up to 0.4 m high) to contain 100 year without freeboard - Bunding along open channel (west side) between Western Highway to Railway across High Street (up to 0.7 m high generally 0.5 m -0.6 m) to contain 100 year without freeboard - Bunding along open channel (east side) between Western Highway to Railway across High Street (up to 1.1 m high generally 0.5 m -0.6 m) to contain 100 year without freeboard	**Yes:** - Bunding - Extensive works - Reduces flooding for considerable areas of existing residential and industrial development

Measure	Preliminary assessment	Feasible measure
	- Raised pavement section across High Street (up to 0.6 m high) to contain 100 year without freeboard Environmental consideration - Sited to minimise/ eliminate natural vegetation removal	
Channel enlargement: – Downstream of South Street to Leichardt Street - Downstream of Western Highway (Neil Street) to High Street	Hydraulic performance: - Downstream of South Street to Leichardt Street: Existing channel capacity: ~ 4 m top width, ~ 0.5 m deep. Indicative capacity:~ 1.2 m3/s - Downstream of Western Highway to High: Existing channel capacity: ~ 8 m top width, ~ 0.8 m deep. Indicative capacity:~ 8 m3/s. Limited by railway culvert capacity Public safety: - Designed to limit depth and velocity Community impact - Lost of minor area of open space adjacent to skate park due to channel enlargement - Improve waterway amenity as part of modification Environmental consideration - Sited to minimise/ eliminate natural vegetation removal - Removal of exotic species	**Yes:** - Upstream of Leichardt Street: Increase channel capacity . - Downstream of Western Highway increase channel capacity downstream. - Extensive excavation Cut material used for bund construction - Reduces flooding for considerable areas of existing residential and industrial development
Culvert upgrade: – Leichardt Street to Downstream of Western Highway (Neil Street) under Primary school oval	Hydraulic performance: - Existing culvert capacity under Primary school and Western Highway Indicative capacity:~ 13 m3/s Public safety: - Designed to limit depth and velocity Community impact - Improve waterway amenity as part of modification Environmental consideration - Sited to minimise/ eliminate natural vegetation removal	**Yes:** - Increase culvert width to upstream channel capacity.

Measure	Preliminary assessment	Feasible measure
Cumberland Creek		
Bund: – Downstream of Western Highway (High Street) along open channel (west side), across Broadbent Court, along eastern boundary of industrial estate, across Racecourse Road, along to the Railway – Rear of 14 Olinda Street along open channel (east side), across Racecourse Road, along the rear of 9-11 Racecourse Road to Murchison Street	Hydraulic performance: - Reduces flooding across residential & industrial land adjacent to Cemetery Creek between High Street and Railway - Increase flood levels within open channel between bunds - Non-return values required on local drainage behind bund to limit backwater flooding - Removal of floodplain storage upstream of railway line may increase flows through railway culvert, and increase downstream water levels Public safety: - Designed to limit depth and velocity Community impact - Bunding along open channel (west side) between Western Highway to Railway(up to 1 m high at rear of 1,3,5 & 7 Racecourse Road, generally 0.4 m -0.6 m) to contain 100 year without freeboard) - Raised pavement section across Broadbent Court (up to 0.3 m high) to contain 100 year without freeboard - Property at 49-51 High Street (north-west corner of Murchison Street and High Street) impacted. Property acquisition. - Bunding along open channel (east side) between rear of 14 Olinda Street along open channel to Murchison Street Western Highway to Railway across High Street (up to 0.8 m high generally 0.5 m -0.6 m) to contain 100 year without freeboard - Raised pavement section across Racecourse Road (up to 0.2 m high) to contain 100 year without freeboard Environmental consideration - Sited to minimise/ eliminate natural vegetation removal	**Yes:** - Bunding: Up to 1.0 m - Extensive works - Reduces flooding for considerable areas of existing residential and industrial development
Channel enlargement & realignment: – Immediately upstream of Western Highway (High Street) to downstream of 49-51 High Street	Hydraulic performance: - Downstream of High Street (Western Highway) Railway: Existing channel capacity: ~ 8 m top width, ~ 0.7 m deep. Indicative capacity:~ 9 m3/s. Limited by railway culvert capacity Public safety:	**Yes:** - Downstream of Western Highway increase channel capacity downstream.

Measure	Preliminary assessment	Feasible measure
realign Cumberland Creek - Downstream of 49-51 High Street to Railway widen and deepen channel width	- Designed to limit depth and velocity Community impact - Sited through property (vacant lot) 49-51 High Street - Improve waterway amenity as part of modification Environmental consideration - Sited to minimise/ eliminate natural vegetation removal - Removal of exotic species	- Extensive excavation Cut material used for bund construction Reduces flooding for considerable areas of existing residential and industrial development
Culvert upgrade: – Western Highway (High Street) – Broadbent Court - Racecourse Road	Hydraulic performance: - Western Highway: Existing culvert capacity:~ 4.5 m3/s - Broadbent Court: Existing culvert capacity:~ 4.5 m3/s - Racecourse Road: Existing culvert capacity:~7.5 m3/s Public safety: - Designed to limit depth and velocity Community impact - Improve waterway amenity as part of modification Environmental consideration - Sited to minimise/ eliminate natural vegetation removal	**Yes:** - Increase culvert width to match upstream channel capacity

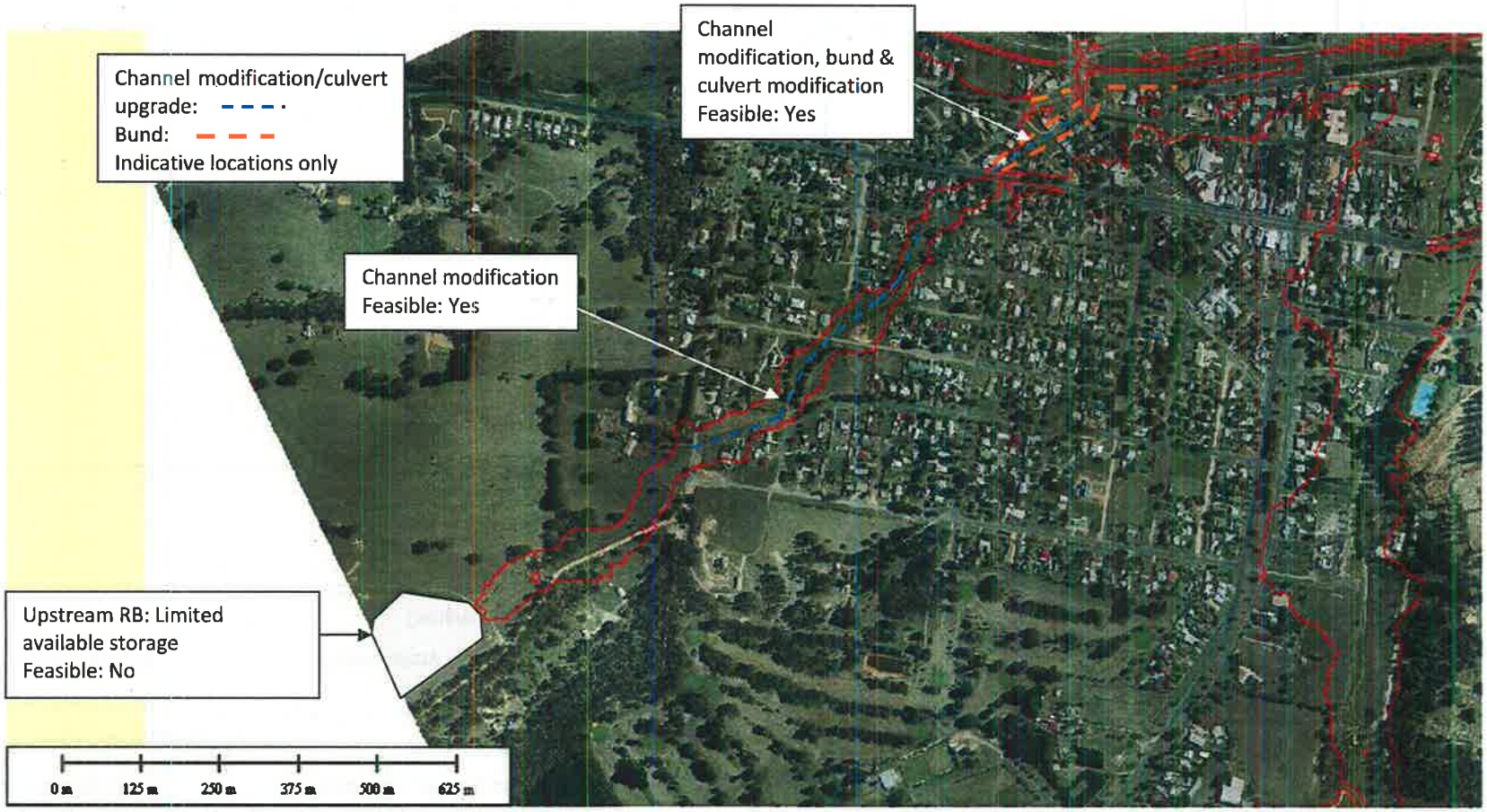


Figure 4-1 Ding Dong Creek Preliminary structural mitigation measure assessment – Indicative works locations

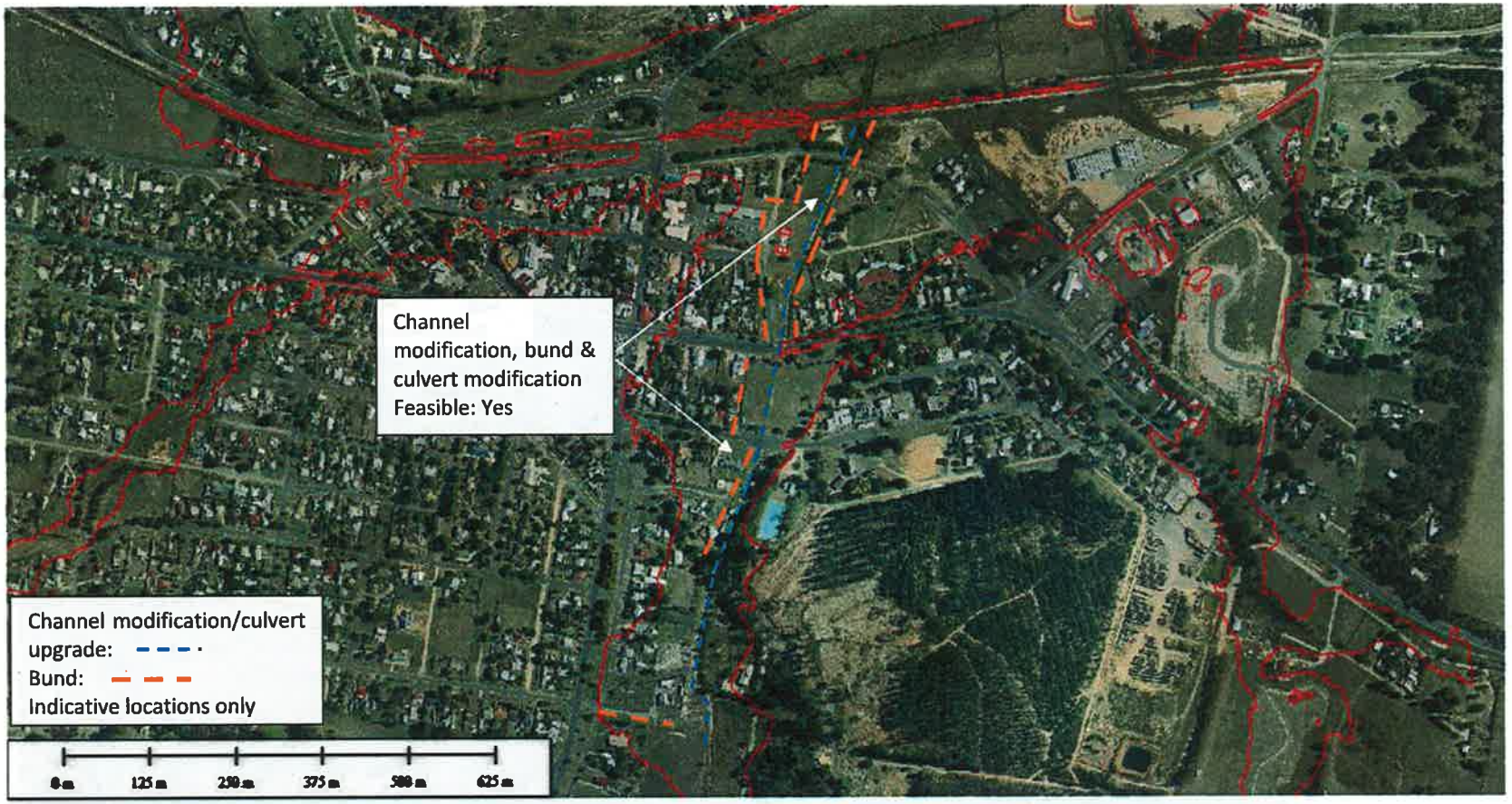


Figure 4-2 Cemetery Creek Preliminary structural mitigation measure assessment – Indicative works locations

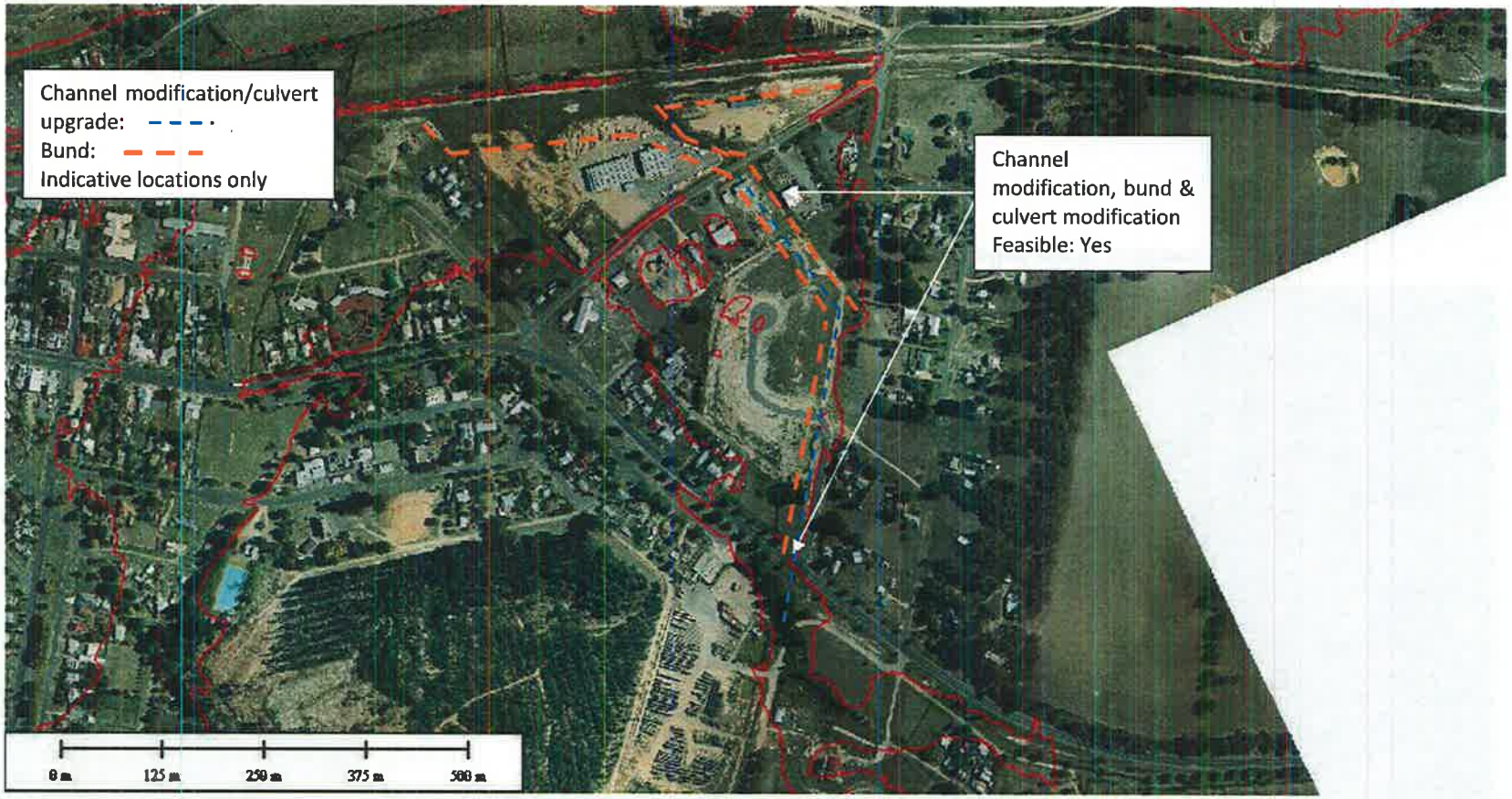


Figure 4-3 Cumberland Creek Preliminary structural mitigation measure assessment

4.2.4 Railway culvert augmentation

The Beaufort Flood Study and subsequent flood modelling (Water Technology 2008) has showed that the capacity of the railway culverts limit flow across the railway (south to north). This limited culvert capacity results in elevated flood levels along the southern side of the railway in the vicinity of Pratt, High, Beggs and Willoby Streets. Previous flood modelling has shown that increasing the size of the existing railway culverts yields decreases in flood levels along the southern side of the railway up to 0.4 m for the 100 year event (Water Technology 2008).

During the course of this study, Pyrenees Shire conducted initial discussions with VicTrack. These discussions have lead to a functional design and costing for the proposed railway culvert augmentation, shown in Figure 4-4, and listed below:

- Cumberland Creek (existing crossing): Additional 1* 2.4 m (wide) * 2.1 m (high) box culvert
- Between Cumberland and Cemetery Creek (new crossing): 3* 2.4 m (wide) * 0.9 m (high) box culverts
- Cemetery Creek (existing crossing): Additional 1* 3.6 m (wide) * 1.5 m (high) box culvert
- Between Cumberland and Cemetery Creek (existing crossing): Additional 4* 1.5 m (diameter) pipes

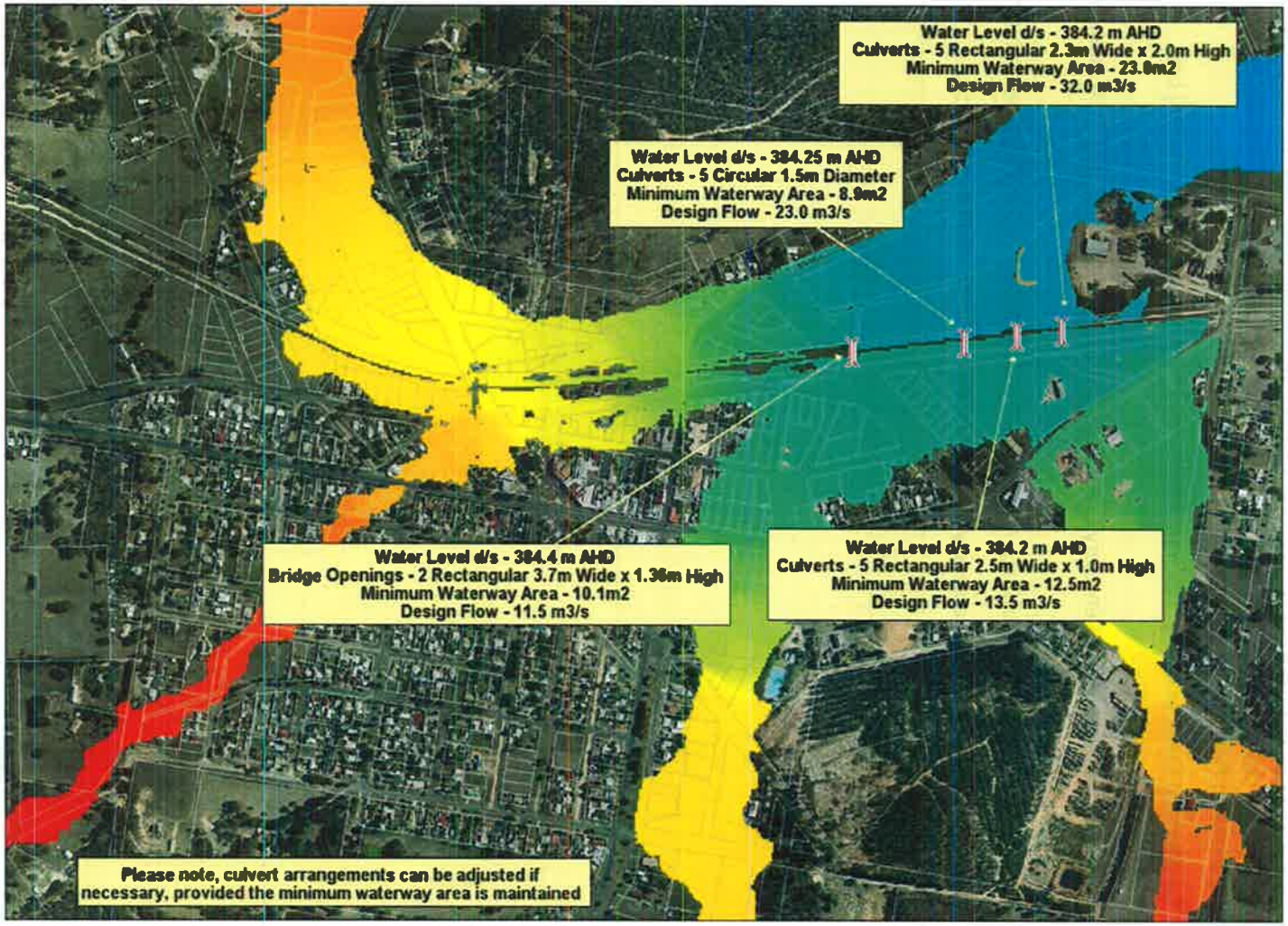


Figure 4-4 Proposed railway culvert augmentation

4.3 Detailed structural mitigation assessment

4.3.1 Overview

From these identified feasible mitigation measures, the study team in consultation with the Pyrenees Shire Council developed and assessed the following six mitigation options:

- Option 1: Ding Dong Creek works – Channel modification, bunds/levee & culvert upgrade
- Option 2: Cemetery Creek works (plus Option 1)– Channel modification, bunds/levee & culvert upgrade
- Option 3: Cumberland Creek works (plus Option 1 &2)– Channel modification, bunds/levee & culvert upgrade
- Option 4: Ding Dong Creek works – Channel modification & culvert upgrade
- Option 5 Cemetery Creek works (plus Option 4)– Channel modification & culvert upgrade
- Option 6 Cemetery Creek works (plus Option 4)– Channel modification & smaller culvert upgrade

The first initial three options (Options 1, 2 & 3) were targeted at reducing flood risk in large flood events (e.g. the 100 year flood event). The assessment of these initial three options identified a number of constraints to their practical implementation, as discussed in Section 4.3.2. A further three options (Options 4, 5 &6) were developed and assessed. These second three options were targeted at reducing flood risk in frequent flood events (10 & 20 year event).

The hydraulic model, developed in Water Technology (2008), was modified to reflect the six options. Flood level differences were prepared against the existing conditions flood mapping (Water Technology 2008).

The heights of modelled bunds were extended to contain the 100 year flood event. A 0.3 m freeboard was included to the assessment of bund heights.

Indicative construction costings for the six options plus railway culvert augmentation were developed. The costings were based on unit costs used by Melbourne Water for the assessment of flood mitigation works. A 20% contingency was included in the indicative costings.

Flood damages were assessed for the three options using the flood damages approach outlined in the Beaufort Flood Study (Water Technology 2008). Revised annual average damages (AAD) estimates for the mitigated conditions were evaluated.

Indicative cost –benefit ratios were assessed using the indicative construction costs and revised AAD. A 6% interest rate and a 30 year project life were assumed. Also, the existing building type and land use were assumed in the mitigated conditions. That is, a vacant land in the existing conditions was assumed to remain vacant in mitigated conditions. Following the mitigation works, there is potential to re-develop current vacant land in line with the prevailing (residual) flood risk and behaviour. No ongoing maintenance costs have been included in the benefit-cost assessment.

For each option, the impacts on flood behaviour and potential general construction constraints were noted. The constraints included impacts on services, property egress, road traffic-ability, and amenity

This study did not consider environmental impacts (vegetation removal, waterway disturbance) or cultural heritage aspects. These aspects will require consideration as part of functional design.

4.3.2 Detailed structural mitigation assessment summary

Table 4-3 outlines the key elements of the structural mitigation option assessment. The general nature of the works and the potential general construction constraints were shown for works on Ding Ding Creek, Cemetery Creek and Cumberland Creek in Figure 4-5 to Figure 4-7 respectively.

The flood level differences in the 100 year event and indicative costings are shown for Options 1 to 6 in Figure 4-8 to Figure 4-13.

Appendix A contains the flood level difference plots for the 10 and 20 year events, and contains details of the flood damage assessment and indicative costing.

Table 4-3 Mitigation option assessment

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
1	**Bunds:** Speke Street cross Western highway along open channel (south side), across Havelock Street to Railway station: *Av. height 0.9 m, Max .height 1.7 m & Length 415 m* Downstream of Western Highway along open channel (north side), to Havelock Street then to corner of Burke and Havelock Streets: *Av. height 1.1 m, Max height 1.8 m & Length 250 m* Across Lawrence Street (Skipton Road) adjacent to railway *Av. height 0.5 m, Max. height 0.6 m & Length 55 m* **Culverts:** Havelock Street: Additional 1* 1.5 m pipe. Length 40 m Railway: refer to Section 4.2.4 **Channel enlargement:** Gregory Street to Cummins Street: Western Highway (Neil Street) to Havelock Street: Widen base with to 2 m. Total excavation 1400 m^3	**Bunds: $22,000** **Culverts:** Havelock Street: $73,000 Railway: $400,000 **Channel enlargement: $63,000** **Project management & design: $141,000** **Contingency: $111,000** **Total: $810,000**	**10 year:** - Above floor: 14 (-7) - Below floor: 156 (-20) **100 year:** - Above floor: 31 (-7) - Below floor: 150 (-23) **AAD:** $320,000 (-$63,000) **Indicative benefit – cost ratio:** ~ 1	Reduced flooding up to 0.15 m along Ding Dong Creek adjacent to Warburton and Stuart Streets Increased flooding up to 0.8 m across three properties along Western Highway adjacent to Speke Street Removes overland flooding across Havelock Street and along Pratt Street Reduced flooding to up 0.35 m due to Railway culvert augmentation	Modified road levels across Western Highway at Ding dong Creek to contain flows. Bunding/raised pavement to up 0.8 m. Bunding across entrance to 80 Neill Street (Western Highway) Bunding/raised pavement across Havelock Street & Willoby Street Bunding/raised pavement across Lawrence Street up to 0.6 m Limited land for bund construction between Western Highway to Havelock Street

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
2	**Option 1 works plus:** **Bunds:** Downstream of South Street along open channel (west side), across Leichardt Street, along western boundary of primary school to Western Highway, Downstream of Western Highway along Willoby and Beggs Street to Railway (west side of Cemetery Creek). *Av. height 1.25 m, Max .height 1.8 m & Length 1110 m* Downstream of Western Highway along eastern bank to Railway across High Street (west of properties at 2 Willoby Street and 1 High. *Av. height 1.4 m, Max .height 1.9 m & Length 470 m* **Culverts:** Leichardt Street to Downstream of Western Highway (Neil Street) under Primary school oval: Additional 1* 1.5 m *1.2 m box culvert. Length 140 m **Channel enlargement:** Downstream of South Street to Leichardt Street: Widen top with to 20 m. Total excavation 4500 m^3 Downstream of Western Highway (Neil Street) to High Street: Widen top with to 20 m. Total excavation 3200 m^3	**Bunds:** Option 1: $22,000 Option 2:$86,000 **Culverts:** Option 1: $473,000 Option 2: $149,000 **Channel enlargement:** Option 1: $63,000 Option 2: $234,000 **Project management & design: $258,000** **Contingency: $205,000** **Total: (includes option 1): $1,490,000**	**10 year:** - Above floor: 7 (-14) - Below floor: 131 (-45) **100 year:** - Above floor: 19 (-19) - Below floor: 124 (-49) **AAD:** $250,000 (-$132,000) **Indicative benefit – cost ratio:** ~ 1.2	Increased flooding up to 0.15 m along Cemetery Creek corridor upstream of South Street Removes overland flooding to the west of Cemetery Creek upstream of Neill Street (Western Highway) Increased flooding up to 0.4 m along Cemetery Creek corridor between Cemetery and Neill Street (Western Highway) Increased flooding up to 0.4 m along Cemetery Creek corridor Western Highway and Railway Removes overland flooding to the west of Cemetery Creek between Western Highway and Railway	Bunding/raised pavement across Leichardt Street Bunding/raised pavement across Western Highway Bunding/raised pavement across High Street Bunding along Willoby and Beggs Street Limited land for bund construction along western side of Cemetery Creek between South and Leichardt Street Limited land for channel widening of Cemetery Creek between South and Leichardt Street

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
3	**Option 3 (includes Option 1 & 2) plus:** **Bunds:** Downstream of Western Highway (High Street) along open channel (west side), across Broadbent Court, along eastern boundary of industrial estate, across Racecourse Road, along to the Railway to join with Option 2 bund along eastern side of Cemetery Creek adjacent to 1 High Street: *Av. height 1.2 m, Max .height 1.8 m & Length 1550 m* Rear of 14 Olinda Street along open channel (east side), across Racecourse Road, along the rear of 9-11 Racecourse Road to Murchison Street: *Av. height 1.1 m, Max .height 2.0 m & Length 530 m* **Culverts:** Western Highway (High Street): Additional 3* 2.4 m *1.2 m box culvert. Length 15 m Broadbent Court: Additional 3* 2.4 m *1.2 m box culvert. Length 15 m **Channel enlargement & realignment:** Immediately upstream of Western Highway (High Street) to downstream of 49-51 High Street realign Cumberland Creek Downstream of 49-51 High Street to Railway: Widen top width to 15 m	**Bunds:** Option 1: $22,000 Option 2:$86,000 Option 3:$59,000 **Culverts:** Option 1: $473,000 Option 2: $149,000 Option 3: $288,000 **Channel enlargement:** Option 1: $63,000 Option 2: $234,000 Option 3: $147,000 **Project management & design: $385,000** **Contingency: $304,000** **Total: (includes option 1 & 2): $2,210,000**	**10 year:** - Above floor: 5 (-16) - Below floor: 121 (-55) **100 year:** - Above floor: 15 (-23) - Below floor: 115 (-58) **AAD:** $216,000 (-$167,000) **Indicative benefit – cost ratio:** ~ 1	Increased flooding up to 0.85 m along Cumberland Creek corridor between Racecourse Road and Western Highway Removes overland flooding to the west of Cumberland Creek adjacent to Broadbent Creek	Bunding/raised pavement across Western Highway Bunding/raised pavement across Broadbent Court Street Bunding/raised pavement across Racecourse Road Realigned channel sited through property (vacant lot) 49-51 High Street

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
4	**Bunds:** Rear of 38 Willoby Street, and the rear of 32 and 34 Willboy Street to the higher ground in the Railway Station carpark adjacent to Pratt Street and Railway Station *Av. height 0.5 m, Max. height 0.6 m & Length 55 m* **Culverts:** Havelock Street: 2*3 m wide * 0.9 m high box culvert **Channel enlargement:** Western Highway (Neil Street) to Havelock Street: Widen base with to 2 m. Total excavation 1400 m^3	**Bunds:** Adjacent to Railway Station: $10,000 **Culverts:** Havelock Street: $284,000 **Channel works:** Neill Street to Havelock Street: $22,000 **Project management & design:** $73,500 **Contingency:** $ 89,000 **Total: $478,500 (excludes Railway culverts)**	**10 year:** - Above floor: 17 (-4) - Below floor: 157 (-19) **100 year:** - Above floor: 36 (-5) - Below floor: 154 (-19) **AAD: AAD:** $333,000 (-$50,000) Indicative benefit – cost ratio: 1.4	Reduction in 20 year flood levels by up to 0.2 m along Ding Ding Creek between Neill and Havelock Streets. Prevented overtopping of Havelock Street and overland flows along Pratt Street commenced adjacent to the Railway Station carpark for events up to 20 year ARI. Overtopping of this bund in larger flood events (1 in 50 year and greater) is likely to coincide with overland flow along Willoby Street. Hence, there is likely to be no significant adverse flood related impacts due to bund overtopping.	Existing services along Havelock Street at existing culvert. Disruption to traffic during construction There are o bunds across roads as part of this option. Hence, the practical difficulties associated with road crossings are avoided as compared to Option 1.

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
5	**Culverts:** Leichardt Street to Downstream of Western Highway (Neil Street) under Primary school oval: Replace existing culverts with 4* 3.3 m (wide) *1.5 m (high) box culvert. Length 140 m **Channel enlargement(same as option 2):** Downstream of South Street to Leichardt Street: Widen top with to 20 m. Total excavation 4500 m^3 Downstream of Western Highway (Neil Street) to High Street: Widen top with to 20 m. Total excavation 3200 m^3	**Culverts:** Leichardt Street: $152,000 Primary School: $1,183,000 Western highway: $214,000 **Channel enlargement:** Option 5: $69,000 **Project management & design: $170,800** **Contingency: $242,700** **Total: $2,031,500**	**10 year:** - Above floor: 21 (no change)) - Below floor: 168 (-8) **100 year:** - Above floor: 36 (-6) - Below floor: 171 (-2) **AAD:** $347,000 (-35,000) Indicative benefit – cost ratio: ~ 0.3	Reduced flood levels (up to 0.25 m) in the area immediately to the west of Cemetery Creek between the Western Highway and Leichardt Street.	Traffic disruption along Leichardt Street and the Western Highway during the culvert construction. However, given the future Western Highway bypass of Beaufort, the Western Highway culvert upgrade could be undertaken following the bypass construction to minimise traffic disruption. There are no bunds as part of this option. Hence, the practical difficulties associated with road crossings are avoided as compared to Option 2. The upgrade of the railway culverts would reduce flood levels between the Western Highway and railway. This complement the flood level reductions from this option.

Option	Works	Indicative costs	Properties affected & flood damages (change in brackets)	Flood impacts	Construction constraints
6	**Culverts:** Leichardt Street to Downstream of Western Highway (Neil Street) under Primary school oval: Replace existing culverts with 2* 3.3 m (wide) *1.5 m (high) box culvert. Length 140 m **Channel enlargement (same as option 2&5):** Downstream of South Street to Leichardt Street: Widen top with to 20 m. Total excavation 4500 m^3 Downstream of Western Highway (Neil Street) to High Street: Widen top with to 20 m. Total excavation 3200 m^3	**Culverts:** Leichardt Street: $116,000 Primary School: $761,000 Western highway: $159,000 **Channel enlargement:** Option 6: $69,000 **Project management & design: $86,500** **Contingency: $95,000** **Total: $1,286,500**	**10 year:** - Above floor: 21 (no change)) - Below floor: 171 (-5) **100 year:** - Above floor: 38 (-4) - Below floor: 171 (-1) **AAD:** $350,000 (-32,000) Indicative benefit – cost ratio: ~ 0.4	Reduced flood levels (up to 0.14 m) in the area immediately to the west of Cemetery Creek between the Western Highway and Leichardt Street.	As noted in Option 5.

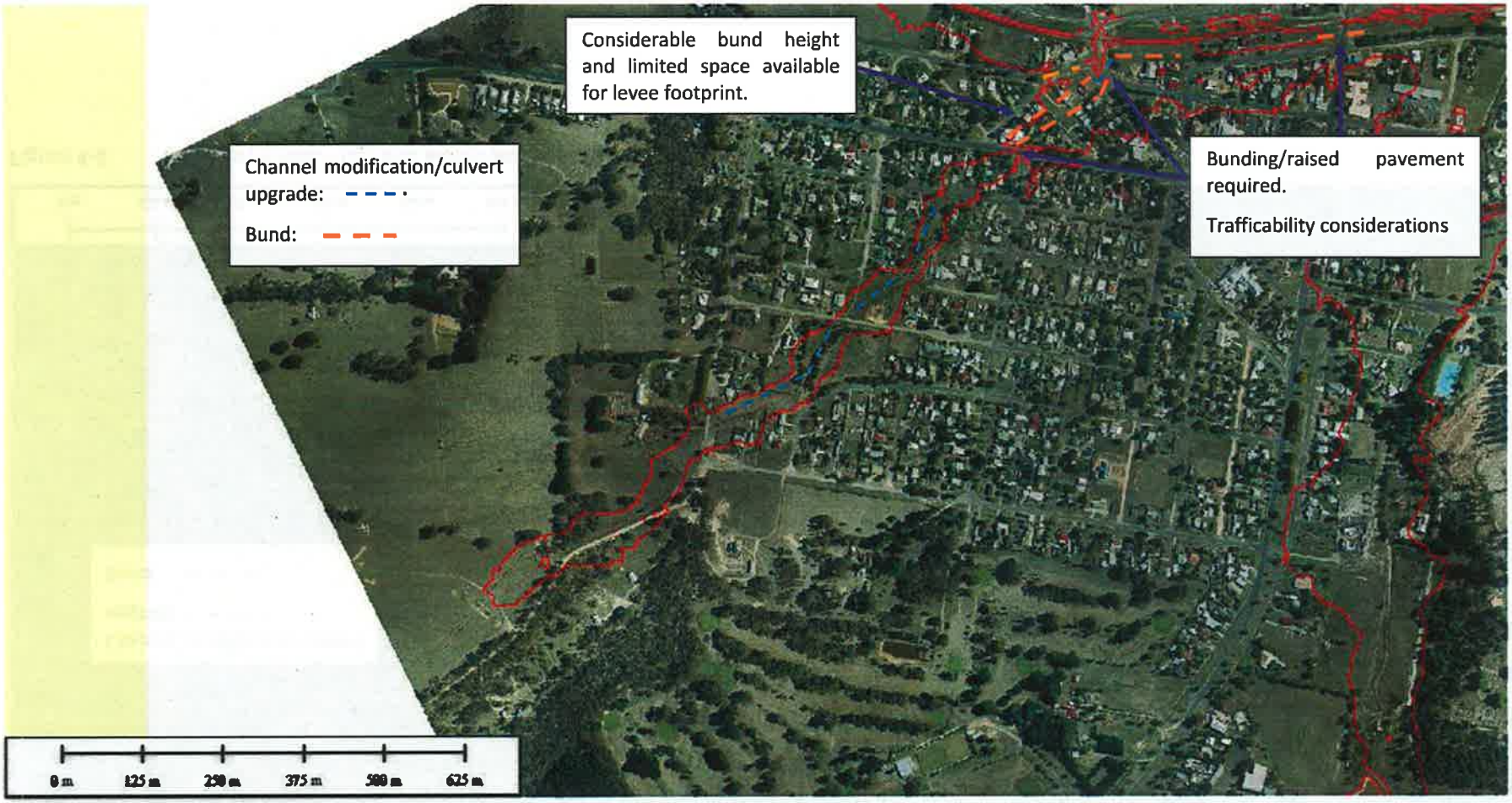


Figure 4-5 Ding Dong Creek – General works and potential construction constraints

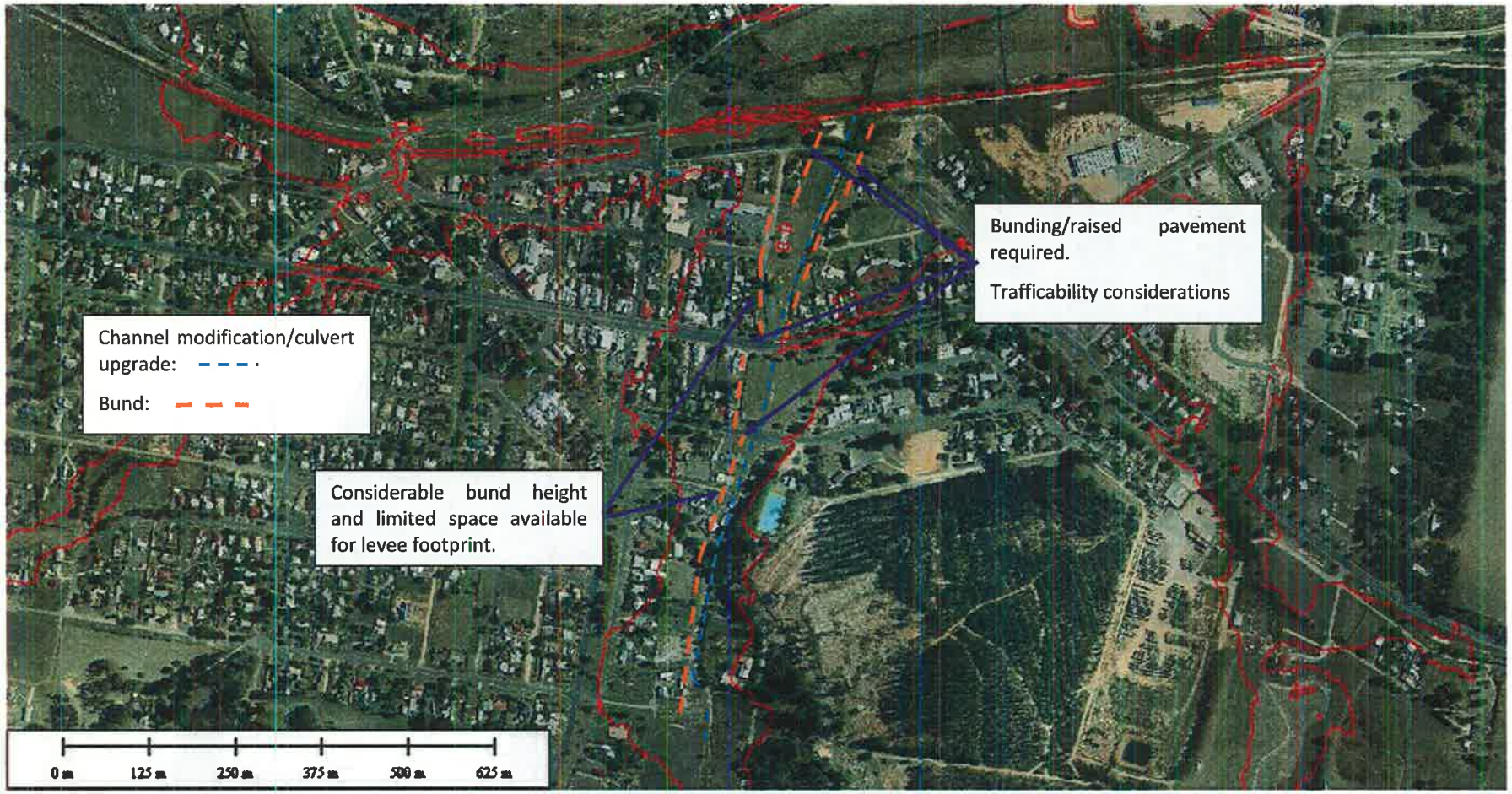


Figure 4-6 Cemetery Creek – General works and potential construction constraints

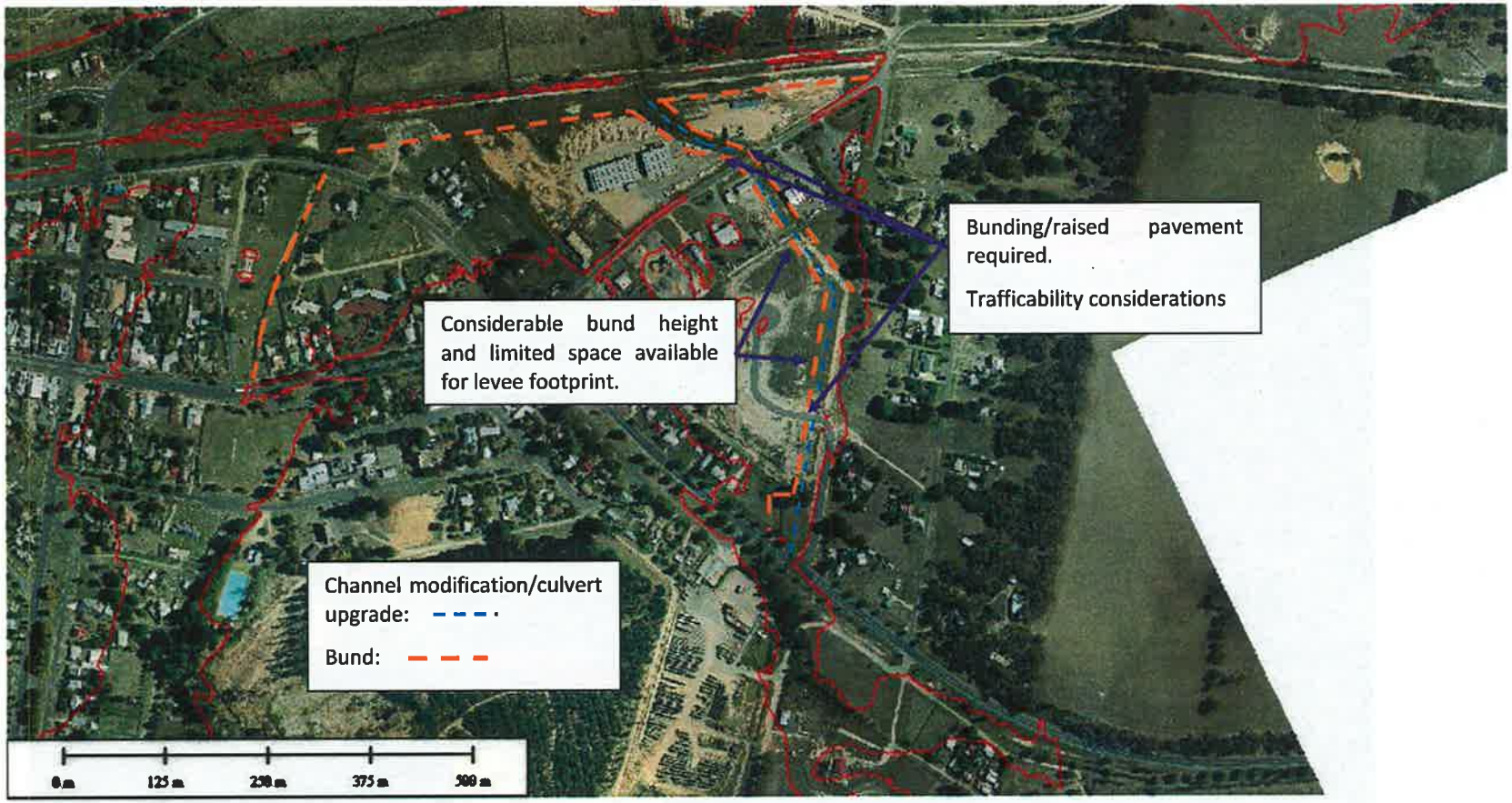


Figure 4-7 Cumberland Creek – General works and potential construction constraints

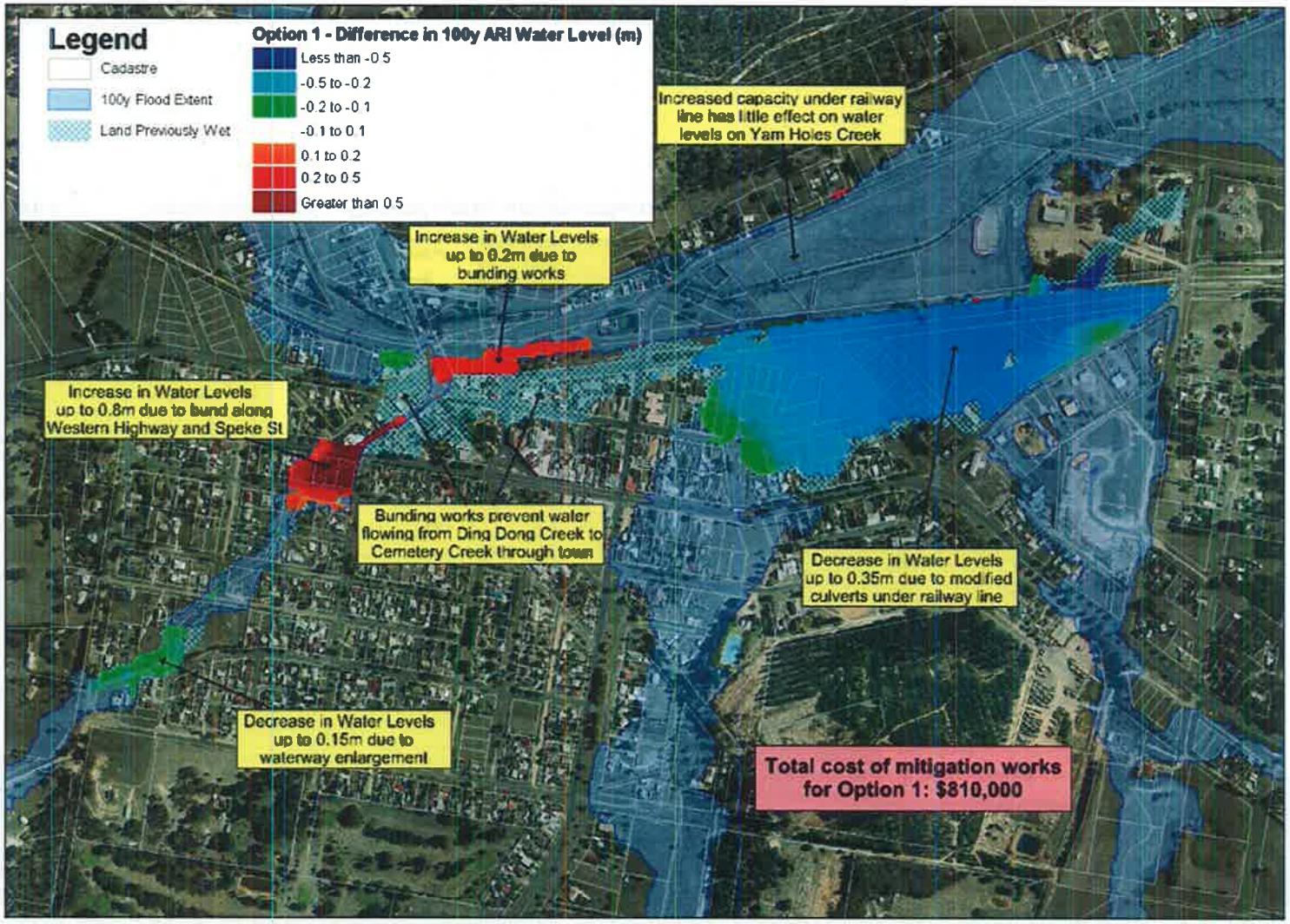


Figure 4-8 Option 1 – 100 year flood level differences and indicative costings

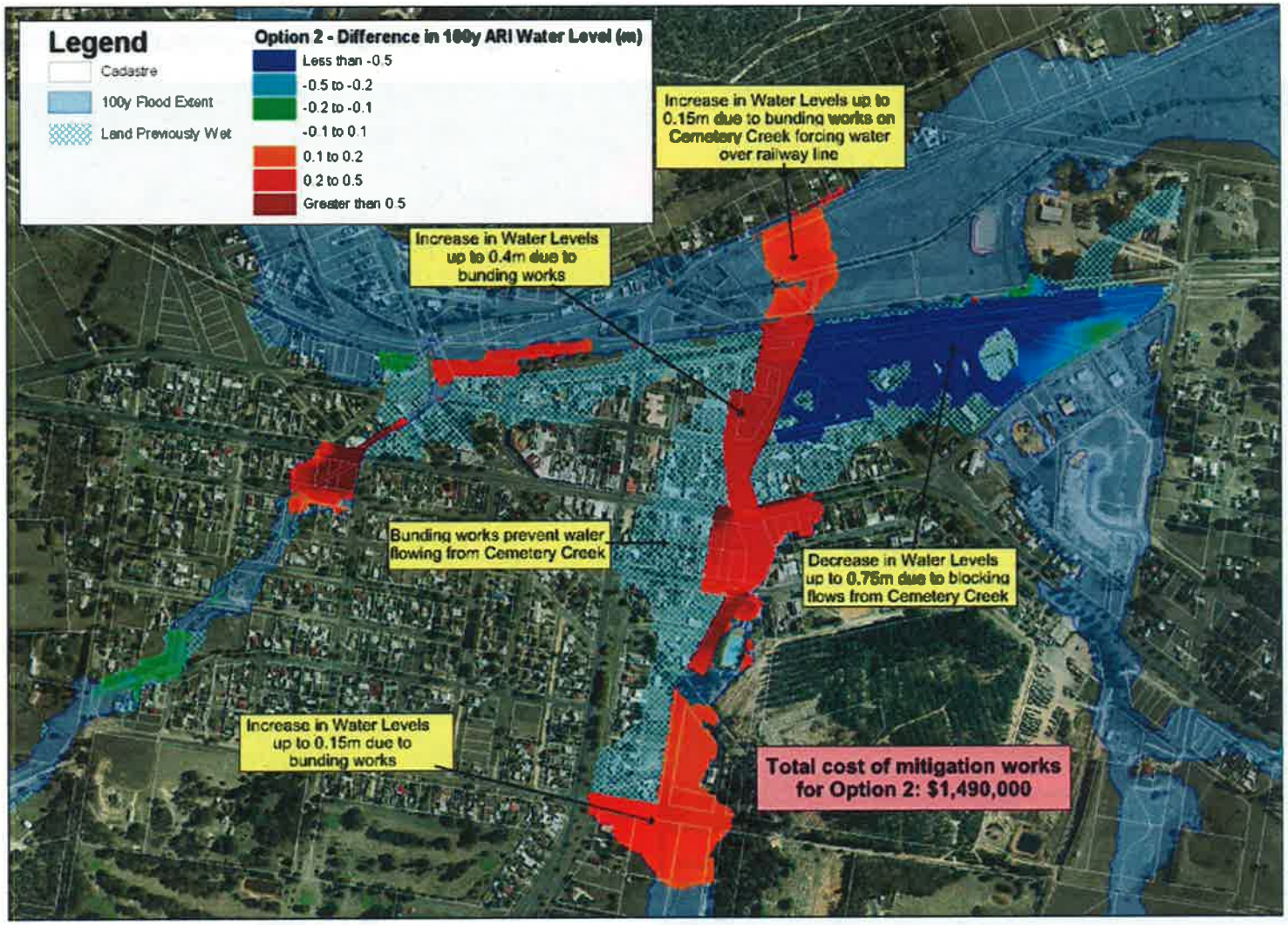


Figure 4-9 Option 2 – 100 year flood level differences and indicative costings

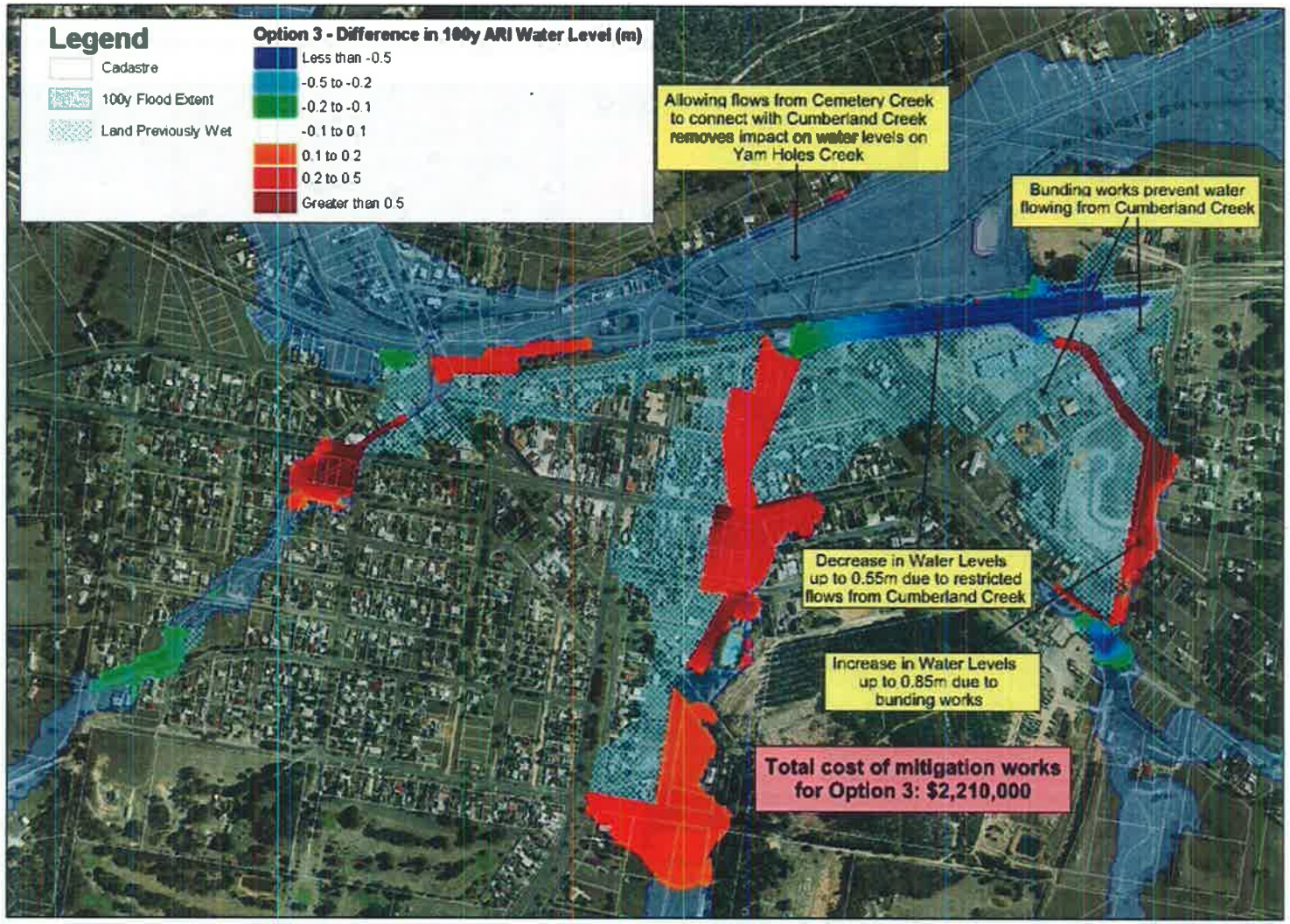


Figure 4-10 Option3 – 100 year flood level differences and indicative costings

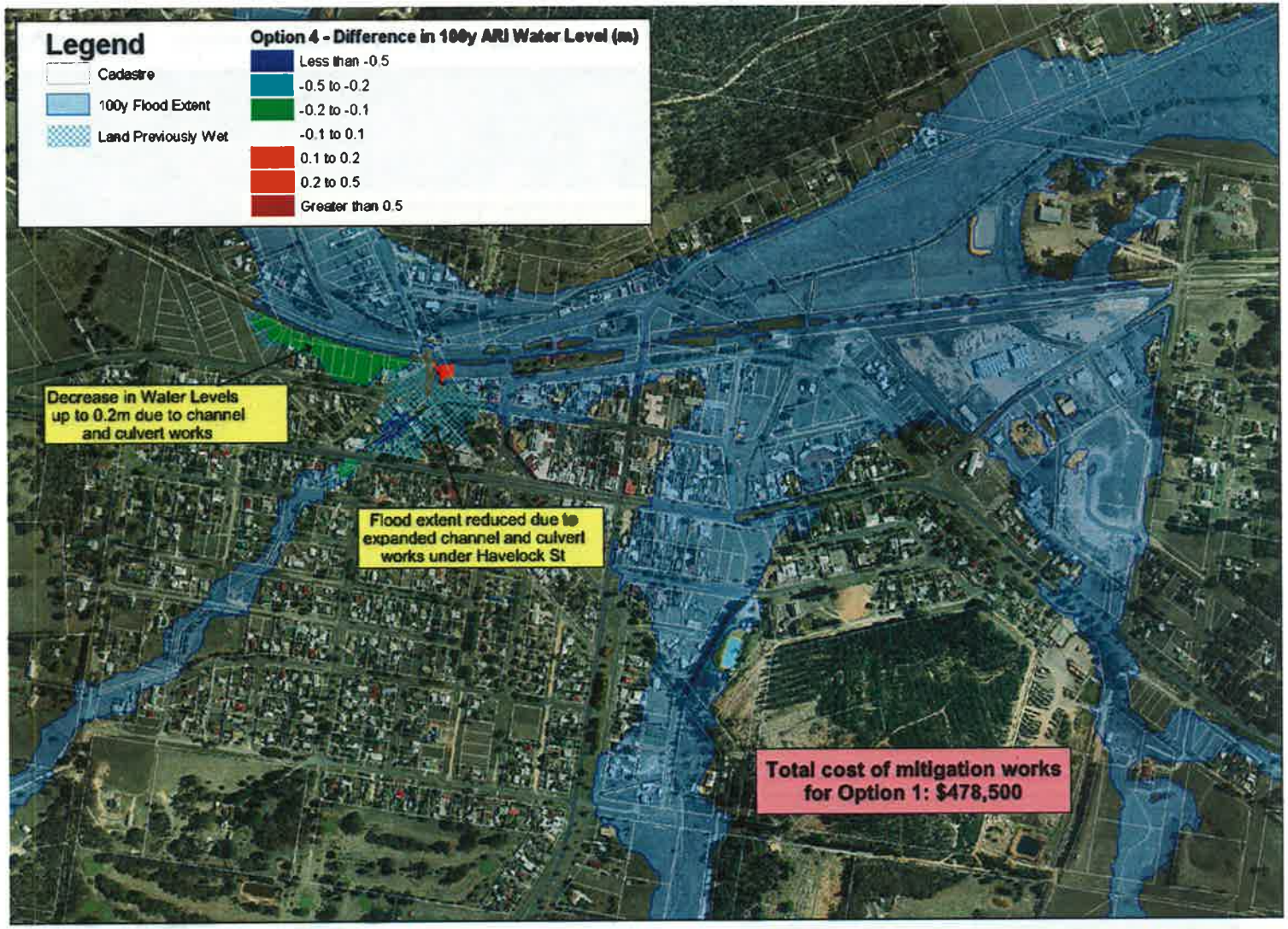


Figure 4-11 Option 4 – 100 year flood level differences and indicative costings

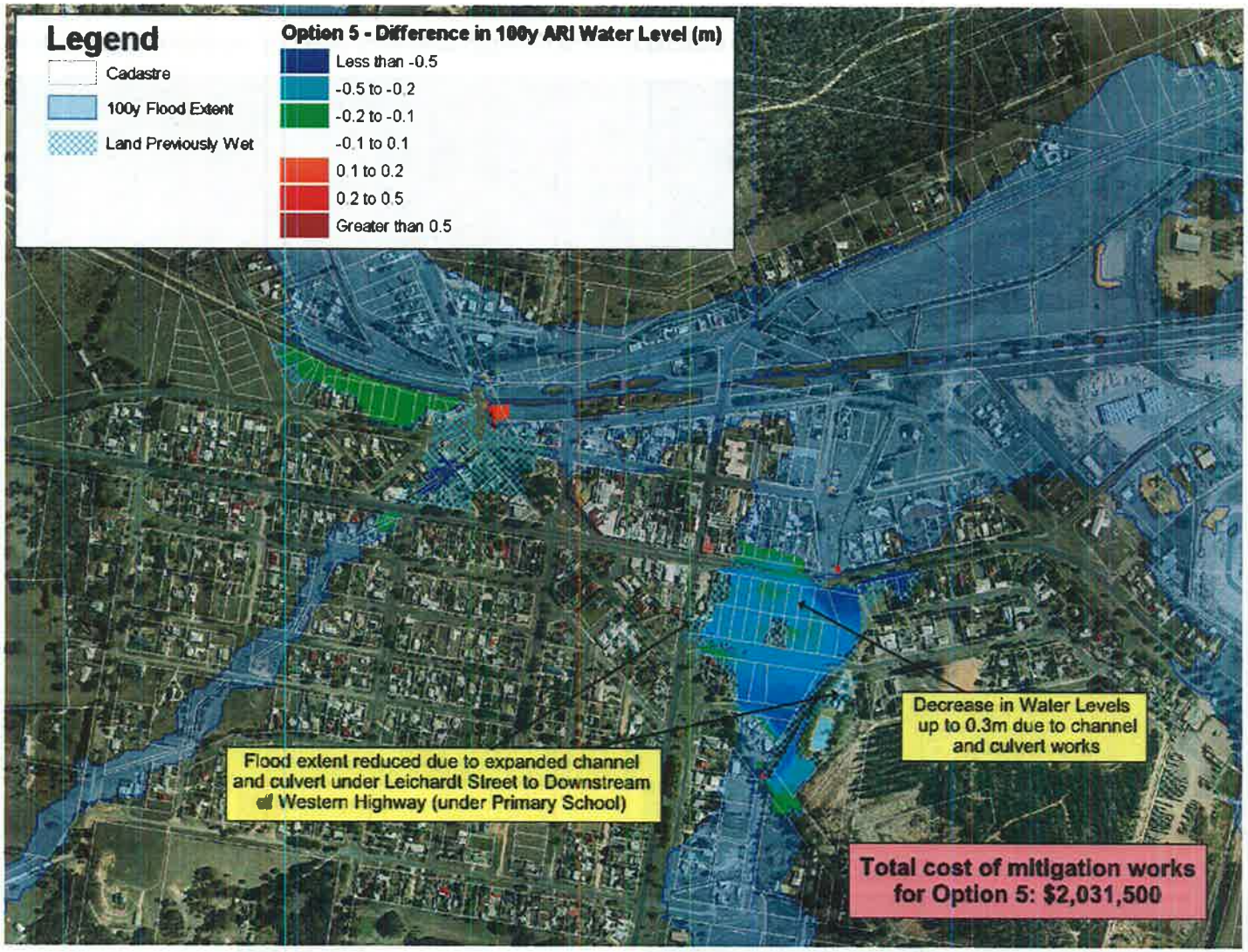


Figure 4-12 Option 5 – 100 year flood level differences and indicative costings

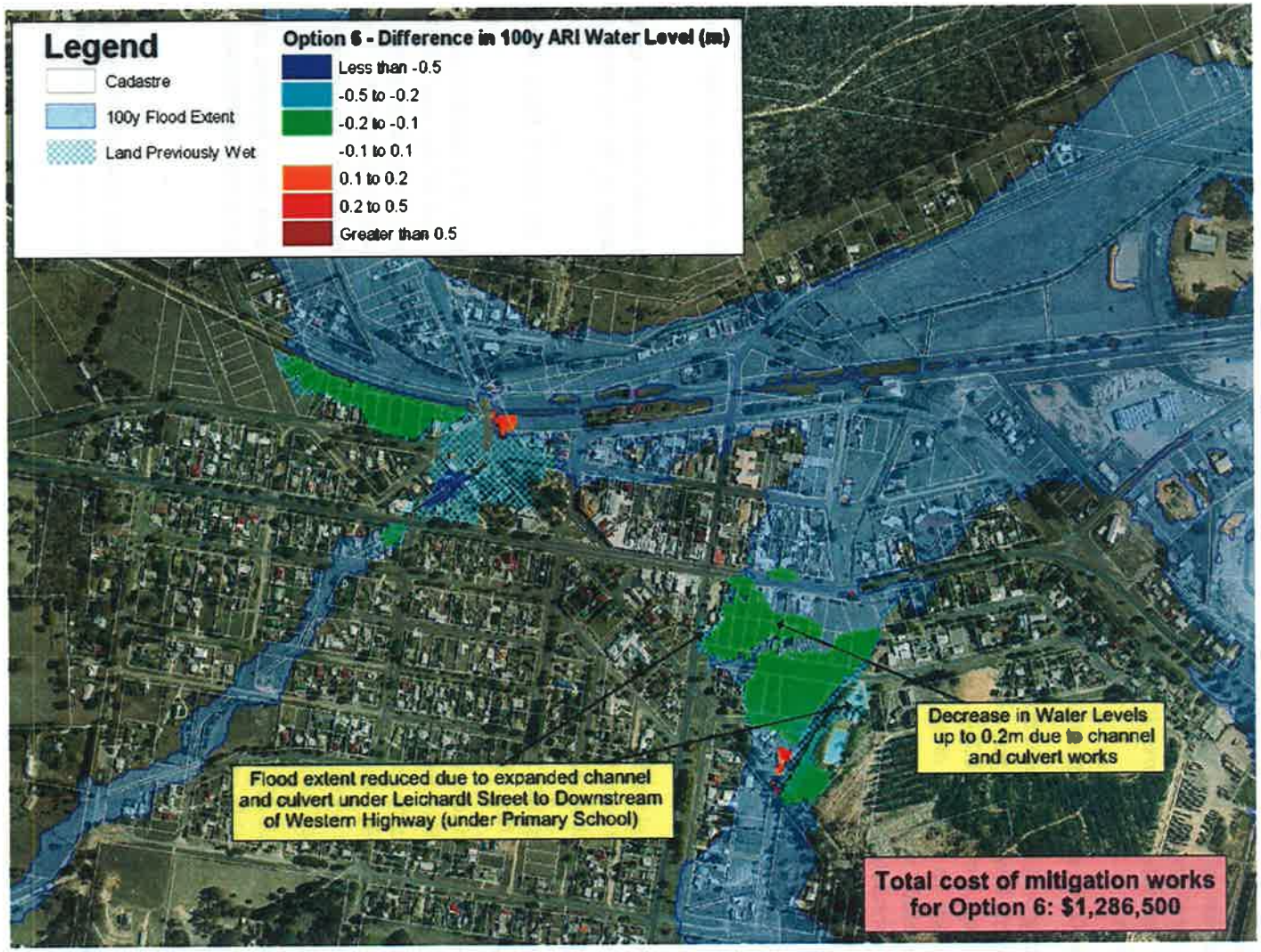


Figure 4-13 Option 6 – 100 year flood level differences and indicative costings

4.3.3 Discussion

This assessment considered six structural mitigation options. These six options were developed in consultation with Pyrenees Shire, and followed on from the Beaufort Flood Study (Water Technology 2008), and subsequent investigations.

Railway culverts

As noted, the existing limited culvert capacity under the railway line results in elevated flood levels on the southern (upstream) side. The proposed culvert augment yielded decreased 100 year flood levels (up to 0.35 m) immediately upstream. The indicative capital costs for the proposed culvert augmentation is ~ $580,000 (including engineering, administration and 20 % contingency).

It is considered to achieve full effectiveness, a structural flood mitigation scheme must include the augmentation of the railway culverts. To this end, it is recommended that further discussion between Pyrenees Shire and VicTrack be pursued in an effort to gain an in principle agreement to augment the railway culverts. It is noted that a functional design of the culvert augmentation is in preparation.

Ding Dong Creek works (Option 1)

Works along Ding Dong Creek, downstream of Neill Street (Western Highway), prevent overland flow to east across Havelock Street along Willoby Street. However, the option results in increased flood levels (up to 0.8 m in the 100 year), for properties at 83, 85 and 87 Neill Street. This increased flood level was due to bunding directing the flows into the open channel downstream of Neill Street. These increases were considered to have a significant impact on the affected properties, and certainly considered unacceptable. A possible approach may be to voluntarily purchase the three properties, if and when available. This approach results in the Shire having limited control over the time of implementation.

As part of the bunding work, raised pavement sections across Neill Street (Western Street) were required. The design of the raised pavement sections need to maintain road safety and useability. Consultation with VicRoads would be required. Further, the bunding was required across the entrance to 80 Neill Street, and landholder consultation would be required.

The proposed channel works, Gregory Street to Cummins Street, lower flood levels within the local area. Limited benefit was realised across the adjacent properties with no change in the number of properties affected above floor.

It was considered Option 1 was not viable, due the adverse flood impacts (increased flood level across 83, 85 and 87 Neill Street).

An alternative option to prevent overland flooding along Willoby Street, consists of a bund through the park (corner of Havelock and Livingstone Streets, across Willoby Street, and at the rear of 38 Willoby Street across to the railway station car park. This alternative requires a raised pavement section across Willboy Street. This alternative option would not provide flood protection for the properties along the western side of Havelock Street. A hydraulic assessment of the alternative is required to assess local flooding impacts.

Option 1 was unviable, due to the significant flood levels increases, considerable bund heights, the constraints in available space for siting of the bunding, and the bunding crossings of Havelock Street and Neill Street.

Cemetery Creek works (Option 2)

Works along Cemetery Creek, downstream of South Street, prevent overland flow to the west towards Skipton Road. The option results in increased flood levels (up to 0.4 m in the 100 year)

within the Cemetery Creek corridor. This increased flood levels reflects the confinement of the flows to the creek corridor. Also, there was associated increase in flow velocity along the creek.

Bunding heights along the western side of Cemetery Creek average 1.25 m with a maximum height 1.8 m (includes 0.3 m freeboard for the 100 year event). Typically, a bund would be constructed with 1 in 5 batter and a minimum 2 m top width. The footprint width for the average height (1.25 m) is approximately 14.5 m. There is limited space available along the rear of properties adjoining the western side of Cemetery Creek. Appropriate landscaping would be required to reduce any impact of resident's amenity.

To enable local drainage from behind the bunding, non-return values would be required on stormwater drainage outfalls.

Similar to Option 1, the bunding work requires raised pavement sections across Leichardt Street and Neill Street (Western Street). The design of the raised pavement sections need to maintain road safety and useability. Consultation with VicRoads would be required.

Option2 was considered unviable, due to the significant flood levels increases, considerable bund heights, the constraints in available space for siting of the bunding, and the bunding crossings of Leichardt Street and Neill Street.

Cumberland Creek works (Option 3)

Works along Cumberland Creek, downstream of the Western Highway South Street, prevent overland flow to the west across Broadbent Court. The option results in increased flood levels (up to 0.8 m in the 100 year) within the Cumberland Creek corridor. This increased flood levels reflects the confinement of the flows to the creek corridor. Also, there was associated increase in flow velocity along the creek.

Bunding heights along the western side of Cumberland Creek average 1.2 m with a maximum height 1.8 m (includes 0.3 m freeboard for the 100 year event). Typically, a bund would be constructed with 1 in 5 batter and a minimum 2 m top width. The footprint width for the average height (1.2 m) is approximately 14 m. There is limited space available along the rear of industrial estate allotments adjoining the western side of Cumberland Creek. Appropriate landscaping would be required to reduce any impact of resident's amenity.

To enable local drainage from behind the bunding, non-return values would be required on stormwater drainage outfalls.

Similar to Option 1 and 2, the bunding work requires raised pavement sections across Broadbent Court and Racecourse Road. The design of the raised pavement sections need to maintain road safety and useability, particularly entrance to the Broadbent Court industrial estate.

Option3 was considered unviable, due to the significant flood levels increases, considerable bund heights, constraints in available space for siting of the bunding, and the bunding crossings of Broadbent Court Leichardt Street and Neill Street.

Option 4 (Ding Dong Creek Works)

The Option 4 works along Ding Dong Creek, downstream of Neill Street (Western Highway), prevent overland flow to east across Havelock Street along Willoby Street for events up to the 1in 100 year ARI. A bund is required along the rear of 38 Willoby Street, and the rear of 32 and 34 Willboy Street to the higher ground in the Railway Station carpark Adjacent to Pratt Street and Railway Station. This bund does not need to cross any street, and hence avoid the impacts of traffic-ability discussed in Option 1.

There no increased flood levels for properties at 83, 85 and 87 Neill Street for events up to the 1 in 100 year event. Again, avoiding the adverse impacts on these properties found in Option 1.

This option reduces above floor flooding in the 10 year and 100 year events by 4 and 5 properties respectively. Similarly for below floor flooding was reduced in the 10 year and 100 year events by 19 properties for both events. The indicative benefit cost ratio is 1.4 (greater than 1)

Option 4 is recommended for further investigation, and inclusion in the floodplain management plan as a viable structural mitigation option. This recommendation is founded on the positive benefit-cost benefit, no adverse impacts on flood levels affecting properties, and manageable construction considerations.

Option 5 & 6

The Option 5 and 6 works consisted of channel enlargement and culvert augmentation along Cemetery Creek downstream of South Street to the Western Highway.

The absence of bunding, as proposed in Option 2, resulted in no increases in flood levels along the Cemetery Creek corridor. Further, the absence of bunding removed the constraints of available space and road crossings, as discussed for Option 2.

Option 5 yielded no reduction in above floor flooding in the 10 year event, and reduced the above floor flooding in the 100 year event by 6 properties. Similarly for below floor flooding was reduced in the 10 year and 100 year by 8 and 2 properties respectively. The indicative benefit cost ratio is 0.3 (less than 1).

Option 6 yielded no reduction in above floor flooding in the 10 year event, and reduced the above floor flooding in the 100 year event by 4 properties. Similarly for below floor flooding was reduced in the 10 year and 100 year events by 8 and 2 properties respectively. The indicative benefit cost ratio is 0.4 (less than 1).

Both Options 5and 6 were considered as a marginal mitigation option. The reduction of the number of properties affected relative to the cost is unfavourable.

4.4 Recommended structural mitigation measures

This section lists the key recommendations and conclusions arising from the structural mitigation measure assessment for consideration by the Shire:

Railway culverts

It is considered to achieve full effectiveness, a structural flood mitigation scheme must include the augmentation of the railway culverts. To this end, it is recommended that further discussion between Pyrenees Shire and VicTrack be pursued in an effort to gain an in principle agreement to augment the railway culverts.

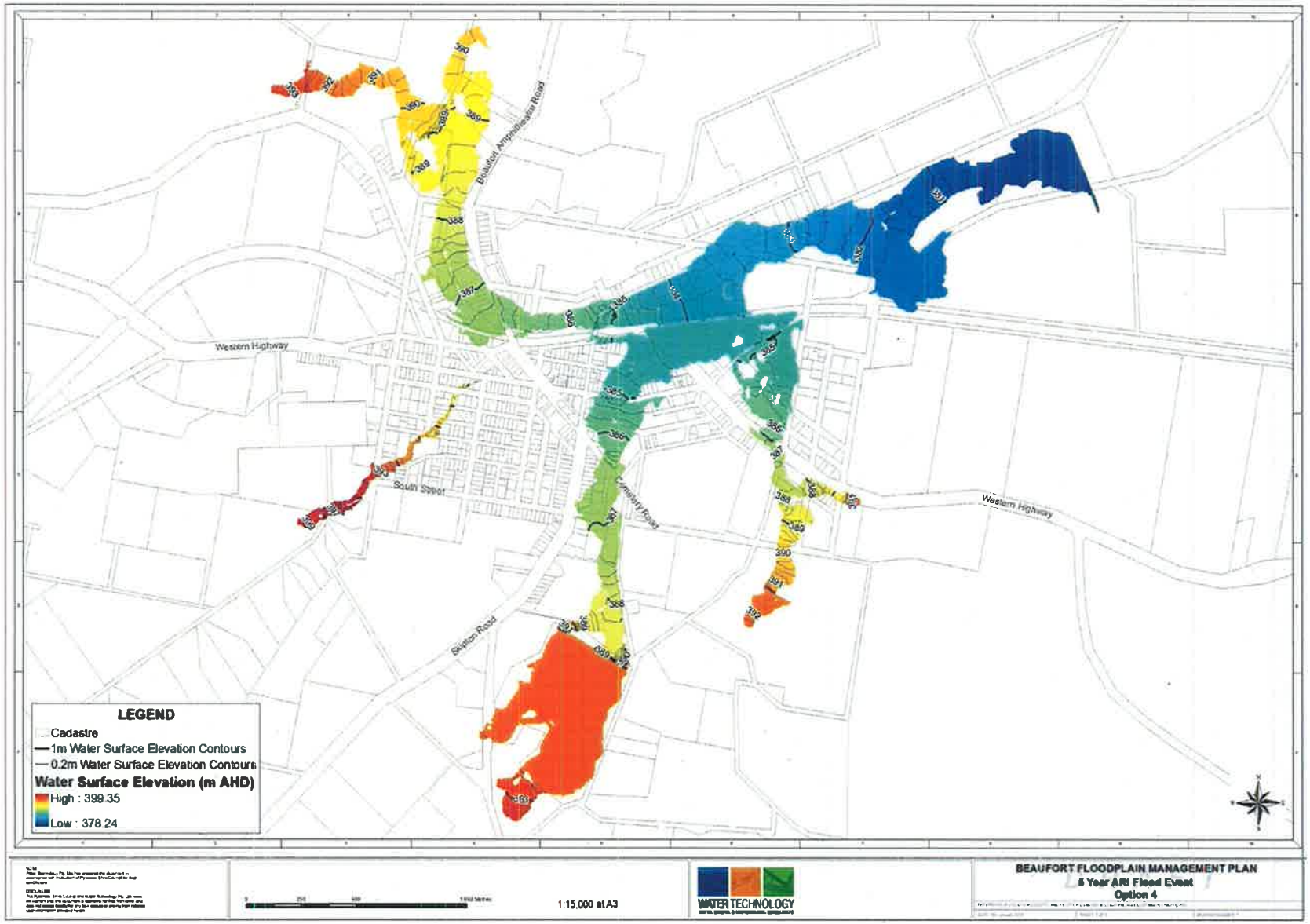
It is considered to achieve the full effectiveness, a structural flood mitigation scheme must include the augmentation of the railway culverts. To this end, further discussion is recommended between Pyrenees Shire and VicTrack in an effort to gain an in principle agreement to augment the railway culverts.

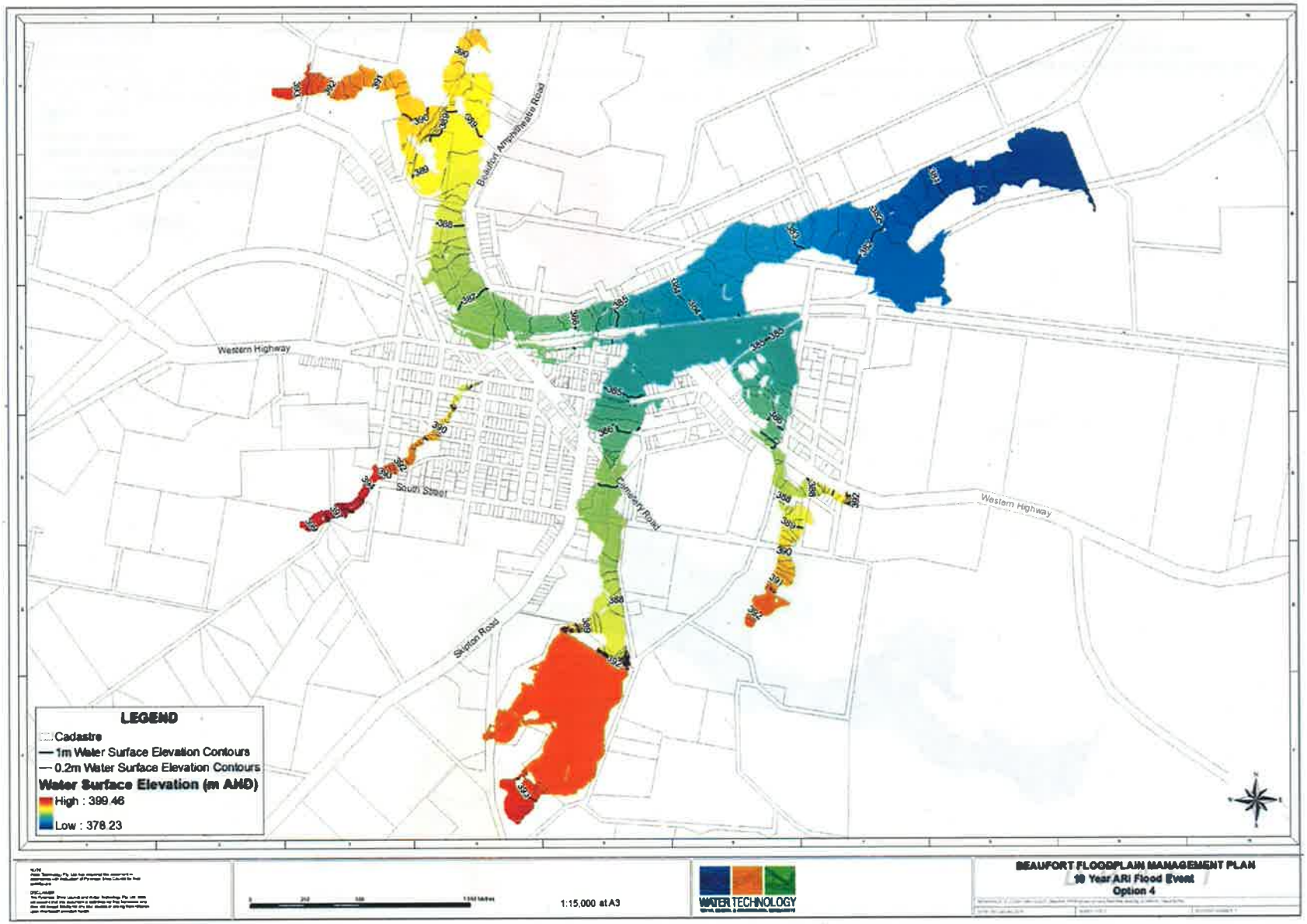
Ding Dong Creek works (Option 4)

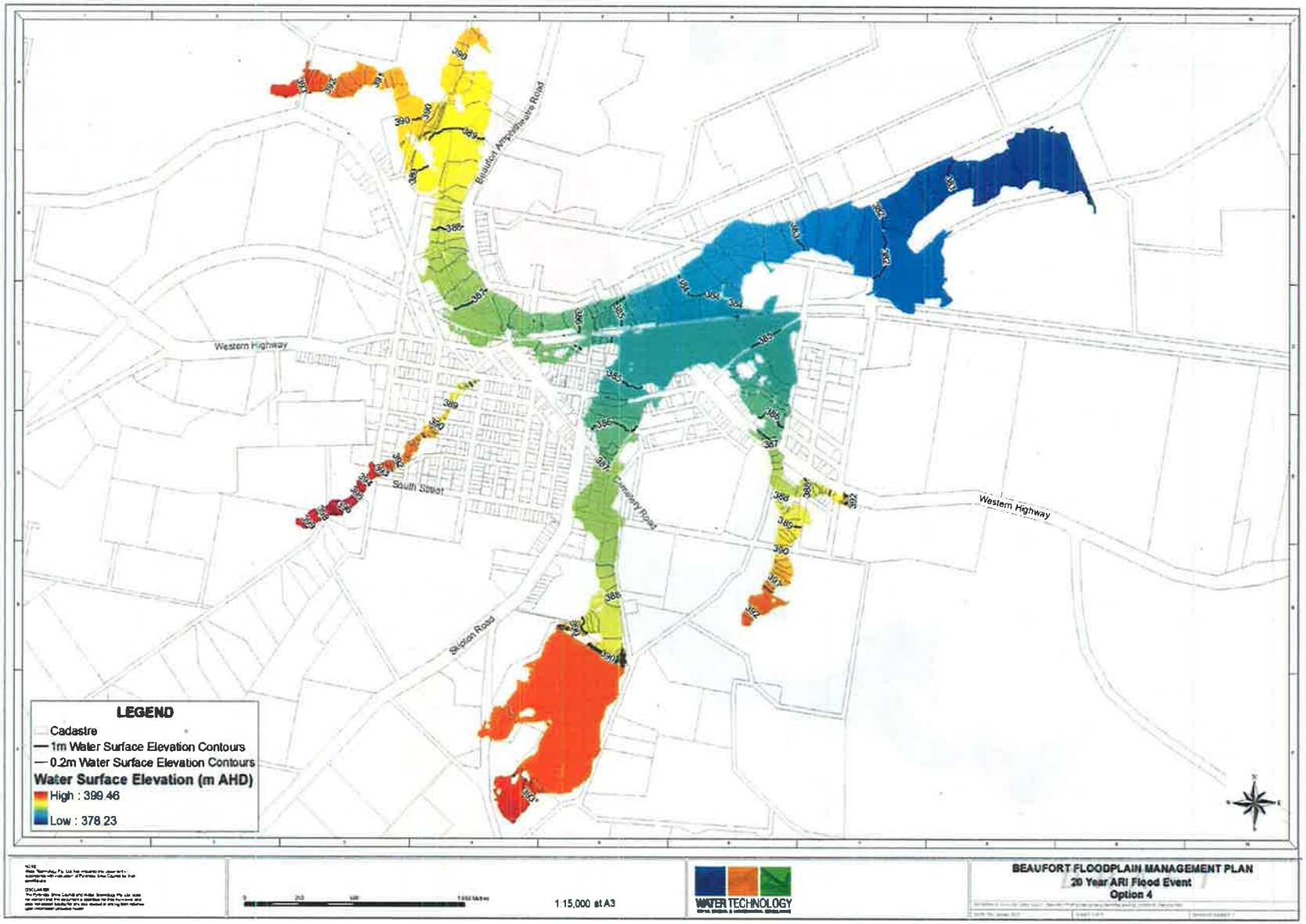
Option 4 is recommended for further investigation, and inclusion in the floodplain management plan as a viable structural mitigation option. This recommendation is founded on the positive benefit-cost benefit, no adverse impacts on flood levels affecting properties, and manageable construction considerations.

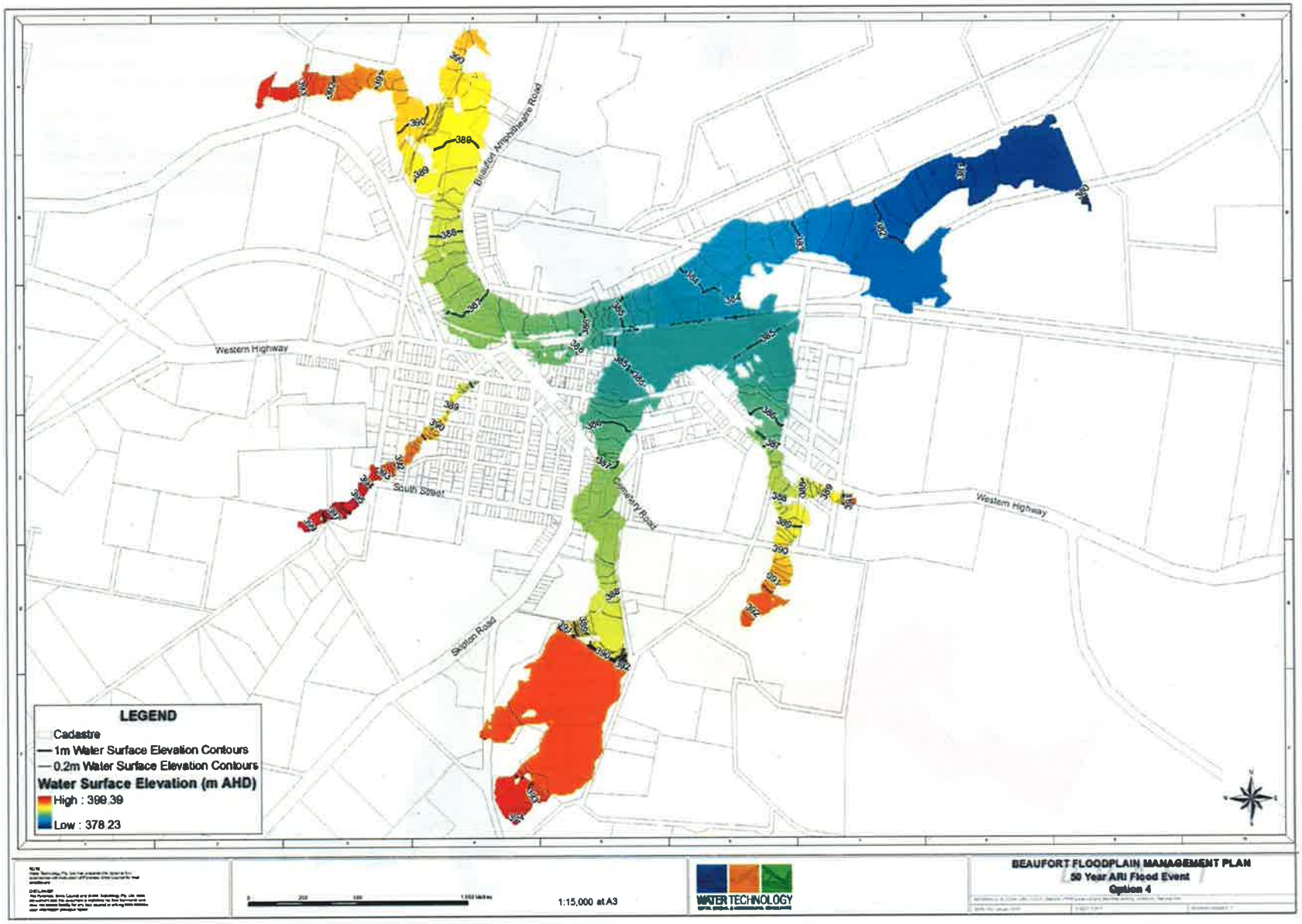
4.5 Inundation Mapping

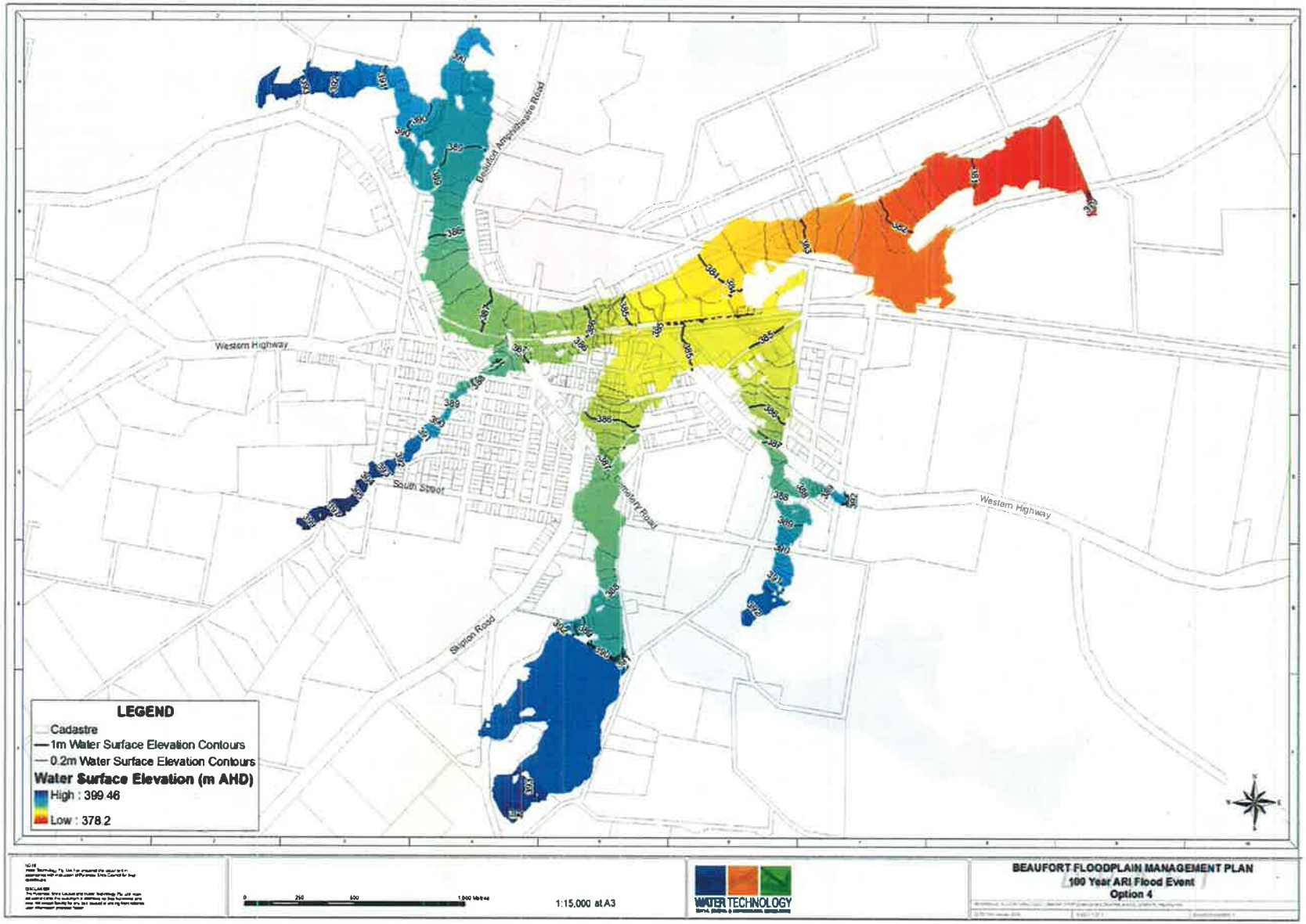
This section shows plots of the inundation extents and water level contours for the 5, 10, 20, 50 and 100 year ARI events for the preferred option 4 mitigation measures.


Beaufort Ampitheatre Road
Western Highway
South Street
Carngham Road
Western Highway
Skipton Road
LEGEND
Cadastre
1m Water Surface Elevation Contours
0.2m Water Surface Elevation Contours
Water Surface Elevation (m AHD)
High : 399.35
Low : 378.24
1:15,000 at A3
WATER TECHNOLOGY
BEAUFORT FLOODPLAIN MANAGEMENT PLAN
5 Year ARI Flood Event
Option 4


Beaufort Amphitheatre Road
Western Highway
South Street
Ramsbury Road
Western Highway
Skipton Road
LEGEND
Cadastre
1m Water Surface Elevation Contours
0.2m Water Surface Elevation Contours
Water Surface Elevation (m AHD)
High : 399.46
Low : 378.23
1:15,000 at A3
WATER TECHNOLOGY
BEAUFORT FLOODPLAIN MANAGEMENT PLAN
10 Year ARI Flood Event
Option 4


Western Highway
South Street
Beaufort Amphitheatre Road
Cemetery Road
Skipton Road
Western Highway
LEGEND
Cadastre
1m Water Surface Elevation Contours
0.2m Water Surface Elevation Contours
Water Surface Elevation (m AHD)
High : 399.46
Low : 378.23
1:15,000 at A3
WATER TECHNOLOGY
BEAUFORT FLOODPLAIN MANAGEMENT PLAN
20 Year ARI Flood Event
Option 4


Western Highway
Beaufort Amphitheatre Road
South Street
Cemetery Road
Western Highway
Skipton Road
LEGEND
Cadastre
1m Water Surface Elevation Contours
0.2m Water Surface Elevation Contours
Water Surface Elevation (m AHD)
High : 399.39
Low : 378.23
1:15,000 at A3
WATER TECHNOLOGY
BEAUFORT FLOODPLAIN MANAGEMENT PLAN
50 Year ARI Flood Event
Option 4


Western Highway
Beaufort Amphitheatre Road
South Street
Skipton Road
Western Highway
LEGEND
Cadastre
1m Water Surface Elevation Contours
0.2m Water Surface Elevation Contours
Water Surface Elevation (m AHD)
High : 399.46
Low : 378.2
1:15,000 at A3
BEAUFORT FLOODPLAIN MANAGEMENT PLAN
100 Year ARI Flood Event
Option 4

4.6 Asset Management

Maintenance of the preferred drainage mitigation measures is essential to ensure they are kept in a safe and efficient manner. Regular inspection of drains and culverts is required to identify any debris or other issues that may compromise the performance of the drainage infrastructure.

It is essential to provide appropriate maintenance to the bunding recommended in option 4 to ensure that the levee can perform adequately. Levees remain unused for long periods, but are then required to perform to a predetermined level, often at short notice. To maintain a minimum level of protection from flooding, it is necessary to provide a basic level of maintenance so that the level, cross-section and general standard of the levee is preserved over time.

Maintenance of the levee should be treated as any other valuable asset. A maintenance program should be developed to include an operations manual, annual inspections, batter maintenance and crest maintenance. A more detailed outline of the required levee maintenance can be found in Section 6 of the 'Levee Design, Construction and Maintenance' manual (DNRE 2002).

4.7 Roadway Public Highway Access

During an inundation event it is important to be able to maintain access for community and emergency service vehicles to the major roads within the township. The main road through Beaufort is the Western Highway (Neil St). Whilst it becomes inundated in the 100 year ARI event at Cemetery and Cumberland Creeks, the depth of flooding is below 0.2 m and the velocities generally less than 1 m/s. According to the Melbourne Water Floodplain Mapping Technical Guidelines (MW 2010), this equates to a safety risk in roads rating of 1, which is the lowest of 5 categories indicating low risk. Therefore it is safe to assume the highway can remain open to vehicles for flood events up to and including the 100 year ARI.

Table 4-4 summaries the flow across roads within the Beaufort Township for each ARI event at the locations shown in Figure 4-14. This table can be used to assess the accessibility of properties along the creeks within the town.

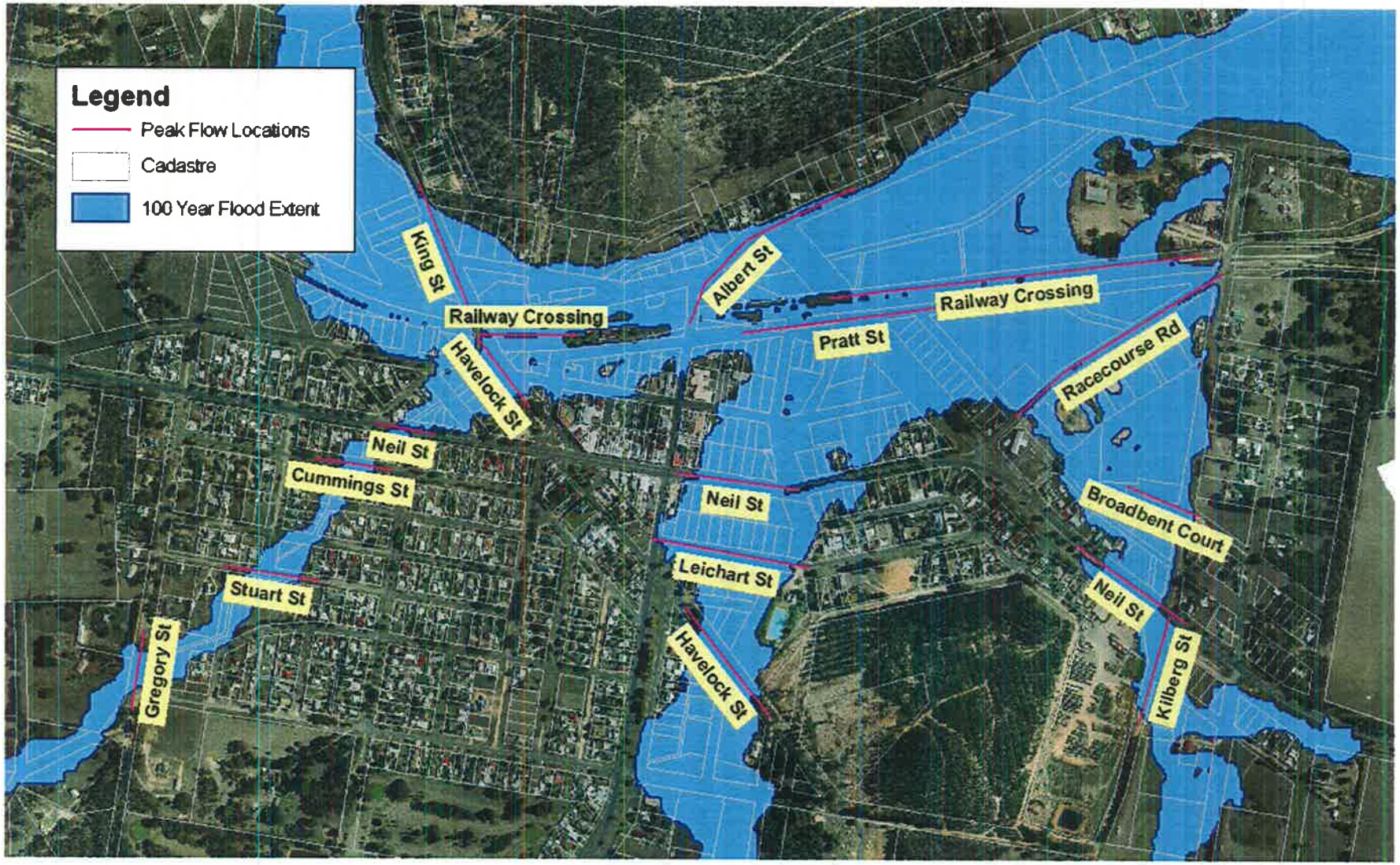


Figure 4-14 Location of Flow Calculations

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Table 4-4 Summary of flows and time to peak for roads within the Beaufort Township

	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)
	100 Year				50 Year				20 Year				10 Year				5 Year			
Ding Dong Creek																				
Gregory St	6.8	-	6.8	6	5.8	-	5.8	6	4.9	-	4.9	6	3.9	-	3.9	6	3.0	-	3.0	6
Stuart St	4.7	2.5	7.2	6	3.7	2.5	6.2	6	2.7	2.5	5.2	6	1.6	2.5	4.1	6	0.6	2.5	3.1	6
Cummings St	1.5	5.8	7.3	6	0.7	5.6	6.3	6	0.1	5.2	5.3	6	0.1	4.0	4.1	6	0.0	3.1	3.1	6.5
Neill St	0.0	7.4	7.4	6	0.0	6.4	6.4	6	0	5.6	5.5	6	0.0	4.3	4.3	6.5	0	3.4	3.4	6.5
Havelock St	6.4	5.0	11.5	6	5.6	4.5	10.0	6	5.1	4.4	9.5	6	4.2	4.9	9.1	6.5	2.6	4.3	6.9	6.5
Rail Embankment	3.6	3.7	7.3	6	3.9	3.5	7.4	6	3.9	3.5	7.4	6	4.0	4.4	8.3	6.5	3.8	3.9	7.6	6.5
Cemetery Creek																				
Havelock St	46.7	16.4	63.1	7	36.1	14.5	50.7	7.5	28.1	13.3	41.3	8	21.1	12.4	33.5	8.5	15.6	6.9	22.5	9.5
Leichardt St	44.7	11.3	55.9	7	34.8	6.8	41.6	7.5	27.0	5.3	32.3	8	20.9	5.3	26.1	8.5	15.8	4.9	20.7	9.5
Neill St	38.5	13.5	52.0	7	28.9	13.1	42.0	7.5	21.0	12.2	33.1	8	15.1	10.7	25.9	8.5	10.6	9.1	19.7	9.5
Pratt St	23.8	2.6	26.3	7.5	19.1	2.6	21.7	8	16.0	2.4	18.5	8.5	13.8	2.5	16.3	9	11.3	2.5	13.8	9.5
Cumberland Creek																				
Kilberg St	19.6	-	19.6	6	16.7	-	1675	6	13.6	-	13.6	6	10.6	-	10.6	6	10.0	-	10.0	6
Neill St	14.5	5.1	19.6	6	11.6	5.0	16.6	6	8.6	4.9	13.5	6	5.8	4.7	10.5	6	3.5	4.6	8.1	6.5
Broadbent Court	11.1	4.5	15.6	6	8.5	4.5	13.0	6	5.8	4.5	10.3	6	3.4	4.4	7.9	6.5	1.9	4.2	6.2	6.5
Racecourse Rd	15.5	7.9	23.4	6	11.7	7.9	19.5	6	8.1	7.9	16.0	6.5	4.8	7.8	12.6	6.5	1.4	7.7	9.1	7
Rail Embankment *(Cemetery & Cumberland Creeks)*	59.6	45.1	104.6	7	45.8	43.7	89.5	7.5	44.0	36.9	80.9	8.5	22.8	27.2	49.9	9	18.5	19.8	38.3	9.5
Yam Holes Creek																				
King St	68.8	-	68.8	7	56.7	-	56.7	7	47.4	-	47.4	7	37.5	-	37.5	7	30.9	-	30.9	8
Albert St	30.4	38.4	68.8	7	21.2	37.5	58.6	7	14.0	36.0	50.0	7.5	6.6	32.2	38.9	7.5	2.9	25.8	28.8	8

N.B. 'Time to peak' is indicative only and represents the time to the peak flow from the beginning of the design 9 hour rainfall event.

4.8 Environmental Health

The Central Highlands Water Treatment facility and associated sub surface sewerage effluent pumping station are in close proximity to the Beaufort Township. A serious environmental health risk would be imposed upon the general public in the event that either of these sites was to be inundated during a flood event.

Fortunately, the dam containment walls of the water treatment facility are above the 100 year ARI water level at that location preventing effluent from surcharging from this facility. The pumping station does however lie within the flood extent. The site is inundated in all events up to and including the 5 year ARI, with the depth of flooding in excess of 1.0m in a 100 year ARI event. The location of the pumping station is shown in Figure 4-15.

The pumping station is located adjacent to high ground outside of the flood extent. A levee wall could be constructed around the pumping station that could tie into this high ground without greatly impacting the floodway. The cost of these works would be minor compared to the health risks associated with sewage effluent surcharging into flood waters. The levee wall would need to be maintained as per section 4.6.

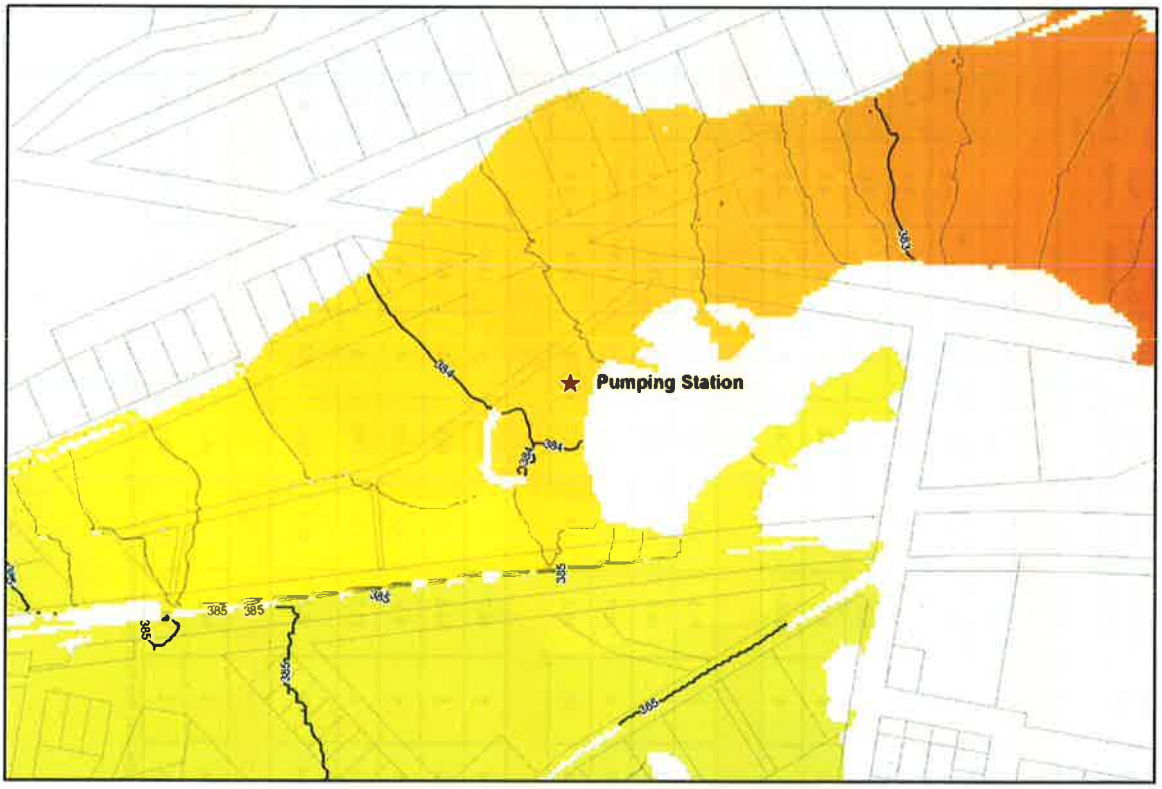


Figure 4-15 Location of pumping station within the 100 year ARI flood extent

5. NON-STRUCTURAL MITIGATION MEASURE ASSESSMENT

5.1 Overview

This section discusses a number of non-structural flood mitigation measures, and recommends specific measures for inclusion in the floodplain management plan. As discussed in Section 4.1, non-structural mitigation measures include land use planning, flood warning and flood response.

5.2 Land use planning

5.2.1 Background

Planning Environmental Design (PED) were engaged to review and recommend flood related planning controls. The following summarises key aspects from PED report, with the full report contained in Appendix B.

The Victorian Planning Provisions (VPPs) contain a number of controls that can be employed to provide guidance for the use and development of land that is affected by inundation from floodwaters. These controls include the Floodway Overlay, the Land Subject to Inundation Overlay, the Special Building Overlay, and the Urban Floodway Zone.

Section 6(e) of the Planning and Environment Act 1987enables planning schemes to 'regulate or prohibit any use or development in hazardous areas, or areas likely to become hazardous'. As a result, planning schemes contain State planning policy for floodplain management requiring, among other things, that flood risk be considered in the preparation of planning schemes and in land use decisions.

The Pyrenees Planning Scheme makes several references to flooding and inundation by floodwaters. The most relevant clauses of the Planning Scheme that address flooding and inundation include the Municipal Strategic Statement (MSS) Clauses 21.04, 21.05, and 21.07; Local Planning Policy Clauses 22.03 and 22.04; and the Design and Development Overlay Schedule 1 (DDO1).

5.2.2 Potential planning measures

Guidance for applying flood controls to Planning Schemes is available from the Department of Planning and Community Development's (DPCD) Practice Note on Applying Flood Controls in Planning Schemes.

Council has a range of tools to choose from to identify flood affected land in its planning scheme. There are four types of flood provisions available; the Urban Floodway Zone (UFZ), Floodway Overlay (FO), Land Subject to Inundation Overlay (LSIO) and Special Building Overlay (SBO). This section of the report discusses how each control may be applied in the Pyrenees Planning Scheme.

Urban Floodway Zone

Increasing the intensity of land use or a change in land use can increase flood risk, therefore in areas of highest flood risk and with a potential for land use intensification, it may be appropriate that land use is restricted. As with any other zone, the UFZ controls the use of land in identified floodway areas. The UFZ is very restrictive on what uses are permissible, as such, use of the UFZ will severely limit the use and development of land to which it is applied.

The difficulty in using the UFZ is that flooding does not follow cadastral boundaries; hence it may not be possible to apply the zone to a complete parcel of land. Best practice is to ensure that only 1 zone applies to any given parcel of land. ***Due to the restrictive nature of the UFZ, it is not recommended for use in the Pyrenees Planning Scheme. It is considered that the Farming Zone,***

the Public Park and Recreation Zone, or the Public Conservation and Resource Zone be applied instead, as these zone more clearly identify the development potential for land.

Floodway Overlay

The Floodway Overlay (FO) applies to mainstream flooding in both rural and urban areas. These areas convey active flood flows or store. The FO is suitable for areas where there is less need for control over land use, and the focus is more on control of development.

The function of the overlay is to trigger the need for a planning permit. The proposed Floodplain Management Local Planning Policy provides guidance on assessment of the permit application. The draft policy proposed seeks to prevent new buildings and works, including earthworks and vegetation clearance in the FO.

It is recommended that the FO be introduced to the Pyrenees Planning Scheme in concert with a Beaufort Floodplain Management Local Planning Policy.

The LSIO/FO Map will identify the land where a permit will be required, whilst the FO Schedule will identify various developments that will be exempt from the need for a permit, with the proposed Local Planning Policy identifying policy objectives to be met by development that do require a permit.

Land Subject to Inundation Overlay

The LSIO applies to mainstream flooding in both rural and urban areas. In general, areas covered by the LSIO have a lower flood risk than FO areas.

The LSIO will act as a trigger for a planning permit. The proposed Beaufort Floodplain Management Local Planning Policy sets out the circumstances where buildings and works would be permitted subject to condition.

It is recommended that the LSIO be introduced to the Pyrenees Planning Scheme in concert with a Floodplain Management Local Planning Policy.

A proposed LSIO Schedule will identify various developments that will be exempt from the need for a permit, with the proposed Local Planning Policy identify policy objectives to be met by development that do require a permit.

Special Building Overlay

The Special Building Overlay (SBO) applies to stormwater flooding in urban areas only. The SBO is intended to apply to areas/locations where the drainage systems are designed to a lower capacity than what may be required during peak storm events resulting in overlay flow of storm water. The purpose of the SBO is to manage development in areas that are subject to overland flow of storm water. As the area covered by the Beaufort Flood Study addresses channel flow only, the circumstances for application of the SBO do not exist. Common practice throughout Victorian Planning Schemes is to apply the SBO to situations where underground drainage pipes are of insufficient capacity to convey storm water. This is clearly not the case in Beaufort.

it is not recommended to introduce the SBO to the Pyrenees Planning Scheme to give effect to the Beaufort Flood Study recommendations.

Local Planning Policy Floodplain Management

The use of local policy to give greater guidance and clarity in the Planning Permit process is considered to be prudent practice. The policy provides guidance to both applicants and Council.

The policy will apply to all permits required under the LSIO and the FO. Applicants will be able to gain guidance from the policy before preparing applications. Whilst Council can rely on the content

of the policy to place conditions on permits, or to refuse permits. The policy can also be relied on to defend Council decisions at appeal.

The policy includes objectives to be achieved, gives policy statements, and provides performance standards that are to be met. A copy of a proposed draft Local Planning Policy is contained in Appendix B. The policy contains a number of objectives and performance measures that seek to ensure that new development does not reduce or impede the ability of the flood plain to store and convey floodwater.

It is recommended that a Floodplain Management Local Planning Policy be introduced to the Pyrenees Planning Scheme.

5.2.3 Recommended planning measures

Flood related planning zone and overlays

Due to the restrictive nature of the UFZ, it is not recommended for use in the Pyrenees Planning Scheme. It is considered that the Farming Zone, the Public Park and Recreation Zone, or the Public Conservation and Resource Zone be applied instead, as these zone more clearly identify the development potential for land.

It is recommended that the LSIO and FO be introduced to the Pyrenees Planning Scheme in concert with a Beaufort Floodplain Management Local Planning Policy. Draft delineation of proposed FO and LSIO are displayed in Figure 5-1, as prepared by the Beaufort flood Study (Water Technology 2010).

Administrative aspects

It is recommended that a planning scheme amendment include:

- Changes to the Municipal Strategic Statement that recognise the existence of the Beaufort Flood Study and the Beaufort Floodplain Management Policy
- New Clause 22.07 Beaufort Floodplain Management Policy
- Replace Map 20DDO with a new Map 20LSIO/FO based on Figure 5-1
- introduce Map 19LSIO/FO based on Figure 5-1,
- Amend Map 19DDO to remove that portion of the exiting DDO area that is to be replaced by LSIO/FO,
- Introduce the Floodway Overlay and Schedule,
- Introduce the Land Subject to Inundation Overlay and Schedule,
- Make sequential changes to relevant clauses of the Planning Scheme to recognise the introduction/deletion of maps and the existence of the Beaufort Floodplain Management Policy.

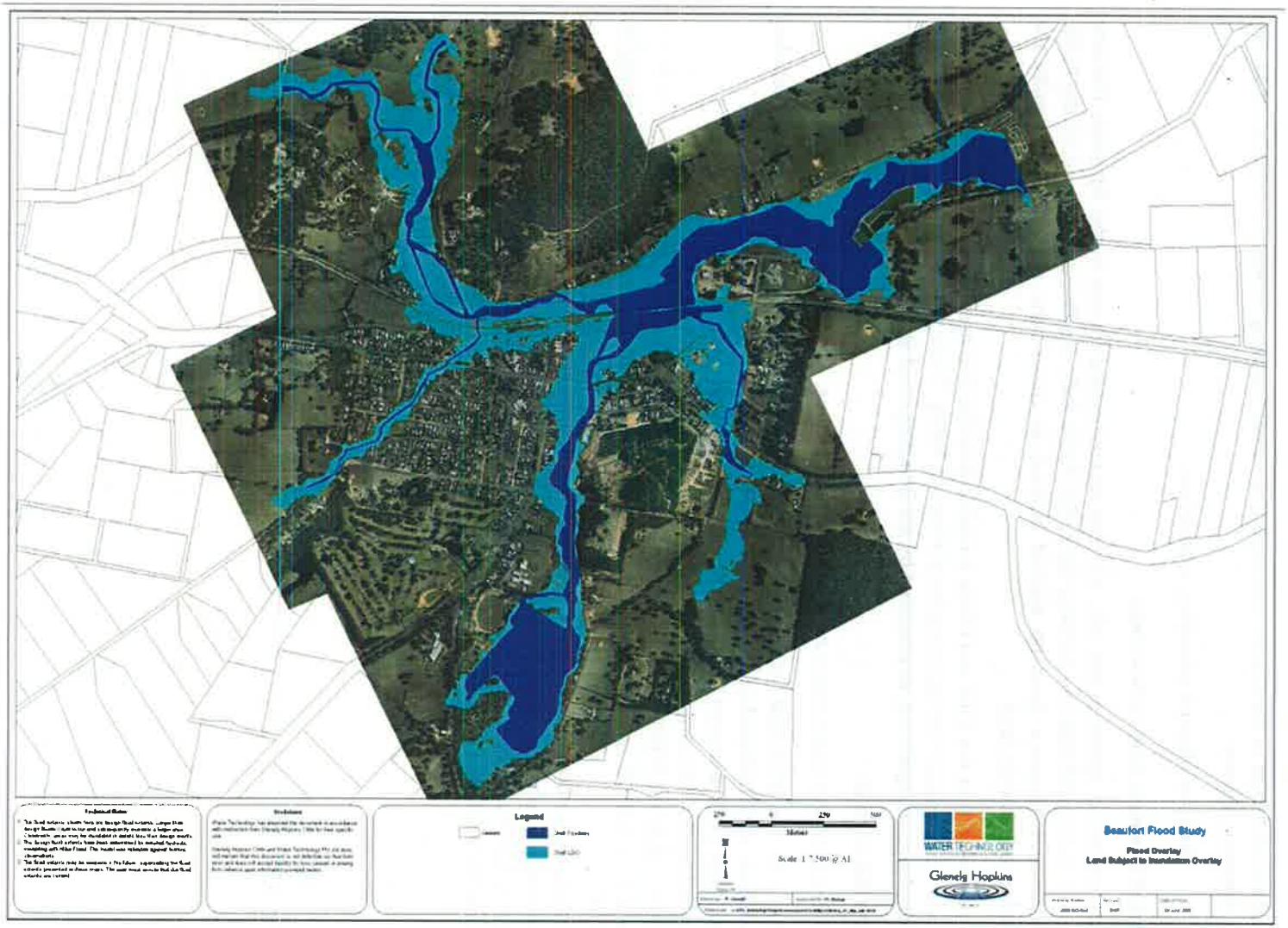


Figure 5-1 Draft FO and LSIO delineation (Source Beaufort Flood Study 2008)

5.3 Flood warning, response and awareness

The Beaufort Flood Study (Water Technology 2008) detailed potential flood response, warning and awareness. Key elements from the Beaufort Flood Study (Water Technology 2008) are summarised below. Information relating to community alerting and notification is also provided.

5.3.1 Flood warning

Flood warning and associated activities aim to reduce growth in flood damages by improving community awareness of flooding and emergency response in the event of a flood. The degree of flood awareness within a community often reflects the frequency of significant flooding (i.e. infrequent insignificant flooding generally leads to lower community flood awareness). Questionnaire responses and contributions at public meetings during the course of the study showed that the Beaufort community is generally unaware of the existing flooding issues and sensitivities. It is likely that the absence of flooding within the Beaufort area in recent times coupled with population mobility has contributed to this lack of awareness.

The Bureau of Meteorology does not provide a flood warning service for the creeks surrounding Beaufort.

The RORB modelling undertaken as part of this study suggests there is only a small delay (of order 3 to 6 hours) between rainfall in the upper parts of the catchments around Beaufort and flood peaks reaching Beaufort. Thus by definition (Bureau of Meteorology, 1996) the township is subject to flash flooding as response time is less than 6 hours.

The principles applying to the provision of flash flood warning services are different from those applying to areas with longer response times and are detailed in VFWCC (2001). Essentially these principles can be summarised as:

- The Bureau of Meteorology has a responsibility to provide predictions of weather conditions likely to lead to flash flooding (e.g. thunderstorms);
- Local Government has prime responsibility for flash flood warning extending from system establishment and operation through to the provision of predictions of stream levels if required; and
- The Bureau of Meteorology will provide specialist technical assistance and advice to Local Government to assist in system establishment and in relation to flood prediction techniques.

It is considered that a flash flood monitoring and warning system would provide some benefit to the Beaufort community. However, this would come at some cost: a cost that would need to be met by Council and that may exceed benefits. While there are recent examples of flash and longer term flood warning system development being funded from the Natural Disaster Resilience Program on a 1/3:1/3:1/3 (Commonwealth : State : Local) basis, all on-going costs, including asset replacement, would need to be funded by Council.

It is recommended that Council consider the costs and potential benefits of a flash flood monitoring and warning system for Beaufort and in the first instance, provided that on-going costs can be met from within Council and that benefits are sufficient to support a case, submit an application for funding for flash flood warning system establishment. Part of the work scope would include consultation with the community on how they would want to be warned of a potential flash flood and the championing of the establishment of a community-based flash flood action group.

5.3.2 Flood Response

It is apparent that flood response at Beaufort is current predominantly reactive and based on ad-hoc arrangements that rely on a mix of local and corporate knowledge. It is suggested that a more structured approach founded on knowledge of potential flood impacts (in terms of those areas/properties likely to be affected, areas of high hazard and of deep and/or fast flowing water, flood progression, etc) would result in an improved and more targeted response and reduce losses, particularly during a future severe event.

It is recommended that a flood response plan be developed for Beaufort using available flood intelligence. The Plan should identify flood effects within the township versus increased flood severity and document the response required to minimise risk to life and property. It is suggested the Plan should give attention to flooding up to the probable maximum flood (PMF) if possible but to the 1% AEP (100 year ARI) event as a minimum.

Appendix C contains flood intelligence for use in the preparation of flood response.

5.3.3 Community Flood Awareness

There are a number of activities that could be initiated to maintain and renew awareness at Beaufort. The emphasis should be on an awareness of public safety issues (including, if installed, the flash flood monitoring system and how it will help) and on demonstrating what people can do to stay safe and protect their property from flooding.

A flash flood action guide or brochure aimed specifically at encouraging local residents and businesses to take a pro-active role in preparing their property and themselves for a flood as well as describing what people need to do in a flood event. These could be given out at community shows and field days, to schools and with council rate notices and/or other council communications. VICSES Floodsafe program provides a template for the preparation of community flood awareness material.

It is recommended that the Pyrenees Shire Council prepare a flash flood action guide or brochure for the Beaufort community. Funding could be sought from the Natural Disaster Resilience Program. It is suggested that if a flash flood monitoring and warning system is contemplated for Beaufort that the scope of work and funding sought include preparation of the MEMP Flood response plan together with appropriate flood awareness raising activities and materials.

5.3.4 Community Alerting and Notification

There are a number of options available for alerting and notifying the owners and occupiers of properties in and around Beaufort of conditions likely to lead to rapid onset (flash) flooding. However, community warning systems have a history of not always being sustainable or successful (Handmer, 2000). It is therefore important to understand the elements that specifically contribute to the success of such systems before deciding to initiate a system for Beaufort.

The definition of 'success' as a measure of community warning / alert system effectiveness is directly linked to the subsequent appropriate and safe decisions and behaviours undertaken by people. The difficulty with current research however, is that there have been limited opportunities for this link to be measured. Handmer identifies the successful principles of community warning / alert systems as being:

- The development and acknowledgment of both formal and informal sources of warning information;
- The public and participating emergency management organisations having a shared understanding about the warning / alert system's operation and intention;
- The recognition of 'local' community needs;

- The inclusion of community education and awareness about the risk and the way in which the warning / alert system interacts with that risk;
- Inter-organisation cooperation.

A number of Councils within Victoria have had to address the issue of how best to alert their flood–prone urban communities to the on-set of flooding. In all cases (City of Greater Shepparton for Shepparton and Mooroopna, Latrobe City for Traralgon, Strathbogie Shire for Euroa, City of Benalla for Benalla, City of Maribyrnong for Maribyrnong Township, City of Greater Geelong for Moolap and Moira Shire for Nathalia) Premier Global Services' Expedite VoiceREACH system was selected to perform the alert and notify task. A formal flood warning service exists for all communities except Moolap. Moolap is a relatively small mixed residential and industrial area in Geelong which is subject to flash flooding. Some parallels can be drawn between Beaufort and Moolap.

The (National) Emergency Alert (System) is available to emergency service organisations (eg. VICSES) and is used to alert individuals within an identified area, by fixed and mobile telephone, of an imminent threat. The Emergency Alert was used to good effect by VICSES to alert threatened communities during the January 2011 floods in Victoria.

A more complete consideration of available approaches to community alerting and notification is provided in Appendix D.

It is recommended that Pyrenees Shire Council consider available options for alerting and notifying the Beaufort community of likely flooding but that any decision regarding implementation have full regard for all elements of the Total Flood Warning System and particularly in relation to community flood awareness. An alerting and notification system that is not understood and appreciated by the at-risk community is unlikely to be heeded and thus will be of very limited value: recipients must understand the message they receive and be able to interpret it for the system to be effective.

6. FLOODPLAIN MANAGEMENT PLAN

6.1 Overview

This section outlines key elements and scope of the Beaufort Floodplain Management Plan. As discussed in Section 3.2, a floodplain management plan may consist of the following elements:

- Recommended structural works
- Recommended non-structural works:
    - Flood warning arrangements
    - Flood response plan
    - Community awareness material
    - Specific land use planning requirements (flood related planning overlays and provisions)

The Beaufort Floodplain Management Plan provides the Pyrenees Shire and Glenelg Hopkins CMA with a number of recommended measures to reduce flood risk into the future.

6.2 Recommended structural mitigation measures

Railway culverts

It is considered to achieve full effectiveness, a structural flood mitigation scheme must include the augmentation of the railway culverts. To this end, it is recommended that further discussion between Pyrenees Shire and VicTrack be pursued in an effort to gain an in principle agreement to augment the railway culverts.

Ding Dong Creek works (Option 4)

Option 4 is recommended for further investigation, and inclusion in the floodplain management plan as a viable structural mitigation option. This recommendation is founded on the positive benefit-cost benefit, no adverse impacts on flood levels affecting properties, and manageable construction considerations.

6.3 Recommended non-structural measures

Planning measures

Due to the restrictive nature of the UFZ, it is not recommended for use in the Pyrenees Planning Scheme. It is considered that the Farming Zone, the Public Park and Recreation Zone, or the Public Conservation and Resource Zone be applied instead, as these zone more clearly identify the development potential for land.

It is recommended that the LSIO and FO be introduced to the Pyrenees Planning Scheme in concert with a Beaufort Floodplain Management Local Planning Policy. Draft delineation of proposed FO and LSIO as prepared by the Beaufort flood Study (Water Technology 2010).

It is recommended that a planning scheme amendment include:

- Changes to the Municipal Strategic Statement that recognise the existence of the Beaufort Flood Study and the Beaufort Floodplain Management Policy
- New Clause 22.07 Beaufort Floodplain Management Policy
- Replace Map 20DDO with a new Map 20LSIO/FO based on Figure 5-1
- introduce Map 19LSIO/FO based on Figure 5-1,
- Amend Map 19DDO to remove that portion of the exiting DDO area that is to be replaced by LSIO/FO,
- Introduce the Floodway Overlay and Schedule,

- Introduce the Land Subject to Inundation Overlay and Schedule,
- Make sequential changes to relevant clauses of the Planning Scheme to recognise the introduction/deletion of maps and the existence of the Beaufort Floodplain Management Policy.

Flood warning

It is recommended that Council consider the costs and potential benefits of a flash flood monitoring and warning system for Beaufort and in the first instance, provided that on-going costs can be met from within Council and that benefits are sufficient to support a case, submit an application for funding for flash flood warning system establishment. Part of the work scope would include consultation with the community on how they would want to be warned of a potential flash flood and the championing of the establishment of a community-based flash flood action group.

Flood response

It is recommended that a flood response plan be developed for Beaufort using available flood intelligence. The Plan should identify flood effects within the township versus increased flood severity and document the response required to minimise risk to life and property. It is suggested the Plan should give attention to flooding up to the probable maximum flood (PMF) if possible but to the 1% AEP (100 year ARI) event as a minimum.

Flood awareness

It is recommended that the Pyrenees Shire Council prepare a flash flood action guide or brochure for the Beaufort community. VICSES Floodsafe program provides a template for the preparation of community flood awareness material. Funding could be sought from the Natural Disaster Resilience Program. It is suggested that if a flash flood monitoring and warning system is contemplated for Beaufort that the scope of work and funding sought include preparation of the MEMP Flood response plan together with appropriate flood awareness raising activities and materials.

6.4 Implementation of the plan

The implementation of the plan requires a number of actions to be undertaken by various agencies. Table 6-1 outlines the required actions, the responsible agencies and considered priority.

For the purposes of the plan, the following priorities have been assigned:

- High (start within 6 months),
- Medium (start within 2 years),
- Low (start 3 years +)

Table 6-1 Key actions required in the implementation of the Plan

Item	Action	Resources	External Cost	Priority	Timing	Responsibility	Comments
Structural mitigation Works Railway culvert	Pyrenees Shire and VicTrack continue discussion in an effort to gain an in principle agreement to augment the railway culverts.	Pyrenees Shire	Nil	High	6 months	Pyrenees Shire	It is considered to achieve full effectiveness, a structural flood mitigation scheme must include the augmentation of the railway culverts. It is noted that a consultant has been appointed to undertake an initial design and cost is underway as at Oct 2010.
	Pyrenees Shire, following agreement with VicTrack, seek funding (internal and external sources) for Railway Culvert augmentation. Funds may be available through Natural Disaster Resilience program. Pyrenees Shire to discuss with Glenelg Hopkins CMA and DSE.	Pyrenees Shire Glenelg Hopkins CMA Department of Sustainability and Environment	Nil	High	6 months	Pyrenees Shire	
Structural mitigation Works Ding Dong Creek works (Option 4)	Pyrenees Shire undertake (internal or via a consultant) a functional design (including costing) for the proposed works.	Pyrenees Shire or consultant	~$30,000 (if consultant engaged)	High	1 year	Pyrenees Shire	Funding through the Natural Disaster Resilience Program (as at Oct 2010) is provided on an equal three way contribution between Federal, State and local governments.

Item	Action	Resources	External Cost	Priority	Timing	Responsibility	Comments
Structural mitigation Works Ding Dong Creek works (Option 4)	Pyrenees Shire seek funding (internal and external sources) for Option 4 works Funds may be available through Natural Disaster Resilience program Funds may be available through Natural Disaster Resilience program. Pyrenees Shire to consult with Glenelg Hopkins CMA and DSE, and other agencies to gain in-principle for the option 4 works.	Pyrenees Shire Glenelg Hopkins CMA	Pyrenees Shire share ~$170,000	High	1 year	Pyrenees Shire	Under this funding model, the Pyrenees Shire would be required source a third of the capital costs. Using the indicative costing in this plan, the Shire's contribution is likely to be up to $170,0000
Planning scheme	Pyrenees Shire undertake (internal or via a consultant) the planning scheme amendment as outlined in this plan.	Pyrenees Shire Glenelg Hopkins CMA Department of Sustainability and Environment Department of Community Development and Planning	~$15,000 (if consultant engaged)Nil	High	1 year	Pyrenees Shire	It is recommended that the LSIO and FO be introduced to the Pyrenees Planning Scheme in concert with a Beaufort Floodplain Management Local Planning Policy. Draft delineation of proposed FO and LSIO as prepared by the Beaufort flood Study (Water Technology 2010).

Item	Action	Resources	External Cost	Priority	Timing	Responsibility	Comments
Flood warning	Pyrenees Shire consult with BoM & GHCMA to scope the potential of a flash flood warning system.	Pyrenees Shire Glenelg Hopkins CMA BoM	Nil	Medium	6 months	Pyrenees Shire	It is recommended that Council consider the costs and potential benefits of a flash flood monitoring and warning system for Beaufort and in the first instance, provided that on-going costs can be met from within Council and that benefits are sufficient to support a case, submit an application for funding for flash flood warning system establishment. Part of the work scope would include consultation with the community on how they would want to be warned of a potential flash flood and the championing of the establishment of a community-based flash flood action group.
	Pyrenees Shire, if potential of flash warning system demonstrated, seek funding for implementation Funds may be available through Natural Disaster Resilience program Funds may be available through Natural Disaster Resilience program. Pyrenees Shire to consult with Glenelg Hopkins CMA, DSE & BoM..	Pyrenees Shire Glenelg Hopkins CMA	Nil	Medium	6 months	Pyrenees Shire	

Item	Action	Resources	External Cost	Priority	Timing	Responsibility	Comments
Flood response	Pyrenees Shire prepare flood response plan using the available flood intelligence Pyrenees Shire consult with GHCMA & VICSES	Pyrenees Shire Glenelg Hopkins CMA VICSES	$15,000 (if consultant engaged)	Medium	1 year	Pyrenees Shire	It is recommended that a flood response plan be developed for Beaufort using available flood intelligence. The Plan should identify flood effects within the township versus increased flood severity and document the response required to minimise risk to life and property. It is suggested the Plan should give attention to flooding up to the probable maximum flood (PMF) if possible but to the 1% AEP (100 year ARI) event as a minimum.
Flood awareness	Pyrenees Shire prepare community flood awareness material using the available flood intelligence Pyrenees Shire consult with GHCMA & VICSES	Pyrenees Shire Glenelg Hopkins CMA VICSES	$15,000 (if consultant engaged)	Medium	1 year	Pyrenees Shire	It is recommended that the Pyrenees Shire Council prepare a flash flood action guide or brochure for the Beaufort community. VICSES Floodsafe program provides a template for the preparation of community flood awareness material. Funding could be sought from the Natural Disaster Resilience Program. It is suggested that if a flash flood monitoring and warning system is contemplated for Beaufort that the scope of work and funding sought include preparation of the MEMP Flood response plan together with appropriate flood awareness raising activities and materials.

7. REFERENCES

Agricultural and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000), Standing committee on Agriculture and Resource Management (SCARM) Report No 73: *Floodplain Management in Australia, Best Principles and Guidelines*, 2000.

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Water Technology (2008): *Beaufort Flood Study*. Consulting report prepared for the Pyrenees Shire. 2008.

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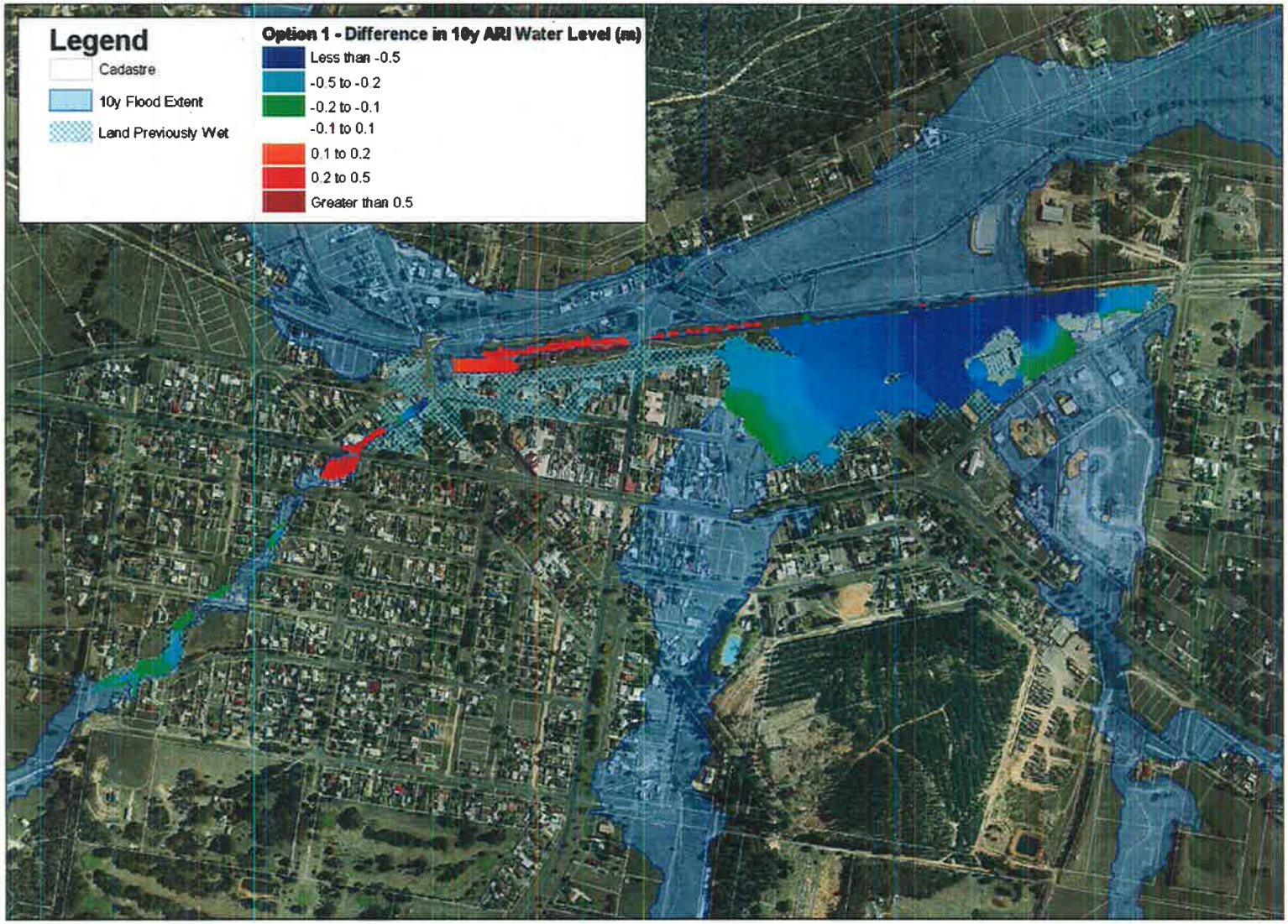
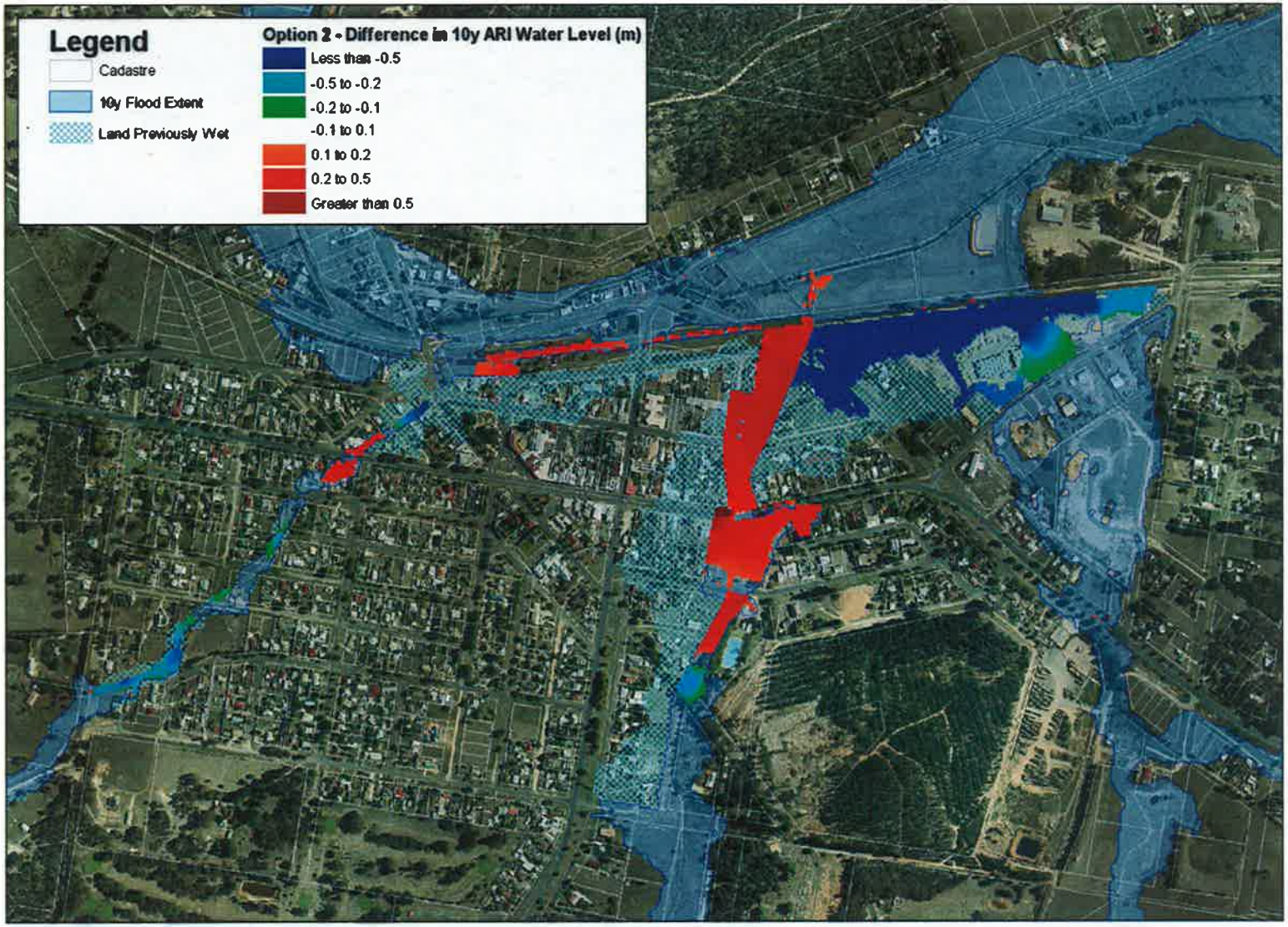
Handmer, J. (2000): *Are Flood Warnings Futile? Risk communication in emergencies.* The Australasian Journal of Disaster and Trauma Studies, Vol 2000-2 N.Z.

APPENDIX A STRUCTURAL MITIGATION ASSESSMENT


Legend
Cadastre
10y Flood Extent
Land Previously Wet
Option 1 - Difference in 10y ARI Water Level (m)
Less than -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5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Cadastre
10y Flood Extent
Land Previously Wet
Option 2 - Difference in 10y ARI Water Level (m)
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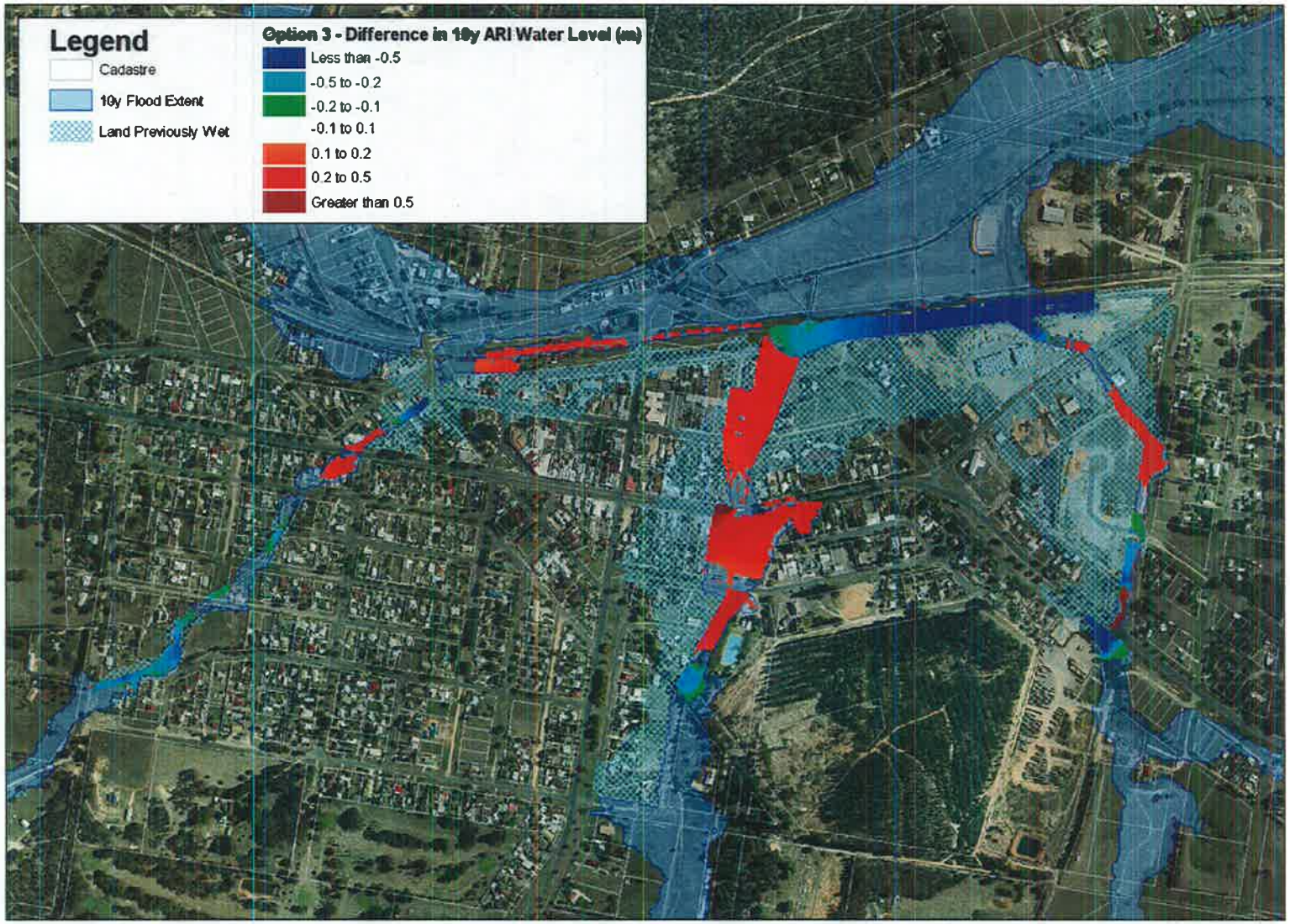
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5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Cadastre
10y Flood Extent
Land Previously Wet
Option 3 - Difference in 10y ARI Water Level (m)
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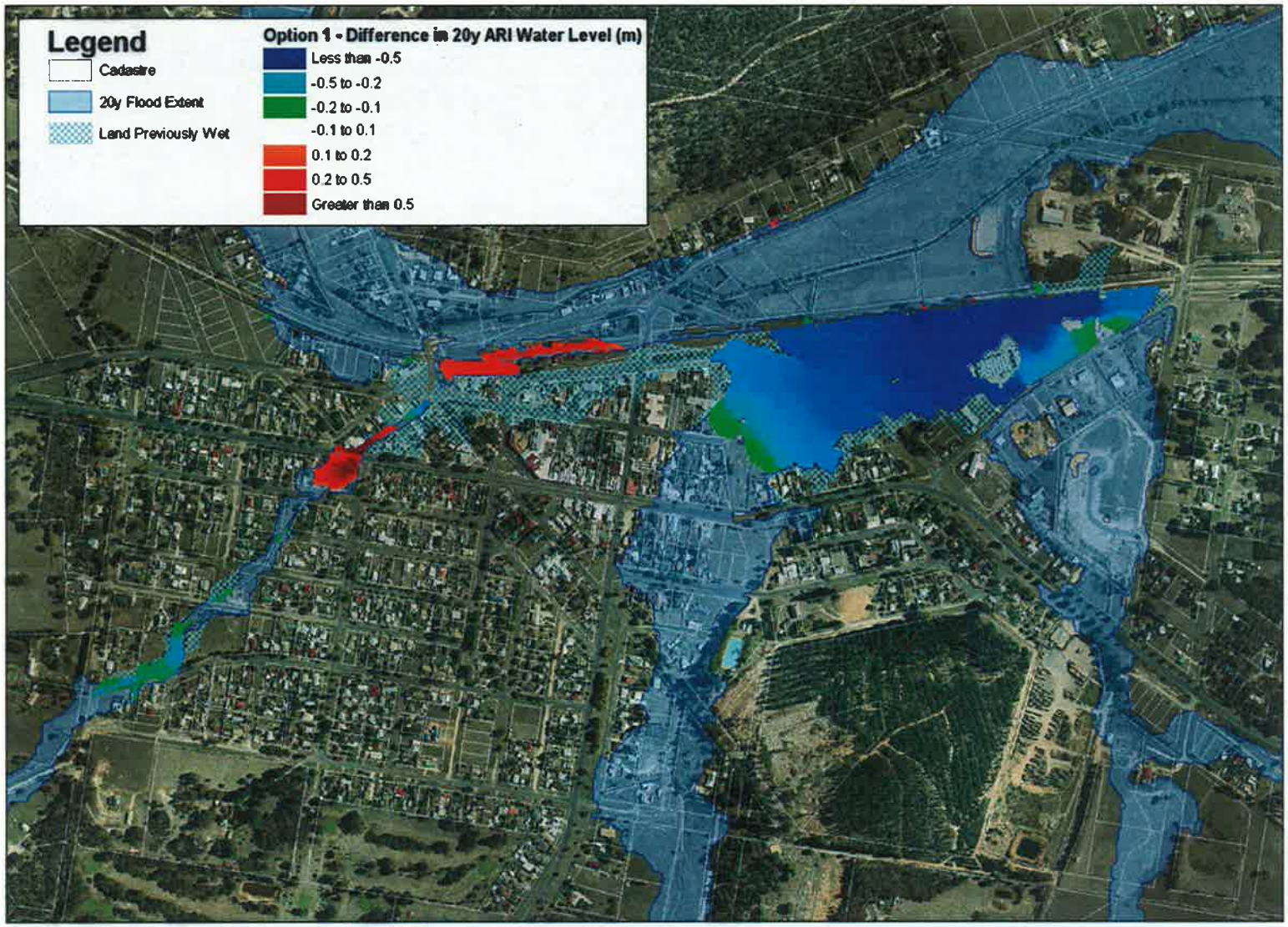
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5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Cadastre
20y Flood Extent
Land Previously Wet
Option 1 - Difference in 20y ARI Water Level (m)
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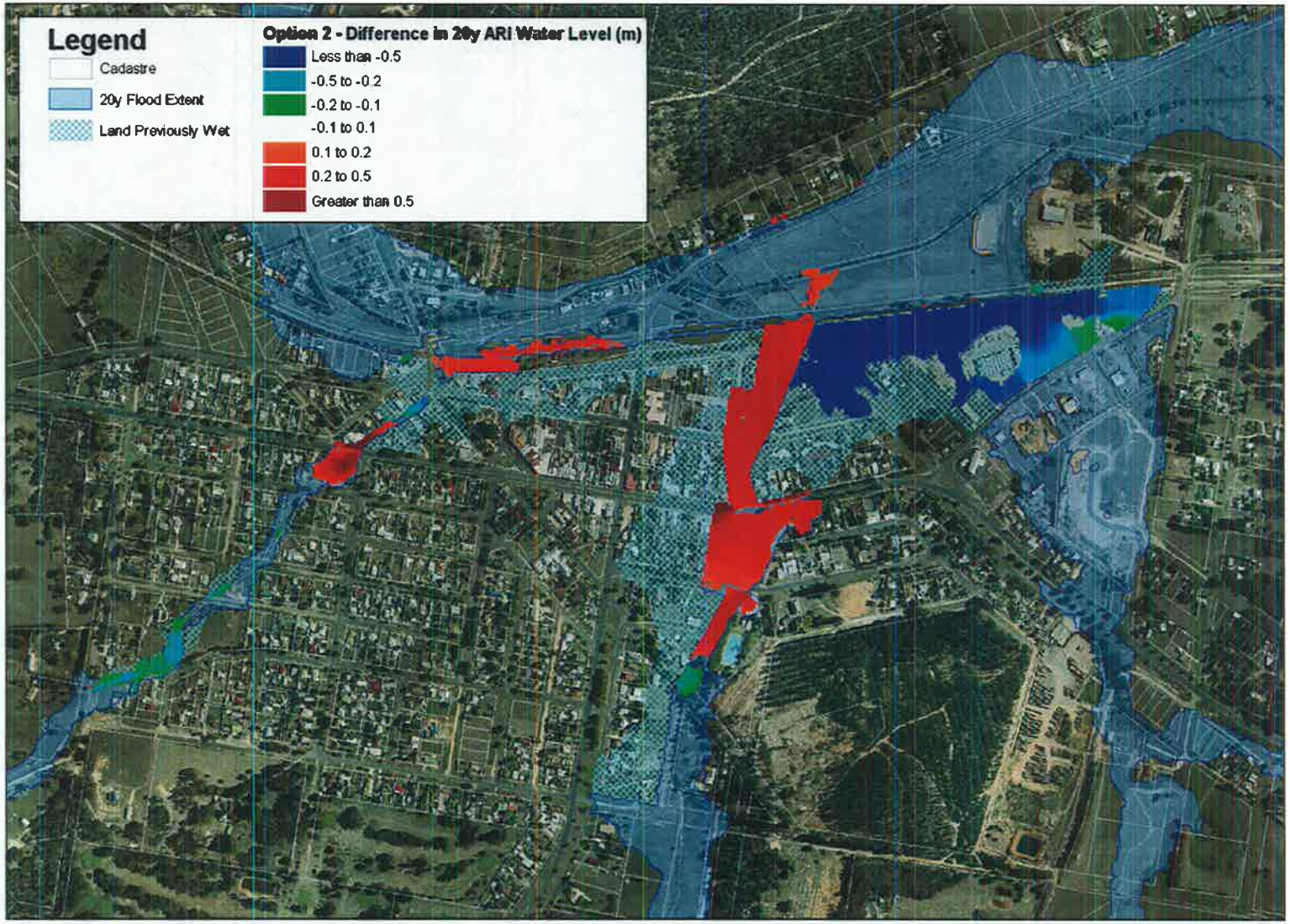
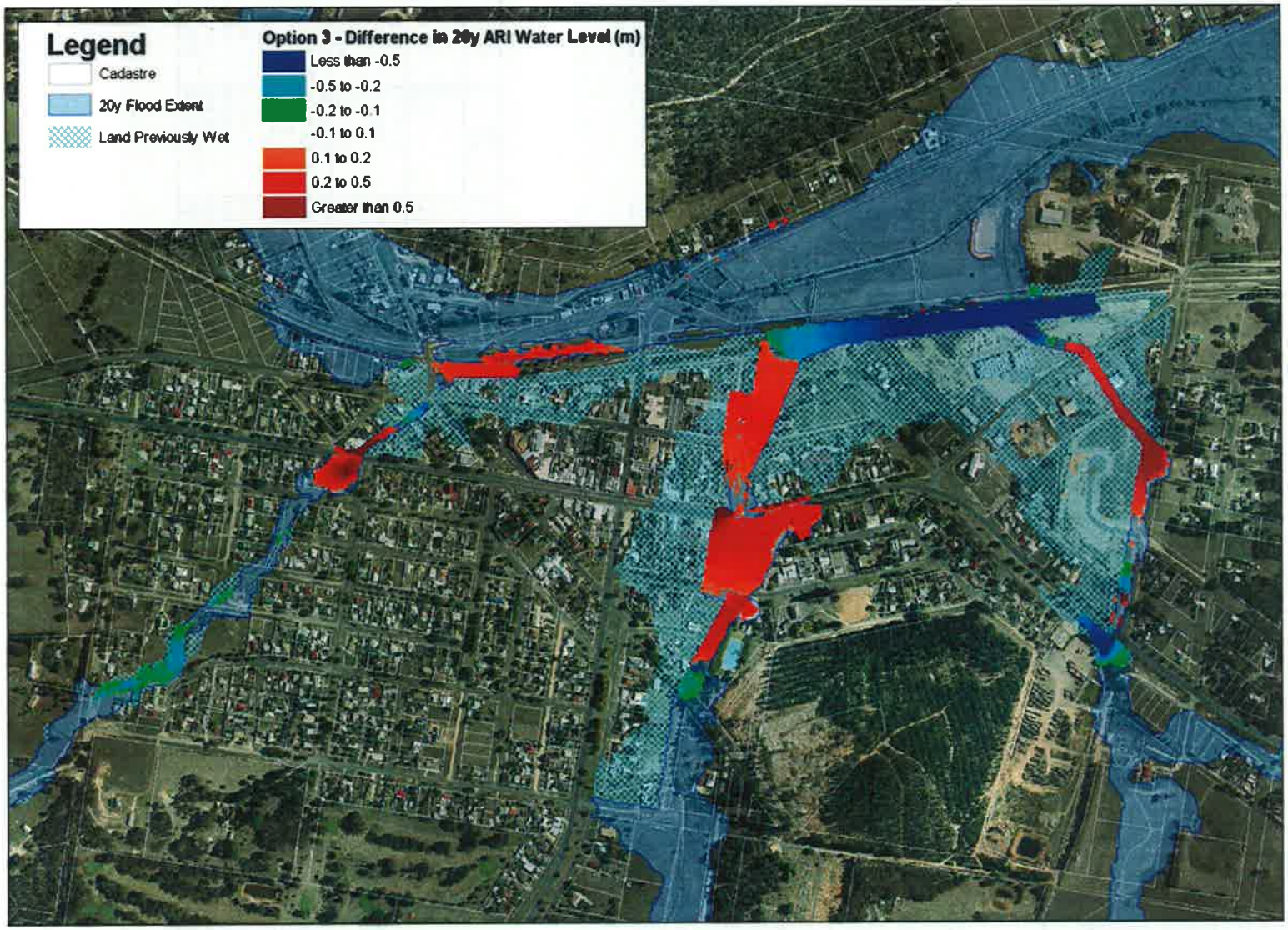
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5


Legend
Cadastre
20y Flood Extent
Land Previously Wet
Option 2 - Difference in 20y ARI Water Level (m)
Less than -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5


Legend
Cadastre
20y Flood Extent
Land Previously Wet
Option 3 - Difference in 20y ARI Water Level (m)
Less than -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to 0.1
0.1 to 0.2
0.2 to 0.5
Greater than 0.5

Flood damage assessment

Option 1 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	31	24	19	14	9
Properties Flooded Below Floor	50	150	155	157	156	60
Total Properties Flooded	**261**	**181**	**179**	**176**	**170**	**69**
Direct Potential External Damage Cost	$82,599	$806,137	$756,078	$705,290	$658,880	$400,791
Direct Potential Residential Damage Cost	$5,146,316	$406,315	$293,194	$209,453	$138,747	$68,013
Direct Potential Commercial Damage Cost	$5,826,844	$456,588	$355,343	$299,840	$248,982	$239,250
Total Direct Potential Damage Cost	**$11,055,760**	**$1,669,040**	**$1,404,616**	**$1,214,582**	**$1,046,609**	**$708,054**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$1,335,232**	**$1,123,693**	**$971,666**	**$837,287**	**$566,443**
Road Infrastructure Damage Cost	**$704,076**	**$409,744**	**$379,231**	**$360,944**	**$340,936**	**$244,195**
Rail Infrastructure Damage Cost	**$147,523**	**$25,762**	**$15,154**	**$6,819**	**$1,515**	**$0**
Indirect Clean Up Cost	$968,257	$250,005	$217,797	$194,080	$169,550	$101,915
Indirect Residential Relocation Cost	$110,824	$15,542	$11,488	$8,785	$6,082	$2,703
Indirect Emergency Response Cost	$20,670	$20,670	$16,536	$12,402	$8,268	$4,134
Total Indirect Cost	**$1,099,751**	**$286,217**	**$245,821**	**$215,267**	**$183,900**	**$108,752**
Total Cost	**$10,795,957**	**$2,056,955**	**$1,763,899**	**$1,554,696**	**$1,363,638**	**$919,390**

Average Annual Damage (AAD)	$320,193

Option 2 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	19	13	12	7	6
Properties Flooded Below Floor	50	124	127	128	131	114
Total Properties Flooded	**261**	**143**	**140**	**140**	**138**	**120**
Direct Potential External Damage Cost	$82,599	$544,633	$521,271	$491,265	$475,232	$383,271
Direct Potential Residential Damage Cost	$5,146,316	$301,306	$185,626	$138,654	$68,075	$75,480
Direct Potential Commercial Damage Cost	$5,826,844	$148,184	$142,971	$137,215	$129,776	$118,970
Total Direct Potential Damage Cost	**$11,055,760**	**$994,123**	**$849,868**	**$767,135**	**$673,083**	**$577,721**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$795,299**	**$679,894**	**$613,708**	**$538,466**	**$462,177**
Road Infrastructure Damage Cost	**$704,076**	**$409,744**	**$379,231**	**$360,944**	**$340,936**	**$244,195**
Rail Infrastructure Damage Cost	**$147,523**	**$25,762**	**$15,154**	**$6,819**	**$1,515**	**$0**
Indirect Clean Up Cost	$968,257	$162,078	$124,353	$117,740	$93,215	$77,045
Indirect Residential Relocation Cost	$110,824	$11,488	$7,433	$6,758	$3,379	$2,703
Indirect Emergency Response Cost	$20,670	$20,670	$16,536	$12,402	$8,268	$4,134
Total Indirect Cost	**$1,099,751**	**$194,236**	**$148,322**	**$136,899**	**$104,862**	**$83,882**
Total Cost	**$10,795,957**	**$1,425,041**	**$1,222,601**	**$1,118,370**	**$985,780**	**$790,254**

Average Annual Damage (AAD)	$250,802

Option 3 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	15	10	9	5	3
Properties Flooded Below Floor	50	115	119	118	121	104
Total Properties Flooded	**261**	**130**	**129**	**127**	**126**	**107**
Direct Potential External Damage Cost	$82,599	$467,560	$465,796	$434,393	$424,032	$353,152
Direct Potential Residential Damage Cost	$5,146,316	$255,172	$172,347	$127,889	$68,075	$40,819
Direct Potential Commercial Damage Cost	$5,826,844	$0	$0	$0	$0	$0
Total Direct Potential Damage Cost	**$11,055,760**	**$722,732**	**$638,143**	**$562,282**	**$492,107**	**$393,971**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$578,186**	**$510,514**	**$449,826**	**$393,686**	**$315,177**
Road Infrastructure Damage Cost	**$704,076**	**$409,744**	**$379,231**	**$360,944**	**$340,936**	**$244,195**
Rail Infrastructure Damage Cost	**$147,523**	**$25,762**	**$15,154**	**$6,819**	**$1,515**	**$0**
Indirect Clean Up Cost	$968,257	$125,289	$102,329	$95,654	$76,667	$59,140
Indirect Residential Relocation Cost	$110,824	$10,136	$6,758	$6,082	$3,379	$2,027
Indirect Emergency Response Cost	$20,670	$20,670	$16,536	$12,402	$8,268	$4,134
Total Indirect Cost	**$1,099,751**	**$156,096**	**$125,623**	**$114,138**	**$88,314**	**$65,301**
Total Cost	**$10,795,957**	**$1,169,787**	**$1,030,522**	**$931,726**	**$824,450**	**$624,673**

Average Annual Damage (AAD)	$216,565

Option 4 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	36	28	26	17	16
Properties Flooded Below Floor	50	154	169	164	157	149
Total Properties Flooded	**261**	**207**	**197**	**190**	**179**	**165**
Direct Potential External Damage Cost	$82,599	$791,289	$735,123	$673,296	$590,993	$546,709
Direct Potential Residential Damage Cost	$5,146,316	$420,732	$333,126	$283,794	$199,969	$133,938
Direct Potential Commercial Damage Cost	$5,826,844	$556,728	$480,558	$429,537	$321,063	$221,937
Total Direct Potential Damage Cost	**$11,055,760**	**$1,768,749**	**$1,548,807**	**$1,386,627**	**$1,112,025**	**$902,583**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$1,414,999**	**$1,239,045**	**$1,109,301**	**$889,620**	**$722,067**
Road Infrastructure Damage Cost	**$704,076**	**$371,209**	**$343,565**	**$326,998**	**$308,871**	**$221,229**
Rail Infrastructure Damage Cost	**$147,523**	**$23,339**	**$13,729**	**$6,178**	**$1,373**	**$0**
Indirect Clean Up Cost	$968,257	$252,737	$219,629	$204,575	$174,497	$152,340
Indirect Residential Relocation Cost	$110,824	$15,305	$12,244	$11,020	$8,571	$6,122
Indirect Emergency Response Cost	$20,670	$18,726	$14,981	$11,236	$7,490	$3,745
Total Indirect Cost	**$1,099,751**	**$286,768**	**$246,854**	**$226,830**	**$190,559**	**$162,208**
Total Cost	**$10,795,957**	**$2,096,315**	**$1,843,193**	**$1,669,307**	**$1,390,423**	**$1,105,503**

Average Annual Damage (AAD)	$333,678

Option 5 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	30	25	24	21	13
Properties Flooded Below Floor	50	171	166	161	150	144
Total Properties Flooded	**261**	**201**	**191**	**185**	**171**	**157**
Direct Potential External Damage Cost	$82,599	$787,098	$750,079	$691,687	$596,602	$559,533
Direct Potential Residential Damage Cost	$5,146,316	$434,433	$352,782	$306,797	$222,195	$132,547
Direct Potential Commercial Damage Cost	$5,826,844	$500,652	$452,880	$420,923	$319,950	$195,857
Total Direct Potential Damage Cost	**$11,055,760**	**$1,722,183**	**$1,555,741**	**$1,419,406**	**$1,138,748**	**$887,937**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$1,377,746**	**$1,244,593**	**$1,135,525**	**$910,998**	**$710,350**
Road Infrastructure Damage Cost	**$704,076**	**$409,744**	**$379,231**	**$360,944**	**$340,936**	**$244,195**
Rail Infrastructure Damage Cost	**$147,523**	**$25,762**	**$15,154**	**$6,819**	**$1,515**	**$0**
Indirect Clean Up Cost	$968,257	$252,008	$225,283	$212,809	$184,740	$147,168
Indirect Residential Relocation Cost	$110,824	$15,542	$12,839	$12,164	$10,136	$6,082
Indirect Emergency Response Cost	$20,670	$20,670	$16,536	$12,402	$8,268	$4,134
Total Indirect Cost	**$1,099,751**	**$288,220**	**$254,658**	**$237,375**	**$203,145**	**$157,384**
Total Cost	**$10,795,957**	**$2,101,472**	**$1,893,636**	**$1,740,663**	**$1,456,594**	**$1,111,929**

Average Annual Damage (AAD)	$347,270	$347,270

Option 6 works

ARI (years) / AEP	PMF 0.00001	100yr 0.01	50yr 0.02	20yr 0.05	10yr 0.1	5yr 0.2
Properties Flooded Above Floor	211	32	26	24	20	13
Properties Flooded Below Floor	50	170	169	166	153	143
Total Properties Flooded	**261**	**202**	**195**	**190**	**173**	**156**
Direct Potential External Damage Cost	$82,599	$815,858	$777,145	$709,800	$606,877	$560,239
Direct Potential Residential Damage Cost	$5,146,316	$444,796	$355,868	$308,988	$222,547	$132,584
Direct Potential Commercial Damage Cost	$5,826,844	$548,863	$476,266	$420,687	$313,976	$195,398
Total Direct Potential Damage Cost	**$11,055,760**	**$1,809,517**	**$1,609,279**	**$1,439,475**	**$1,143,401**	**$888,221**
Total Actual Damage Cost *(0.8*Potential)*	**$8,844,608**	**$1,447,614**	**$1,287,423**	**$1,151,580**	**$914,721**	**$710,577**
Road Infrastructure Damage Cost	**$704,076**	**$409,744**	**$379,231**	**$360,944**	**$340,936**	**$244,195**
Rail Infrastructure Damage Cost	**$147,523**	**$25,762**	**$15,154**	**$6,819**	**$1,515**	**$0**
Indirect Clean Up Cost	$968,257	$261,789	$230,611	$216,856	$184,409	$147,145
Indirect Residential Relocation Cost	$110,824	$16,218	$12,839	$12,164	$10,136	$6,082
Indirect Emergency Response Cost	$20,670	$20,670	$16,536	$12,402	$8,268	$4,134
Total Indirect Cost	**$1,099,751**	**$298,677**	**$259,986**	**$241,422**	**$202,813**	**$157,361**
Total Cost	**$10,795,957**	**$2,181,797**	**$1,941,794**	**$1,760,765**	**$1,459,985**	**$1,112,133**

Average Annual Damage (AAD)	$350,105

Box Culverts

Location	Description		Quantity		Unit	Unit Rate	Estimated Cost	Estimated Cost including Engineering, Administration & Contingencies
			Equiv. No.	Dimension			$	$
Railway Line								
	Design ARI	100						
Upgrade culverts on	Design Flow (m^3/s)							
Cumberland Creek	Supply - Crown Units	2400 x 2100	1	8	m	$1,666	$13,327	$20,704
Option 1, 2 & 3	Supply - Base Slab		1	8	m	$894	$7,152	$11,110
	Supply - Link Slab		1	8	m	$894	$7,152	$11,110
	Installation (Laying)		1	8	m	$3,454	$9,118	$14,165
	Headwalls & Endwalls		2	7	m^3	$2,200	$31,152	$48,395
	Road re-surfacing		Item	22	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$67,900	$105,483
Railway Line								
	Design ARI	100						
new culverts b'ween	Design Flow (m^3/s)							
Cumberland &	Supply - Crown Units	2400 x 900	3	8	m	$1,148	$27,547	$42,795
Cemetery Creeks	Supply - Base Slab		1	8	m	$894	$7,152	$11,110
Option 1, 2 & 3	Supply - Link Slab		2	8	m	$894	$14,303	$22,220
	Installation (Laying)		1	8	m	$2,936	$7,750	$12,040
	Headwalls & Endwalls		2	6	m^3	$2,200	$26,488	$41,149
	Road re-surfacing		item	22	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$83,240	$129,314
Railway Line								
	Design ARI	100						
upgrade of bridge	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3600 x 1500	1	8	m	$2,329	$18,628	$28,939
Option 1, 2 & 3	Supply - Base Slab		1	8	m	$1,409	$11,274	$17,514
	Supply - Link Slab		0	8	m	$0	$0	$0
	Installation (Laying)		1	8	m	$3,738	$9,868	$15,329
	Headwalls & Endwalls		2	11	m^3	$2,200	$47,256	$73,412
	Road re-surfacing		item	31	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$87,026	$135,194
Primary School								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	1200 x 750	1	120	m	$381	$45,720	$71,026
Option 2 & 3	Supply - Base Slab		1	120	m	$225	$26,964	$41,889
	Supply - Link Slab		0	120	m	$0	$0	$0
	Installation (Laying)		1	120	m	$606	$32,708	$50,812
	Headwalls & Endwalls		2	1	m^3	$2,200	$6,204	$9,638
	Road re-surfacing		item	180	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$111,596	$173,364
Western Hwy								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	1500 x 1200	1	16	m	$797	$12,755	$19,815
Option 2 & 3	Supply - Base Slab		1	16	m	$495	$7,926	$12,314
	Supply - Link Slab		0	16	m	$0	$0	$0
	Installation (Laying)		1	16	m	$1,293	$6,825	$10,603
	Headwalls & Endwalls		2	2	m^3	$2,200	$9,108	$14,149
	Road re-surfacing		item	29	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$36,615	$56,881
Broadbent Court								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cumberland Crk	Supply - Crown Units	2400 x 1200	3	18.5	m	$1,384	$76,809	$119,323
Option 3	Supply - Base Slab		1	19	m	$894	$16,538	$25,692
	Supply - Link Slab		1	19	m	$894	$16,538	$25,692
	Installation (Laying)		1	19	m	$3,172	$19,364	$30,082
	Headwalls & Endwalls		2	6	m^3	$2,200	$27,588	$42,858
	Road re-surfacing		item	50	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$156,838	$243,647
Western Hwy								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cumberland Crk	Supply - Crown Units	2400 x 1200	3	15	m	$1,384	$62,278	$96,748
Option 3	Supply - Base Slab		1	15	m	$894	$13,409	$20,831
	Supply - Link Slab		1	15	m	$894	$13,409	$20,831
	Installation (Laying)		1	15	m	$3,172	$15,701	$24,391
	Headwalls & Endwalls		2	6	m^3	$2,200	$27,588	$42,858
	Road re-surfacing		item	41	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	$132,385	$205,660

Location	Description		Quantity		Unit	Unit Rate	Estimated Cost	Estimated Cost including Engineering, Administration & Contingencies
			Equiv. No.	Dimension			$	$
Havlock St								
	Design ARI	100						
	Design Flow (m^3/s)							
on Ding Dong Creek	Supply - Crown Units	3000 x 900	2	40	m	$1,634	$130,752	$203,123
Option 4 & 5	Supply - Base Slab		1	40	m	$1,231	$49,222	$76,466
	Supply - Link Slab		0	40	m	$0	$0	$0
	Installation (Laying)		1	40	m	$2,865	$37,817	$58,749
	Headwalls & Endwalls		2	11	m^3	$2,200	$47,256	$73,412
	Road re-surfacing		item	132	m^2	$28	$3,656	$5,680
	Traffic management		item			$15,000	$15,000	$23,303
						Subtotal	**$283,704**	**$440,734**
Primary School								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	3	120	m	$1,878	$675,972	$1,050,123
Option 4 & 5	Supply - Base Slab		1	120	m	$1,231	$147,666	$229,399
	Supply - Link Slab		1	120	m	$1,231	$147,666	$229,399
	Installation (Laying)		1	120	m	$4,339	$171,816	$266,917
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	396	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	**$1,183,160**	**$1,838,040**
Western Hwy								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	3	16	m	$1,878	$90,130	$140,016
Option 4 & 5	Supply - Base Slab		1	16	m	$1,231	$19,689	$30,587
	Supply - Link Slab		1	16	m	$1,231	$19,689	$30,587
	Installation (Laying)		1	16	m	$4,339	$22,909	$35,589
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	53	m^2	$28	$1,478	$2,297
	Traffic management		item			$20,000	$20,000	$31,070
						Subtotal	**$213,934**	**$332,347**
Leichart St								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	3	10	m	$1,878	$56,331	$87,510
Option 4 & 5	Supply - Base Slab		1	10	m	$1,231	$12,306	$19,117
	Supply - Link Slab		1	10	m	$1,231	$12,306	$19,117
	Installation (Laying)		1	10	m	$4,339	$14,318	$22,243
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	33	m^2	$28	$924	$1,435
	Traffic management		item			$15,000	$15,000	$23,303
						Subtotal	**$151,224**	**$234,927**

Location	Description		Quantity		Unit	Unit Rate	Estimated Cost	Estimated Cost including Engineering, Administration & Contingencies
			Equiv. No.	Dimension			$	$
Havlock St								
	Design ARI	100						
	Design Flow (m^3/s)							
on Ding Dong Creek	Supply - Crown Units	3000 x 900	2	40	m	$1,634	$130,752	$203,123
Option 4 & 6	Supply - Base Slab		1	40	m	$1,231	$49,222	$76,466
	Supply - Link Slab		0	40	m	$0	$0	$0
	Installation (Laying)		1	40	m	$2,865	$37,817	$58,749
	Headwalls & Endwalls		2	11	m^3	$2,200	$47,256	$73,412
	Road re-surfacing		item	132	m^2	$28	$3,656	$5,680
	Traffic management		item			$15,000	$15,000	$23,303
						Subtotal	**$283,704**	**$440,734**
Primary School								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	2	120	m	$1,878	$450,648	$700,082
Option 4 & 6	Supply - Base Slab		1	120	m	$1,231	$147,666	$229,399
	Supply - Link Slab			120	m	$0	$0	$0
	Installation (Laying)		1	120	m	$3,108	$123,087	$191,215
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	396	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	**$761,441**	**$1,182,898**
Western Hwy								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	2	16	m	$1,878	$60,086	$93,344
Option 4 & 6	Supply - Base Slab		1	16	m	$1,231	$19,689	$30,587
	Supply - Link Slab			16	m	$0	$0	$0
	Installation (Laying)		1	16	m	$3,108	$16,412	$25,495
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	53	m^2	$28	$1,478	$2,297
	Traffic management		item			$20,000	$20,000	$31,070
						Subtotal	**$157,705**	**$244,995**
Leichart St								
	Design ARI	100						
	Design Flow (m^3/s)							
on Cemetery Creek	Supply - Crown Units	3000 x 1500	2	10	m	$1,878	$37,554	$58,340
Option 4 & 6	Supply - Base Slab		1	10	m	$1,231	$12,306	$19,117
	Supply - Link Slab			10	m	$0	$0	$0
	Installation (Laying)		1	10	m	$3,108	$10,257	$15,935
	Headwalls & Endwalls		2	9	m^3	$2,200	$40,040	$62,202
	Road re-surfacing		item	33	m^2	$28	$924	$1,435
	Traffic management		item			$15,000	$15,000	$23,303
						Subtotal	**$116,081**	**$180,331**

Pipe Culverts

Havelock St								
Option 1, 2 & 3	Design ARI	100						
	Design Flow (m^3/s)	12						
	Pipe diameter (mm)	1500	1	40	m			
	Installation (Laying)	IFJ-100% FCR	1	40	m	$841	$43,732	$67,938
		Minor & Major Roads						
	Headwalls & Endwalls		2	2.48	m^3	$2,200	$10,912	$16,952
	Minor regrading of channel d/s of culverts		item					$0
	Road re-surfacing		item	72	m^2	$27.70	$1,994	$3,098
	Traffic management		item			$15,000	$15,000	$23,303
						Subtotal	**$71,638**	**$111,290**

Railway Line								
upgrade of existing culvert between Cumberland & Cemetery Creeks	Design ARI	100						
	Design Flow (m^3/s)							
	Pipe diameter (mm)	1500	4	8	m			
Option 1, 2 & 3	Installation (Laying)	IFJ-100% FCR	4	8	m	$841	$118,413	$183,954
		Railway Line						
	Headwalls & Endwalls		8	2.48	m^3	$2,200	$43,648	$67,807
	Minor regrading of channel d/s of culverts		item					$0
	Road re-surfacing		item	58	m^2		$0	$0
	Traffic management		item				$0	$0
						Subtotal	**$162,061**	**$251,761**

TOTAL - Option 1	**$471,866**	**$733,043**
TOTAL - Option 2	**$620,076**	**$963,288**
TOTAL - Option 3	**$909,298**	**$1,412,595**
Total - Railway only	**$400,227**	**$621,753**

Bunding

Ref	Description	Qty	Unit	Rate	Estimated Cost	Estimated Cost including Engineering, Administration & Contingencies
				($/unit)	$	$
Option 1 Bunds						
	Embankment					
	Construction and Compaction	800	m^3	$18	$14,400	$22,370
	Topsoiling (100mm)	265	m^3	$17	$4,505	$6,999
	Grassing	2,650	m^2	$1	$2,650	$4,117
				Subtotal	**$21,555**	**$33,486**
Option 2 Bunds						
	Land within drainage / electricity easement		ha			
	Embankment					
	Construction and Compaction	4,300	m^3	$18	$77,400	$120,241
	Topsoiling (100mm)	1,100	m^3	$17	$18,700	$29,050
	Grassing	11,000	m^2	$1	$11,000	$17,089
				Subtotal	**$107,100**	**$166,380**
Option 3 Bunds						
	Land within drainage / electricity easement		ha			
	Embankment					
	Construction and Compaction	6,600	m^3	$18	$118,800	$184,556
	Topsoiling (100mm)	1,800	m^3	$17	$30,600	$47,537
	Grassing	18,000	m^2	$1	$18,000	$27,963
				Subtotal	**$167,400**	**$260,056**

Total Land Acquisition Cost		
Total Estimated Bunding Cost - Option 1	**$21,555**	**$33,486**
Total Estimated Bunding Cost - Option 2	**$107,100**	**$166,380**
Total Estimated Bunding Cost - Option 3	**$167,400**	**$260,056**

Option 1,2 &3

Waterway works

Reference	Main Channel													Reinstatement					Total Cost	
	Main Channel Depth (d_2)	Base Width (B_2)	Manning's 'n'	Side Slope	Area A	Velocity v	Freeboard	Top Width with freeboard	Channel Capacity Q_{full}	Excavation Area	Excavation Volume V	Excavation Rate	Cost	Terrestrial Revegetation	Revegetation Rate	Topsoiling	Topsoiling Rate	Cost	Total Estimated Cost excluding Land Acquisition	Total Estimated Cost including Engineering, Administration & Contingencies
	m	m			m^2	m/s	m	m	m^3/s	m^2	m^3	$/$m^3$	$	m^2	$/$m^2$	m^3	$/$m^3$	$	$	$
Ding Dong	0.50	2.00	0.03	3	1.75	1.45	0.00	5.00	2.54	1.75	1,400.00	$ 12	$ 16,800	4,000.00	$ 10	400.00	17.00	$ 46,800	$ 63,600	$ 98,803
Cemetery Creek	0.80	12.00	0.03	5	12.80	1.59	0.00	20.00	20.35	12.80	7,680.00	$ 12	$ 92,160	12,000.00	$ 10	1,200.00	17.00	$ 140,400	$ 232,560	$ 361,282
Cumberland Cre	0.70	8.00	0.03	5	8.05	1.48	0.00	15.00	11.87	8.05	4,427.50	$ 12	$ 53,130	8,250.00	$ 10	825.00	17.00	$ 96,525	$ 149,655	$ 232,489
													$162,090					$283,725	$445,815	$692,574

TOTAL - Option 1	$63,600	$98,803
TOTAL - Option 2	$296,160	$460,085
TOTAL - Option 3	$445,815	$692,574

Reference	Design Flow $Q_{100\ year}$	Main Channel												Reinstatement					Total Cost	
		Main Channel Depth (d_2)	Base Width (B_2)	Manning's 'n'	Side Slope	Area A	Velocity v	Freeboard	Top Width with freeboard	Channel Capacity Q_{full}	Excavation Area	Excavation Volume V	Excavation Rate	Cost	Terrestrial Revegetation	Revegetation Rate	Topsoiling	Topsoiling Rate	Cost	Total Estimated Cost excluding Land Acquisition	Total Estimated Cost including Engineering, Administration & Contingencies
	m^3/s	m	m			m^2	m/s	m	m	m^3/s	m^2	m^3	$/$m^3$	$	m^2	$/$m^2$	m^3	$/$m^3$	$	$	$
Ding Dong (opt 4,5 & 6)		1.00	6.50	0.03	0	6.50	1.67	0.00	6.50	13.81	6.50	910.01	$ 12	$ 10,920	910.03	$ 10	91.00	17.00	$ 10,647	$ 21,567	$ 33,505
Cemetery Creek (opt 5&6)		1.00	16.00	0.03	0	16.00	1.85	0.00	16.00	29.63	16.00	2,880.02	$ 12	$ 34,560	2,880.04	$ 10	288.00	17.00	$ 33,696	$ 68,257	$ 106,037

APPENDIX B LAND USE PLANNING

Report by Planning Environmental Design (2010)

Pyrenees Planning Scheme
Beaufort Flood Study
Flood Controls Report

Prepared by Planning and Environmental Design in conjunction with Water Technology

February 2010

Pyrenees Planning Scheme Beaufort Flood Study Flood Controls Report

1 Introduction

The township of Beaufort has a population of approximately 1,500 (ABS, 2006 Census) and is situated some 45 km west of Ballarat on the Western Highway, midway between Ballarat and Ararat. It is situated within a circle of hills, at the confluence of Ding Dong, Cemetery, Cumberland and Yam Holes Creeks. Yam Holes Creek is the main waterway through the town and a major tributary of Mount Emu Creek. The confluence of Yam Holes Creek with

Mount Emu Creek is approximately 10 km downstream of the Beaufort township. This area is contained within the Pyrenees Shire. The Pyrenees Planning Scheme controls Land use and development within this area.

The Pyrenees Planning Scheme contains a number of clauses that seek to provide guidance with respect to the use and development of land that is within the flood plain of waterways and/or affected by inundation by floodwaters. These controls were prepared prior to the completion of the Beaufort Flood Study 2009, and as such are not informed by flood modelling data.

With the completion of the Beaufort Flood Study it is possible for Council to up date the Pyrenees Planning Scheme with the new information contained within the study. This report makes recommendations on which controls may be used for this purpose.

1.1 Intent of flood controls in Planning Schemes

Flooding is a natural hazard but, unlike most other natural hazards, floods are to a great degree predictable in terms of their location, depth and extent. This means that appropriate measures can be developed to reduce flood damage. The use and development of land may be permissible on land affected by floodwaters, however the particular use and/or development must be compatible with flood risk.

Land use planning is recognised as being the best means of avoiding future flooding problems. Through careful planning, flood risks to life, property and community infrastructure can be minimised and the environmental significance of floodplains protected.

The Victorian Planning Provisions (VPPs) contain a number of controls that can be employed to provide guidance for the use and development of land that is affected by inundation from floodwaters. These controls include the Floodway Overlay, the Land Subject to Inundation Overlay, the Special Building Overlay, and the Urban Floodway Zone.

Section 6(e) of the Planning and Environment Act 1987enables planning schemes to 'regulate or prohibit any use or development in hazardous areas, or areas likely to become hazardous'. As a result, planning schemes contain State planning policy for floodplain management requiring, among other things, that flood risk be considered in the preparation of planning schemes and in land use decisions.

1.2 Relevance of Beaufort Flood Study

The recently completed Beaufort Flood Study forms the basis for the recommendations in this report. The Beaufort Flood Study (the study) contains more accurate information on the extent and depth of floodwaters within the study area than is currently contained within the Pyrenees Planning Scheme. As such, it is recommended that this new information be translated into new Planning Scheme controls that address flooding and inundation in Beaufort. Amending the Planning Scheme in this way will ensure that the most accurate and up to date information is being used to guide decision making on development proposals.

Section 7.4 of the Beaufort Flood Study makes recommendations for the delineation of the Land Subject to Inundation Overlay and the Floodway Overlay areas in Beaufort. Figure 1 below, taken from the Beaufort Flood Study, shows these proposed areas. It is recommended that this map form the basis for new Planning Scheme maps that identify areas of inundation in Beaufort.

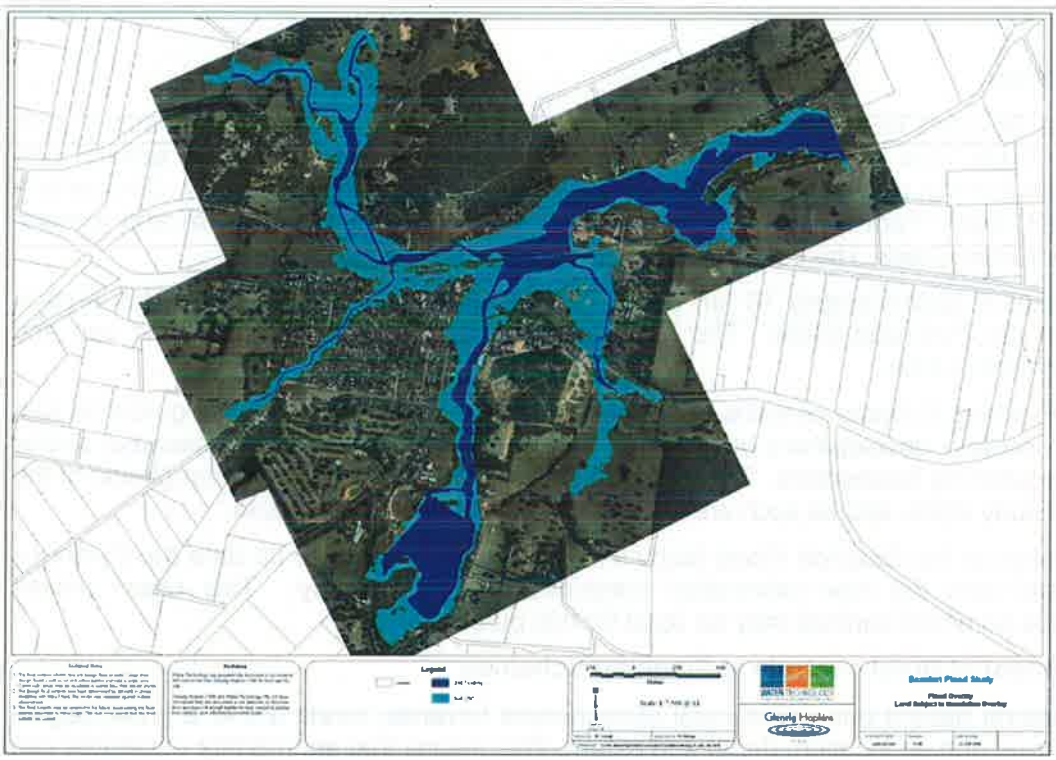


Figure 1. Beaufort Flood Study FO and LSIO Areas

2 Current Scheme Controls

The Pyrenees Planning Scheme makes several references to flooding and inundation by floodwaters. The most relevant clauses of the Planning Scheme that address flooding and inundation include the Municipal Strategic Statement (MSS) Clauses 21.04, 21.05, and 21.07; Local Planning Policy Clauses 22.03 and 22.04; and the Design and Development Overlay Schedule 1 (DDO1).

It is recognised that land outside the boundaries of the Beaufort Flood Study may be affected by flooding and inundation. As such, recommendations in this report are limited to land contained within the Beaufort Flood Study only.

3 Victorian Planning Provisions

Guidance for applying flood controls to Planning Schemes is available from the Department of Planning and Community Development's (DPCD) Practice Note on Applying Flood Controls in Planning Schemes. In the previous section, recommendations were made for new controls. This section discusses all available controls, to ensure that Council is aware of all options available to it.

Council has a range of tools to choose from to identify flood affected land in its planning scheme. There are four types of flood provisions available; the Urban Floodway Zone (UFZ), Floodway Overlay (FO), Land Subject to Inundation Overlay (LSIO) and Special Building Overlay (SBO). This section of the report discusses how each control may be applied in the Pyrenees Planning Scheme.

3.1 Urban Floodway Zone

Increasing the intensity of land use or a change in land use can increase flood risk, therefore in areas of highest flood risk and with a potential for land use intensification, it may be appropriate that land use is restricted. As with any other zone, the UFZ controls the use of land in identified

floodway areas. The UFZ is very restrictive on what uses are permissible, as such, use of the UFZ will severely limit the use and development of land to which it is applied.

The difficulty in using the UFZ is that flooding does not follow cadastral boundaries; hence it may not be possible to apply the zone to a complete parcel of land. Best practice is to ensure that only 1 zone applies to any given parcel of land. Due to the restrictive nature of the UFZ, it is not recommended for use in the Pyrenees Planning Scheme. It is considered that the Farming Zone, the Public Park and Recreation Zone, or the Public Conservation and Resource Zone be applied in stead, as these zone more clearly identify the development potential for land.

3.2 The Floodway Overlay

The Floodway Overlay (FO) applies to mainstream flooding in both rural and urban areas. These areas convey active flood flows or store. The FO is suitable for areas where there is less need for control over land use, and the focus is more on control of development. It is recommended that the FO apply to land where flood hazard conforms to the Floodway overlay flood hazard criteria Figure 7-1 on page 54 of the Beaufort Flood Study.

The function of the overlay is to trigger the need for a planning permit. The proposed Floodplain Management Local Planning Policy (refer to section 3.4 below) provides guidance on assessment of the permit application. The draft policy proposed seeks to prevent new buildings and works, including earthworks and vegetation clearance in the FO.

It is recommended that the FO be introduced to the Pyrenees Planning Scheme in concert with a Beaufort Floodplain Management Local Planning Policy.

The LSIO/FO Map will identify the land where a permit will be required, whilst the FO Schedule will identify various developments that will be exempt from the need for a permit, with the proposed Local Planning Policy identifying policy objectives to be met by development that do require a permit.

A draft Overlay Schedule that may be incorporated into the scheme is included in **Appendix 1**.

3.3 The Land Subject to Inundation Overlay

The LSIO applies to mainstream flooding in both rural and urban areas. In general, areas covered by the LSIO have a lower flood risk than FO areas. The LSIO is suitable for areas where flood hazard conforms to the Floodway overlay flood hazard criteria Figure 7-1 on page 54 of the Beaufort Flood Study.

The LSIO will act as a trigger for a planning permit. The proposed Beaufort Floodplain Management Local Planning Policy (refer to section 3.4 below) sets out the circumstances where buildings and works would be permitted subject to condition. Section 3.4 develops this issue further

It is recommended that the LSIO be introduced to the Pyrenees Planning Scheme in concert with a Floodplain Management Local Planning Policy.

The LSIO/FO Map will identify the land where a permit will be required, whilst the LSIO Schedule will identify various developments that will be exempt from the need for a permit, with the proposed Local Planning Policy identify policy objectives to be met by development that do require a permit.

A draft Overlay Schedule that may be incorporated into the scheme is included in **Appendix 2**.

3.4 The Special Building Overlay

The Special Building Overlay (SBO) applies to stormwater flooding in urban areas only. The SBO is intended to apply to areas/locations where the drainage systems are designed to a lower capacity than what may be required during peak storm events resulting in overlay flow of storm water. The purpose of the SBO is to manage development in areas that are subject to overland flow of storm water. As the area covered by the Beaufort Flood Study addresses channel flow only, the circumstances for application of the SBO do not exist. Common practice throughout Victorian Planning Schemes is to apply the SBO to situations where underground drainage pipes are of insufficient capacity to convey storm water. This is clearly not the case in Beaufort.

It is not recommended to introduce the SBO to the Pyrenees Planning Scheme to give effect to the Beaufort Flood Study recommendations.

3.5 Local Planning Policy Floodplain Management

The use of local policy to give greater guidance and clarity in the Planning Permit process is considered to be prudent practice. The policy provides guidance to both applicants and Council.

The policy will apply to all permits required under the LSIO and the FO. Applicants will be able to gain guidance from the policy before preparing applications. Whilst Council can rely on the content of the policy to place conditions on permits, or to refuse permits. The policy can also be relied on to defend Council decisions at appeal.

The policy includes objectives to be achieved, gives policy statements, and provides performance standards that are to be met. A copy of a proposed draft Local Planning Policy is contained in **Appendix 3** to this report. The policy contains a number of objectives and performance measures that seek to ensure that new development does not reduce or impede the ability of the flood plain to store and convey floodwater.

Other performance measures are also included that seek to ensure that damage to property from floodwater is limited, and that water quality of floodwaters is maintained. As such the policy does not permit new buildings in the FO area, as this area conveys floodwater that has both depth and velocity. Where new buildings are permitted, floor levels will at 300mm above the average recurrence interval for their location. More detail is included in the draft policy. It is proposed that similar requirements are made for new extensions to existing buildings.

The policy also seeks to ensure that no new lots are created that are wholly within the FO; and that no new lots be created that are wholly within the LSIO unless it can be demonstrated there is an adequate building envelope on each lot where the inundation is < 500 mm; and that access to the building envelope does not traverse land where inundation is > 500 mm.

Fencing should be designed in a way that enables movement of floodwaters through the fence and should not act as a partial or continuous barrier to floodwaters; should not be constructed of solid contiguous materials including timber palings, metal sheet, concrete, brick or masonry; should not contain a plinth less than 300mm above the ground; and should not trap debris in floodwaters.

The construction of a swimming pool, or a dam for stock or domestic water supply purposes may be permitted provided excavated material is removed off site and away from land within flood extent and there is no increase in the surface level of land surrounding the swimming pool or dam, including embankments. Pool fencing is subject to the Fences Performance Measure and Standards, as listed above.

Any approved earthworks must not impede the flow of floodwaters or reduce the capacity of the floodplain to store and convey floodwaters.

Chemical Storage is to be at a height of at least 1.5m above the 100 year ARI.

Water tanks should ideally be located outside of the inundated area. If located in inundated area, water tanks should not be located in a continual line – i.e. water tanks should allow for the movement of water around them. Fill/pads should be restricted to the footprint of the water tank.

3.6 Incorporation of Floodplain Management Plan

It is noted that the Beaufort Flood Study recommends that Council and the GHCMA continue to develop a full Floodplain Management Plan for Beaufort. Once prepared, this will become a reference document to be used when assessing planning permit applications trigger by the LSIO and FO.

It is not recommended to incorporate this Floodplain Management Plan into the Planning Scheme as it may potentially duplicate matters addressed in the Floodplain Management Policy. Further to this, further development or refinement of the Floodplain Management Plan will be difficult as an amendment to the Planning Scheme will be required for any future changes to the Floodplain Management Plan

4 Conclusion

This report recommends that an amendment be prepared to the Pyrenees Planning Schemes to update the Planning Scheme with new controls that will give effect to the Beaufort Flood Study.

Based on the discussion above, it is recommended that the amendment include changes to the Municipal Strategic Statement that recognise the existence of the Beaufort Flood Study and the Beaufort Floodplain Management Policy, a new Clause 22.07 Beaufort Floodplain Management Policy, replace Map 20DDO with a new Map 20LSIO/FO based on Figure 1 in this report, introduce Map 19LSIO/FO based on Figure 1 in this report, amend Map 19DDO to remove that portion of the exiting DDO area that is to be replaced by LSIO/FO, introduce the Floodway Overlay and Schedule, introduce the Land Subject to Inundation Overlay and Schedule, and sequential changes to relevant clauses of the Planning Scheme to recognise the introduction/deletion of maps and the existence of the Beaufort Floodplain Management Policy.

Appendix 1

Draft Floodway Overlay Schedule

--/--/20-- **SCHEDULE TO THE FLOODWAY OVERLAY**

Shown on the planning scheme map as **FO**.

1.0 Permit requirement

--/--/20--

A permit is not required to construct the following buildings and works:

- Any buildings and/or works on land that has been filled in accordance with the requirements of a planning permit for subdivision of the land, or other planning permit issued for the land.
- Any buildings and works, if appropriately detailed information is submitted to the satisfaction of the responsible authority showing that the natural level of the land on which the buildings and works are proposed is at least 300mm above the Average Recurrence Interval flood level.
- A pergola.
- A veranda.
- An open sided carport.
- The addition of a second story, or other additional stories, on top of the existing building where there is no increase in building footprint.
- An open sports ground excluding change rooms, pavilions, shelters, other buildings, and raised viewing areas, provided that the natural surface level is not altered.
- An outdoor recreation facility, excluding any buildings or structures that alter water movement across or storage capacity of the floodplain, and works that alter the topography of the land.
- Road works or works to any other access way (public or private) that:

  - do not change the finished level of the road surface; or

  - are limited to resurfacing of an existing road.
- Cycle or pedestrian tracks where there is no increase in the natural ground level.

Appendix 2

Draft Land Subject to Inundation Overlay

--/--/20--

SCHEDULE TO THE LAND SUBJECT TO INUNDATION OVERLAY

Shown on the planning scheme map as **LSIO**.

1.0 Permit requirement

--/--/20--

A permit is not required to construct the following buildings and works:

- Any buildings and/or works on land that has been filled in accordance with the requirements of a planning permit for subdivision of the land, or other planning permit issued for the land.
- Any buildings and works if appropriately detailed information is submitted to the satisfaction of the responsible authority showing the natural level of the land on which the buildings and works are proposed is at least 300mm above the Average Recurrence Interval flood level.
- A pergola.
- A veranda.
- An open sided carport.
- The addition of a second story, or other additional stories, on top of the existing building where there is no increase in building footprint.
- An open sports ground excluding change rooms, pavilions, shelters, other buildings, and raised viewing areas, provided that the natural surface level is not altered.
- An outdoor recreation facility, excluding any buildings or structures that alter water movement across or storage capacity of the floodplain, and works that alter the topography of the land.
- Road works or works to any other access way (public or private) that:

  - do not change the finished level of the road surface; or

  - are limited to resurfacing of an existing road.
- Cycle or pedestrian tracks where there is no increase in the natural ground level.
- One domestic rainwater tank of 4,500 litres capacity or less.

Appendix 3

Beaufort Floodplain Management Policy

22.07 **FLOODPLAIN MANAGEMENT POLICIES**

--/--/20--

This policy applies to all land within the Floodway Overlay and the Land Subject to Inundation Overlay.

Policy Basis

Some land in Pyrenees Shire is subject to flooding. Development in these areas is at risk from flooding, and can also impact on the capacity of the floodplain to contain and convey flood waters, as such development in these areas need to be managed to minimise risk and damages to property as well as maintain the capacity of the floodplain. This policy applies the floodplain management objected stated in clause 15.02 of the SPPF.

This policy implements the Glenelg Hopkins Catchment Management Authority's Regional Catchment Strategy and the Beaufort Flood Study (2008).

Objectives

- To minimise flood risk and promote sustainable use and development of the floodplain.

- To ensure development and land use on the floodplain is compatible with flood risk.
- To ensure that where permitted, development in the floodplain:
  - Maintains the free passage and temporary storage of floodwaters;
  - Minimises flood damage;
  - Will not cause any significant rise in flood level or flow velocity;
  - Will not cause any impact on adjacent property.

- To discourage the intensification of zonings/land use in the floodplains of the Yam Holes, Ding Dong, Cemetery and Cumberland Creeks at Beaufort.
- To recognise the natural flood carrying capacity of rivers, streams and wetlands and the flood storage function of floodplains.

- To protect surface and ground water quality, and preserve important wetlands and areas of environmental significance.
- To minimise risk associated with overland flow of storm water.

Policy

Exercising discretion

When a planning permit is required, it is policy to:

- Prevent any new buildings and works, including earthworks and vegetation clearance in the Floodway Overlay.
- Discourage landfill in all areas subject to inundation, other than for approved buildings, and other than in the Residential 1 and Residential 2 Zone.
- Discourage buildings and works in the LSIO, except where those buildings and works are demonstrated to be of low flood risk and where the buildings and works support the preferred dominant land use as identified by the objective and purpose of the relevant zone.
- Discourage large extensions to buildings at levels below the 100 Year Average Recurrence Interval (ARI) Flood.
- Prevent the construction of levees in areas regarded by the floodplain management authority as important for flood storage and/or environmental values, except where identified in an adopted Floodplain Management Plan.
- Discourage earthworks that obstruct natural flow paths or drainage lines.
- Encourage the retention of natural drainage corridors with vegetated buffer zones at least 30m wide along waterways to maintain the natural drainage function, stream habitat and wildlife corridor and landscape values.
- Minimise erosion of stream banks and verges and to reduce polluted surface runoff from adjacent land uses.
- Minimise the quantity and retard the flow of stormwater runoff from developed areas.
- Encourage new buildings and works to occur on land outside the FO and LSIO.

Performance Measures and Standards

Buildings and Works

Where permitted, any buildings and works shall be subject to the following measures and standards:-

- Be located on land outside the FO and the LSIO, and where this can be demonstrated to not be practical, be on the highest available natural ground.
- Have a 100-year Average Recurrence Interval (ARI) flood depth less than 500 mm above the natural ground level at the building site.

- Have a minimum floor level at least 300mm above the 100 year ARI.
- Be aligned with their longitudinal axis parallel to the predicted predominant direction of flood flow. This requirement may override other alignment requirements.
- Include flood-proofing measures that minimise the effects of flooding on the building structure and its contents, e.g. the use of water resistant building materials for foundations, footings and floors.
- Limit the size of building (fill) pads to as near as practical to the building exterior.
- Construct foundations compatible with the flood risk.
- Minimise site coverage and hard surface areas.
- Maximise permeable surfaces to minimise run-off.
- Provide offset earthwork excavation as compensatory storage for new buildings and works.

Subdivision

It is policy to prevent any new subdivision on land covered by the FO that creates lots that are wholly contained within the FO.

Subdivision applications for land that contains land in the LSIO, should not create lots with land wholly in the LSIO unless it can be demonstrated that:-

- There is an adequate building envelope on each lot where the inundation is < 500 mm.
- Access to the building envelope does not traverse land where inundation is > 500 mm.

Fences

Fencing should be designed in a way that enables movement of floodwaters through the fence and: -

- Should not act as a partial or continuous barrier to floodwaters.
- Should not be constructed of solid contiguous materials including timber palings, metal sheet, concrete, brick or masonry.
- Should not contain a plinth less than 300mm above the ground.
- Should not trap debris in floodwaters.

Extensions to buildings

Where permitted, any extension to a building:-

- Should have a floor level of at least 300mm above the 100 year ARI.
- Should have a 100-year ARI flood depth less than 500 mm above the natural surface level along the existing and/or proposed roads, internal driveways and access tracks to the building from land outside of the defined flood area.
- Be aligned with their longitudinal axis parallel to the predicted predominant direction of flood flow. This requirement may override other alignment requirements.

Chemical Storage

The storage of chemicals is to be at a height of at least 1.5m above the 100 year ARI.

Earthworks

Construction of a swimming pool, or a dam for stock or domestic water supply purposes may be permitted provided excavated material is removed off site and away from land within flood extent and there is no increase in the surface level of land surrounding the swimming pool or dam, including embankments. Pool fencing is subject to the Fences Performance Measure and Standards, as listed above.

Any approved earthworks must not impede the flow of floodwaters or reduce the capacity of the floodplain to store and convey floodwaters.

Other Uses

Water tanks should ideally be located outside of the inundated area. If located in inundated area:

- Water tanks should not be located in a continual line – i.e. water tanks should allow for the movement of water around them.
- Fill/pads should be restricted to the footprint of the water tank.

Application Requirements

An application must be accompanied by the following information, as appropriate:

- A flood risk report prepared by a suitably qualified person that addresses the following matters:
  - Details of the proposed development, site conditions, and site context plan;
  - The flood extent, flood levels and flow directions relevant to the site;
  - The frequency, duration, depth and velocity of flooding and flood warning time applicable to the development site and access way;
  - The susceptibility of the development to flood damage;
  - The potential flood risk to life health and safety;
  - The effect of the development on reducing flood storage and on redirecting or obstructing floodwater, stormwater or drainage water;

- The effect of the development on environmental values, for example flora, fauna and wetlands;
- Whether the proposed development could be located on flood-free land or land with a lesser flood hazard.

- A site description, which may use a site plan (drawn to scale), photographs or any other relevant technique, that accurately describes:
  - The boundaries, dimensions, shape, size, orientation, slope and elevation of the site;
  - Relevant existing and proposed ground levels of the site, to Australian Height Datum taken by or under the direct supervision of a licensed land surveyor, and the difference in levels between the site and surrounding properties.
  - Location, layout, size and use of existing and proposed buildings and works on the site and on surrounding properties.
  - Floor levels of any existing and proposed buildings, to Australian Height Datum, taken by or under the direct supervision of a licensed surveyor.
  - The use of surrounding properties and buildings.
  - Location of significant environmental values including flora, fauna and wetlands on the site and surrounding properties.
  - Adjoining roads, internal driveways, and access tracks.
  - Any other notable features or characteristics of the site.
- Elevations of all proposed buildings, drawn to scale.
- Construction details of all buildings, fences, works and driveways.
- In the case of fences, a report that demonstrates that the fence does not significantly obstruct flood flows.
- A report that responds to the objectives and standards of this schedule and any relevant objectives set out in the State Planning Policy Framework and the Local Planning Policy Framework including the Municipal Strategic Statement and local planning policies.

This information is not required for:

- A single dwelling on a lot,
- Minor earthworks, or
- If advised by the responsible authority that the information is not required.

References

Glenelg Hopkins Catchment Management Authority, Regional Catchment Strategy

Beaufort Flood Study 2008

APPENDIX C FLOOD RESPONSE INTELLIGENCE

Note there are deliberate gaps in the following intelligence report. This is due to incomplete knowledge/systems at this time. This includes relevant flood gauges and specific emergency arrangements that will be determined by Council. Some tables are blank and in places bold/italic notes indicate where additional information needs to be updated by Council at a later date. A digital copy of the flood intelligence report has been provided to Council and can be updated in the future as further information becomes available.

The following document comprises flood intelligence relating to Beaufort. The intelligence has been extracted from a variety of sources including:

- Flood Data Transfer Project reports;
- TGM group (2004): *Beaufort Flood Scoping Study.* Consulting report prepared for Glenelg Hopkins Catchment Management Authority, November 2004;
- Water Technology (2008): *Beaufort Flood Study.* Consulting report (J558/R04) prepared for the Pyrenees Shire, June 2008;
- Water Technology (2011): *Beaufort Floodplain Management Plan Study Report.* Consulting report (1222-01/R02V02) prepared for the Pyrenees Shire, May 2011; and
- Flood inundation mapping produced as part of the Beaufort Flood Study (Water Technology, 2008).

Intelligence for Beaufort is presented as a series of Appendices. These Appendices will fit within the framework of an AIIMS complaint Flood Emergency Plan (previously referred to as a MEMP Flood Sub-Plan) template recently adopted by VICSES[1]. The template has regard for individual Council MEMPs.

The Appendices can be expanded to accommodate intelligence relating to all areas within the Municipality subject to flooding. That intelligence should be derived from past experience, flood and drainage study outputs and other sources of flood related information.

The Appendices are structured to contain key information. They can 'stand alone' when being used in flood response operations: they can be copied and those copies removed for operational / in-field use. For example, the flood intelligence contained in Appendix A provides a guide for those responding to a flood situation and a basis for managing flood response. Thus the Incident Controller, in conjunction with the EMT and IMT will, where appropriate, would ensure that the actions listed were undertaken.

If Council adopts the Flood Emergency Plan template, the current MEMP will need to be reviewed and possibly updated:

- Any and all flood related matters contained in the MEMP and related Sub-Plans should be moved to and incorporated in the following Appendices while being replaced by a reference to the Flood Emergency Plan.
- Any and all references to "Flood Plan" or "Flood Emergency Plan" in the MEMP must be consistent and refer to the relevant part and section of the Flood Emergency Plan. This will necessitate review of the MEMP and possible update.

The contents page from the generic Flood Emergency Plan is provided below as an indicator of how the following Appendices fit within the document.

[1] The MEMP Flood Emergency Plan contains intelligence on what is at risk from riverine and stormwater flooding within the Municipality along with information on what needs to be done to reduce flood related damages during a flood event. It also contains information on other matters that impact on flood prevention, preparedness, response and recovery.

1. General

The Shire covers parts of the upper reaches of the Wimmera, Avoca, Loddon and Hopkins catchments.

In using the information contained in this Appendix, consideration needs to be given to the time of travel of the flood peak. A flood on a 'dry' waterway will generally travel more slowly than a flood on a 'wet' waterway (eg. the first flood after a dry period will travel more slowly than the second flood in a series of floods). Hence, recent flood history, soil moisture and forecast weather conditions all need to be considered when using the following information to direct flood response activities.

A history of notable flood events within the Municipality is provided in Appendix C of this Plan.

2. Riverine Flooding

Large severe floods within the Municipality generally occur as a result of a moist warm airflow from northern Australia bringing moderate to heavy rainfall over a period of 12 hours or more following a prolonged period of general rainfall. The period of general rainfall "wets up" the catchments and (partially) fills the natural floodplain storage. These two effects combine to increase the runoff generated during the subsequent period of heavy rainfall resulting in a large flood in those catchments receiving the heavy rainfall.

3. Flash Flooding and Overland Flows

Short duration, high intensity rainfall (usually associated with thunderstorms) can also cause localised flooding within the urbanised areas of the Municipality and along overland flow paths when the local urban drainage system surcharges. Such events, which are mainly confined to the summer months, do not generally create widespread flooding since they only last for a short time and affect limited areas. Flooding from these storms occurs with little warning and localised damage can be severe.

High intensity rainfall such as associated with thunderstorms giving average rainfall rates of typically more than 20 mm/hour for an hour or more) is likely to lead to high flows in local creeks as well as flash flooding and / or overland flows, particularly in the more urbanised parts of the Municipality.

Blocked or capacity impaired stormwater drains can also lead to overland flows and associated flooding: the drain surcharges and excess water flows above ground. The likely location of such flooding is hard to predict other than in cases where a drain has a past history of surcharging. Council maintenance records may provide some guidance in such cases.

4. Flood Inundation Mapping

Water Technology (2008) delivered flood inundation maps for Beaufort (for Ding Dong, Yam Holes, Cemetery and Cumberland creeks) for the 5, 10, 20, 50 and 100 year ARI events as well as for the PMF (worst possible case) events.

For areas of the Municipality not covered by detailed flood maps, the Pyrenees Planning Scheme shows areas along the waterways within the Shire likely to be inundated by a 1% AEP (100-year ARI) flood event as LSIO (Land Subject to Inundation Overlay). While it is not practical to reproduce the overlay as an attachment to this Plan, hard copies are available from the Pyrenees Shire. They are also available in hard copy form and as PDF digital copies at the Pyrenees MECC and in digital form at the DSE website www.doi.vic.gov.au/planningschemes.

Course flood extent maps were also developed for the whole of the Pyrenees Municipality in 2000 as part of a state-wide Flood Data Transfer Project (FDTP) (DNRE, 2000). Although this flood extent mapping has a low level of accuracy the maps can be a useful guide to highlight areas subject to flooding where detailed mapping is not yet available.

5. Digital Flood Extent Datasets and Aerial Flood Photography

5.1 Beaufort

The flood inundation maps delivered by Water Technology (2008) are available digitally through the VFD.

Aerial flood photography is not available for Beaufort.

5.2 Other locations within the Shire

Digital flood inundation maps and aerial flood photography are not available for other locations within the Shire.

6. Overview of Flooding Consequences

6.1 Introduction

The flooding of floodplains within river and creek corridors is much easier to predict than flash flooding and overland flows in existing urban areas. The latter tends to be relatively localised, not necessarily in contiguous areas and occur when heavy rainfall (often associated with thunderstorms) is concentrated in some part of or across a small catchment. Other factors can significantly affect the extent and depth of inundation in a given area: for example, blocked drains; silted, blocked or insufficient number of side entry pits; no entry to drains from low points; undersized drains (insufficient capacity – both piped and table); inappropriate road and footpath cross-falls; footpaths not high enough to contain flow in roadway and / or roadside drainage not sufficiently sized; the extent of inspection and maintenance, etc. Fences and other obstructions can block overland flow paths resulting in flooding that may otherwise not have been expected. These factors can result in the inundation of properties by overland flows, even for storms of much less intensity than the 1% AEP or design event.

Localised severe thunderstorm events may cause the capacity of the underground drainage system to be exceeded. The excess stormwater moves along overland flow paths. As formalised overland flow paths have generally not been delineated across the Shire, properties in or close to local drainage lines may flood unexpectedly.

6.2 Beaufort

The township of Beaufort is situated within a circle of hills at the confluence of Ding Dong, Cemetery, Cumberland and Yam Holes Creeks. Yam Holes Creek is the main waterway through the town and a major tributary of Mount Emu Creek. The confluence of Yam Holes Creek with Mount Emu Creek is approximately 10km downstream of the Beaufort township. Mount Emu Creek is a major tributary of the Hopkins River which flows into the Southern Ocean just east of Warrnambool.

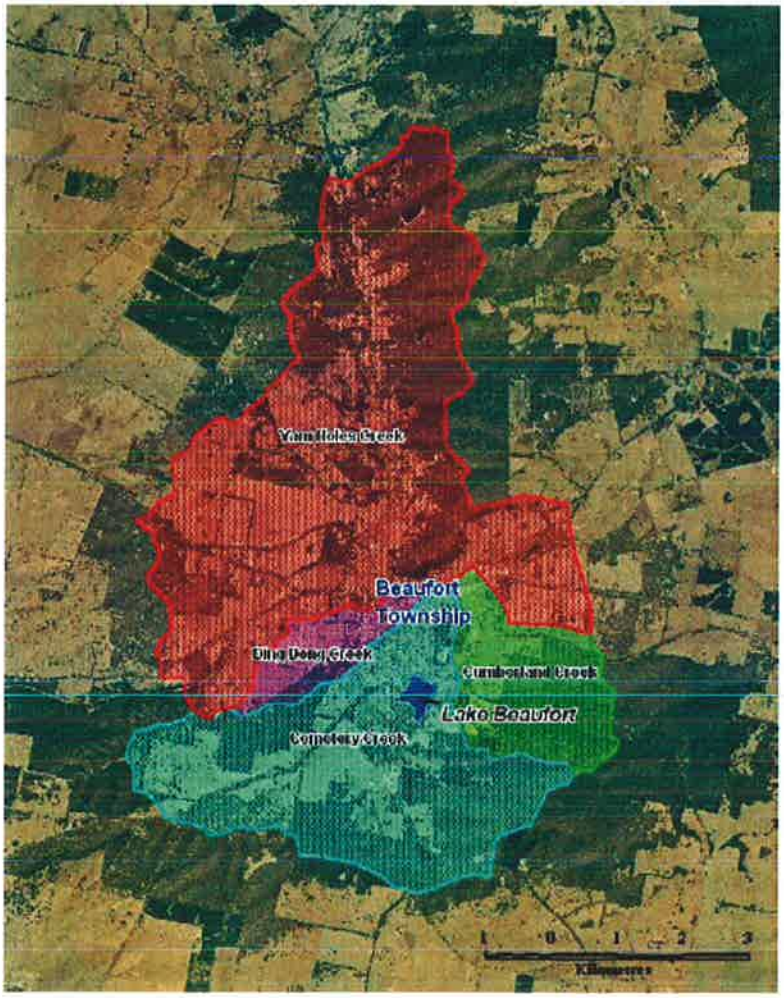
Lake Beaufort on Cemetery Creek is the only main storage on the creeks upstream of Beaufort. During large events, the initial water level in the lake has little effect (~50mm or so) on flood levels downstream through the township.

The sub catchments for each of the streams within the Yam Holes Creek catchment are shown in the adjacent diagram. The areas associated with each sub catchment are as follows:

- Ding Dong Creek: 2.2 km^2
- Cemetery Creek: 14.5km^2
- Cumberland Creek: 5.1km^2
- Yam Holes Creek: 27.2km^2

As can be seen, the Yam Holes Creek tributaries vary significantly in size, from the smallest (Ding Dong Creek) which is only about 5% of the total area to the largest (Cemetery Creek) which is close to 30% of the total catchment area to just downstream of Beaufort.

While Yam Holes Creek upstream of Beaufort has a larger area than the tributary streams, it has a significantly smaller longitudinal slope with large areas available for floodplain storage. These two features act to attenuate flood flows.



The Beaufort township suffers significant inundation in moderate to major flood events. Rises are rapid – of order 3 to 8 hours.

Areas of most significant flood depth are along Cemetery Creek downstream from Lake Beaufort, the northern part of the town (ie. the area south or upstream of the railway line[2]) between the Western Highway (Neil Street) and the railway lines in the Cemetery Creek and Cumberland Creek catchments and the downstream portion of Yam Holes Creek.

The Cemetery Creek catchment contributes most of the flows upstream of the railway line and also contributes the greatest potential damage to property, predominantly along its channel.

Ding Dong Creek, due to its relatively small catchment size, is mostly contained within its drainage channel and poses little threat to property.

Flows break out at the downstream end of Cumberland Creek. However, this is mostly due to the large backwater pool caused by flows down Cemetery Creek.

The constructed part of the Yam Holes Creek channel has insufficient capacity to convey 100 year ARI flows and water breaks out upstream of the Beaufort-Amphitheatre Road. The large floodplain downstream of the town and adjacent to Yam Holes Creek becomes inundated from the 5 year ARI event.

	Design Flood ARI (years)					
	5	**10**	**20**	**50**	**100**	**PMF**
Properties Flooded Above Floor	12	21	31	32	41	211
Properties Flooded Below Floor	169	176	178	179	173	50
Total Flooded Properties	**181**	**197**	**209**	**211**	**214**	**261**

Table 1: Number of properties affected by flooding in Beaufort (see Appendix B1)

ARI (years)	Flow downstream of Beaufort (m^3/s)
5	56.3
10	68.0
20	85.1
50	104.3
100	123.3
PMF	1,420

Table 2: Design peak flood estimates at Beaufort

6.3 Other Locations

6.4 Drainage Hot Spots –areas that have a high risk of flooding during heavy rain events

As at April 2011			
Town & Street Name	**Map Reference**	**Catchment**	**Notes**

[2] Culverts and bridge structures capacity constraints have a significant influence on the depth and extent of flooding - there is a difference in water surface in the 100 year ARI event of approximately 0.5m at the railway bridge on Cemetery Creek, and approximately 0.8m difference through the culverts on Cumberland Creek.

As at April 2011			
Town & Street Name	Map Reference	Catchment	Notes

6.5 Major Dam Failure

Cemetery Creek includes a significant recreational online storage, Lake Beaufort, just upstream of the township. The lake has a maximum surface area of approximately 16Ha and a reported volume of 297ML (TGM, 2004). This implies an average depth of about 1.8m. Pyrenees Shire Council is responsible for the dam.

The Lake overtopped during the January 2011 flood event which led to some concerns regarding possible failure.

Failure of the dam would likely cause significant structural and community damage within Beaufort.

While DSE is the Control Agency for dam safety incidents (see Appendix I), VICSES is the Control Agency for any flooding that may result.

There are a number of large private dams within the Municipality.

6.6 Failure of a Retarding Basin

There are no stormwater retarding basins within the Municipality.

6.7 Floor Level Information

6.7.1 Beaufort

The Beaufort flood study (Water Technology, 2008) produced flood inundation and extent maps for the town and immediate surrounding area. The maps also show the location of all properties within the town affected by below and above-floor inundation for a range of floods up to the 1% AEP (100 year ARI) event. These maps are available from the Pyrenees Shire and from the Glenelg Hopkins Catchment Management Authority.

A list of properties likely to experience below and above-floor inundation for the PMF, 1%, 2%, 5%, 10% and 20% AEP flood events is provided in Appendix B1. It should be noted that properties in addition to those listed may also be flooded from time to time depending on the severity of the event.

There are no streamflow or level gauges at Beaufort or upstream in the Ding Dong, Yam Holes, Cemetery or Cumberland Creek catchments. The nearest streamflow gauge is around 27km downstream of Beaufort on Mt Emu Creek at Mena Park, approximately 17 km downstream of its confluence with Yam Holes Creek.

6.7.2 Other Locations

7. Historic Floods

Information on historic flood events within the Municipality is included in Appendix C.

8. Flood Intelligence Cards

All flood intelligence records are approximations. This is because no two floods at a location, even if they peak at the same height, will have identical impacts. Flood intelligence cards detail the relationship between flood magnitude and flood consequences. More details about flood intelligence and its use can be found in the Australian Emergency Management Manuals flood series.

9. Flood Impacts and Required Actions

9.1 Introduction

Flood impacts described in the following tables relate primarily to riverine flooding. It should be noted that local impacts, or impacts in excess of those indicated, may occur as a result of local stormwater runoff and drainage and / or be attributable to flooding emanating from tributary streams. Similarly, local increases in flood levels and impacts may result from local factors such as blockages at bridges and from obstructions to overland flows such as works, channels, fences, buildings and the like.

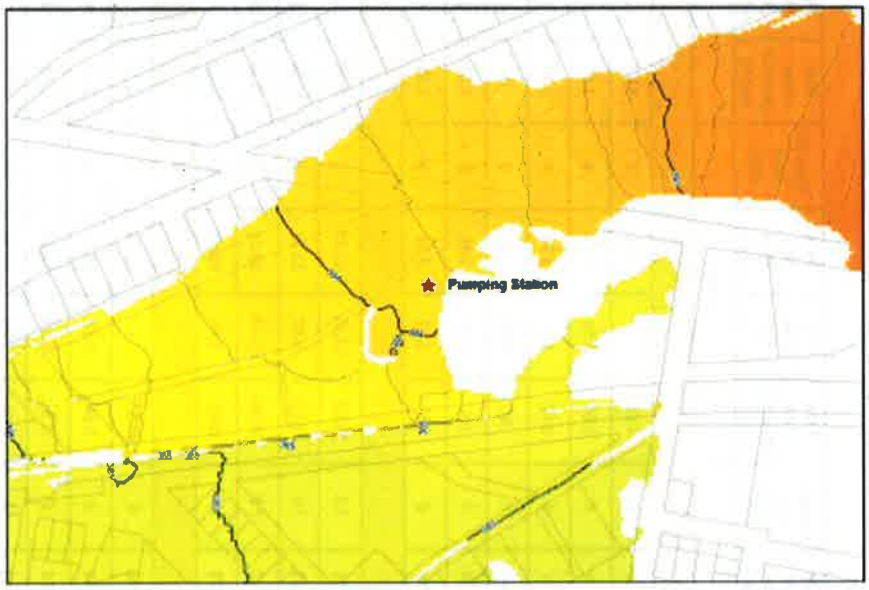
9.2 Beaufort

The Western Highway (Neil Street) becomes inundated in the 100 year ARI event at Cemetery and Cumberland creeks. However, the depth of inundation is less than 200mm and the velocities are generally less than 1m/s. At this depth and flow rate (ie. up to the 100 year ARI event), it is safe to assume the Highway could remain open to vehicles.

A more detailed summary of flow across roads within Beaufort is provided on the following page. This list could be used to assess the accessibility of properties along the creeks within the town and, in conjunction with the table of likely property inundations, assist in the determination of the need to initiate evacuations.

The sub-surface sewerage effluent pumping station operated by central Highlands Water at Beaufort is located immediately downstream of the confluence of Cumberland and Yam Holes creeks, between Yam Holes Creek and the railway line (see adjacent map). It is inundated by all floods from the 5 year ARI event upwards. The depth of flooding during a 100 year ARI event would be in excess of 1.0m.

The containment bunds associated with the water treatment facility at Beaufort are higher than the 100 year ARI water level.



The flood inundation maps show that access to the Shire Offices in Beaufort as well as the Ambulance depot (both near the corner of Willoby and Lawrence streets) is affected by flooding from the 5 year ARI event upwards. The fire station, Police station and the Beaufort Campus of the Beaufort and Skipton Heath Service are all above the 100 year ARI flood extent.

There are two culverts within Beaufort protected by mesh on the upstream side. Both culverts would be susceptible to blockage from rubbish and organic material during a high flow event and should be checked (and cleaned) in the early stages of a developing flood.

- Ding Dong Creek where it passes under the side fence of 18 Cummins Street; and
- Cemetery Creek where it passes under Leichardt Street.

	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)	Peak Flow Overland (m3/s)	Peak Flow Pipe (m3/s)	Peak Flow Total (m3/s)	Time to Peak (hrs)
	100 Year				50 Year				20 Year				10 Year				5 Year			
Ding Dong Creek																				
Gregory St	6.76	-	6.76	6	5.82	-	5.82	6	4.85	-	4.85	6	3.87	-	3.87	6	2.99	-	2.99	6
Stuart St	4.71	2.51	7.22	6	3.72	2.51	6.23	6	2.68	2.51	5.19	6	1.55	2.50	4.05	6	0.59	2.48	3.07	6
Cummings St	1.53	5.75	7.28	6	0.65	5.60	6.25	6	0.13	5.17	5.30	6	0.04	4.02	4.06	6	0.01	3.1	3.11	6.5
Neill St	0	7.40	7.40	6	0	6.44	6.44	6	0	5.63	5.53	6	0	4.32	4.32	6.5	0	3.37	3.37	6.5
Havelock St	6.43	5.02	11.45	6	5.56	4.48	10.04	6	5.1	4.39	9.49	6	4.23	4.91	9.14	6.5	2.62	4.25	6.87	6.5
Rail Embankment	3.62	3.66	7.28	6	3.87	3.54	7.41	6	3.86	3.52	7.38	6	3.95	4.36	8.31	6.5	3.78	3.85	7.63	6.5
Cemetery Creek																				
Havelock St	46.65	16.41	63.06	7	36.14	14.54	50.68	7.5	28.07	13.25	41.32	8	21.05	12.44	33.49	8.5	15.58	6.89	22.47	9.5
Leichardt St	44.65	11.26	55.91	7	34.81	6.80	41.61	7.5	27.01	5.30	32.31	8	20.86	5.25	26.11	8.5	15.8	4.88	20.68	9.5
Neill St	38.5	13.50	52.00	7	28.91	13.12	42.03	7.5	20.96	12.15	33.11	8	15.14	10.73	25.87	8.5	10.56	9.14	19.70	9.5
Pratt St	23.79	2.55	26.34	7.5	19.12	2.58	21.70	8	16.01	2.44	18.45	8.5	13.82	2.51	16.33	9	11.3	2.45	13.75	9.5
Cumberland Creek																				
Kilberg St	19.62	-	19.62	6	16.65	-	16.65	6	13.55	-	13.55	6	10.57	-	10.57	6	9.98	-	9.98	6
Neill St	14.51	5.12	19.63	6	11.62	5.00	16.62	6	8.64	4.88	13.52	6	5.80	4.70	10.50	6	3.48	4.64	8.12	6.5
Broadbent Court	11.06	4.52	15.58	6	8.46	4.52	12.98	6	5.8	4.49	10.29	6	3.44	4.41	7.85	6.5	1.94	4.22	6.16	6.5
Racecourse Rd	15.46	7.89	23.35	6	11.65	7.88	19.53	6	8.08	7.88	15.96	6.5	4.75	7.84	12.59	6.5	1.37	7.72	9.09	7
Rail Embankment *(Cemetery & Cumberland Creeks)*	59.57	45.05	104.62	7	45.79	43.66	89.45	7.5	43.99	36.9	80.89	8.5	22.77	27.16	49.93	9	18.49	19.77	38.26	9.5
Yam Holes Creek																				
King St	68.76	-	68.76	7	56.71	-	56.71	7	47.35	-	47.35	7	37.45	-	37.45	7	30.93	-	30.93	8
Albert St	30.39	38.37	68.76	7	21.16	37.47	58.63	7	14.01	36.0	50.01	7.5	6.6	32.28	38.88	7.5	2.91	25.83	28.84	8

N.B. 'Time to peak' is indicative only and represents the time to the peak flow from the beginning of the design 9 hour rainfall event.

Summary of flows and times to peak for roads within Beaufort

9.3 Gauge Location: Avoca River at Avoca (Example)

Avoca River at Avoca				
River Height (m)	**River Flow (ML/d)**	**Consequence / Impact within the Pyrenees Shire Refer to maps and lists at Appendix J**	**Action[3]**	**Comments**
		No information other than more damaging than the 100 year ARI event.		Probable Maximum Flood (PMF)
				1% AEP (100 year ARI)
x.xxm	xxML/d	Over floor flooding likely at the xxxxxxx. Floor of house in at xx xxxx Street in xxxxx likely to be wetted.	Evacuate the xxxxxx. Raise valuables and evacuate xx xxxx Street.	
x.xxm	**xxML/d**			**Major Flood Level x% AEP (xx year ARI)**
	xxML/d	Floor of house in xxxxxx Road in xxx likely to be wetted.		
x.xxm	**xxML/d**			**Moderate Flood Level x% AEP (xx year ARI)**
x.xxm	xxML/d	Public recreation areas downstream from xxxxx Street likely to begin flooding.	Restrict access to public recreation areas.	
x.xxm	**xxML/d**			**Minor Flood Level x% AEP (xx year ARI)**

[3] All references to unsafe driving depths have been extracted from Appendix J of *Floodplain Management in Australia, Best Practice Principles and Guidelines* (ARMCANZ, 2000)

10. Typical Flood Peak Travel Times

To be determined once gauge arrangements in place

APPENDIX B1 – PROPERTIES LIKELY TO BE FLOODED – BEAUFORT

Introduction

The following is a list of properties expected to experience flooding (and the depth of that flooding) for various sized floods at Beaufort along with an indication of the likely depth of over floor flooding. **It is strongly recommended that the following list be used in conjunction with the flood inundation maps (see Appendix J)** particularly if inundation mapping has identified the location of each floor level lower than the expected flood height (ie. where over floor flooding is likely).

Update of List of Properties Likely to be Flooded

The list of properties likely to be flooded (with corresponding levels and indication of over floor flood depth) should be updated within five (5) weeks of a flood peak with information collected as part of post-flood information recording activities and as may be collected as a consequence of the event debrief (see Part 3 Section x) as well as from the collective experience of the IMT. Procedures detailed in Part 4 Section 3 of this Plan should be followed to ensure a comprehensive and coordinated approach to update.

Beaufort

It is suggested that this table be used in conjunction with the flood inundation maps

Location of House (Street Name & Number)	Depth of flooding at lowest part of property for selected severity of flooding					Depth of over floor flooding at property for selected severity of flooding					Comments
	5 yr	10 yr	20 yr	50 yr	100 yr	5 yr	10 yr	20 yr	50 yr	100 yr	
1 Albert St	0.40	0.43	0.49	0.54	0.60						Detached house
4 Albert St	0.84	0.89	0.96	1.02	1.08	0.39	0.44	0.50	0.56	0.63	Detached house
4 Albert St	0.88	0.92	1.00	1.05	1.12					0.02	Detached house
8 Albert St	1.17	1.21	1.27	1.32	1.38	0.17	0.21	0.27	0.32	0.38	Detached house
10 Albert St	0.68	0.68	0.73	0.77	0.82			0.05	0.09	0.14	Detached house
2 Back Raglan Rd		0.79	0.84	0.89	0.95						Detached house
Beaufort-Lexton Rd	1.41	1.50	1.62	1.72	1.84	0.24	0.32	0.44	0.54	0.66	Detached house
2 Burke St	0.91	0.94	0.96	0.97	0.99						Shop
2 Havelock St		1.32	1.34	1.36	1.38						Detached house
4 Havelock St	0.47	0.53	0.57	0.59	0.61						Detached house
6 Havelock St		0.19	0.23	0.25	0.27						Detached house
8 Havelock St		0.13	0.16	0.19	0.21						Detached house
10 Havelock St		0.13	0.16	0.19	0.21						Detached house
35 Havelock St	0.60	0.60	0.64	0.68	0.73						Detached house
36 Havelock St	0.80	0.85	0.91	0.98	1.05	0.24	0.29	0.35	0.42	0.49	Detached house
37 Havelock St	1.08	1.02	1.07	1.13	1.19						Detached house

Beaufort

It is suggested that this table be used in conjunction with the flood inundation maps

Location of House (Street Name & Number)	Depth of flooding at lowest part of property for selected severity of flooding					Depth of over floor flooding at property for selected severity of flooding					Comments
	5 yr	10 yr	20 yr	50 yr	100 yr	5 yr	10 yr	20 yr	50 yr	100 yr	
38 Havelock St		2.46	2.53	2.61	2.70					0.01	Detached house
1 High St	0.93	1.10	1.24	1.30	1.35	0.80	0.97	1.11	1.17	1.22	Detached house
3 High St	0.91	1.08	1.22	1.28	1.33	0.62	0.78	0.92	0.98	1.03	Detached house
5 High St	0.60	0.77	0.90	0.97	1.01	0.04	0.21	0.34	0.41	0.45	Detached house
7 High St	0.35	0.52	0.66	0.72	0.77				0.03	0.08	Detached house
9 High St	0.47	0.64	0.77	0.84	0.88			0.10	0.17	0.21	Detached house
19 High St		0.85	0.98	1.104	1.09					0.05	Rural residential with house
20 High St		0.34	0.47	0.53	0.58			0.05	0.11	0.16	Detached house
62 High St		0.15	0.30	0.31	0.33						Detached house
2 Jackson St	0.48	0.56	0.67	0.75	0.85				0.03	0.13	Detached house – No 1
2 Jackson St		0.68	0.78	0.85	0.93		0.42	0.52	0.59	0.67	Detached house – No 2
4 Jackson St	0.54	0.63	0.73	0.82	0.92	0.19	0.28	0.38	0.47	0.57	Detached house
6 Jackson St	0.68	0.76	0.87	0.95	1.04					0.06	Detached house
10 Jackson St		1.46	1.56	1.64	1.72					0.07	Detached house
Lilbeg St	0.78	0.75	0.76	0.77	0.79						Vacant residential land
King St	1.28	1.35	1.45	1.53	1.63					0.10	Club / Clubroom
2 King St	1.23	1.27	1.32	1.37	1.43	0.03	0.07	0.12	0.17	0.23	Detached house
4 King St	0.76	0.79	0.84	0.89	0.95	0.05	0.08	0.13	0.18	0.24	Detached house
6 King St	0.70	0.73	0.78	0.83	0.89		0.01	0.06	0.11	0.17	Detached house
8 King St	0.62	0.66	0.71	0.76	0.82						Detached house
10 King St	0.84	0.89	0.94	0.99	1.04			0.01	0.06	0.11	Detached house
14 King St	0.63	0.68	0.73	0.78	0.83				0.04	0.09	Detached house
1 Lawrence St		0.11	0.24	0.26	0.28						Municipal Offices

Beaufort

It is suggested that this table be used in conjunction with the flood inundation maps

Location of House (Street Name & Number)	Depth of flooding at lowest part of property for selected severity of flooding					Depth of over floor flooding at property for selected severity of flooding					Comments
	5 yr	10 yr	20 yr	50 yr	100 yr	5 yr	10 yr	20 yr	50 yr	100 yr	
25 Lawrence St		0.22	0.24	0.27	0.30						Detached house
49 Lawrence St		0.58	0.66	0.74	0.83						Detached house
51 Lawrence St		0.72	0.80	0.88	0.97						Detached house
53 Lawrence St	0.98	1.05	1.13	1.21	1.30	0.20	0.27	0.35	0.43	0.52	Detached house
12 Leichardt St		0.51	0.54	0.57	0.60						Detached house
14 Leichardt St		0.41	0.44	0.47	0.50						Detached house
15 Leichardt St	0.52	0.54	0.58	0.62	0.66		0.01	0.05	0.09	0.13	Detached house – No 1
15 Leichardt St	0.61	0.65	0.70	0.75	0.82	0.13	0.17	0.22	0.27	0.34	Detached house – No 2
16 Leichardt St	0.47	0.46	0.50	0.53	0.58						Detached house
17 Leichardt St	0.35	0.37	0.40	0.44	0.49						Detached house
18 Leichardt St	0.40	0.41	0.44	0.48	0.52						Detached house
19 Leichardt St	0.30	0.33	0.36	0.40	0.44						Detached house
20 Leichardt St	0.32	0.34	0.38	0.42	0.47						Detached house
22 Leichardt St	0.27	0.30	0.33	0.37	0.42				0.02	0.07	Detached house
24 Leichardt St	0.19	0.21	0.25	0.29	0.34						Detached house
2 Livingstone St	0.24	0.28	0.30	0.32	0.35						Detached house
12 Neil St	0.47	0.63	0.67	0.82	0.88	0.26	0.42	0.55	0.61	0.67	Motel – No 1
12 Neil St	0.41	0.54	0.67	0.73	0.79	0.17	0.29	0.43	0.49	0.54	Motel – No 2
23 Neil St	0.53	0.52	0.55	0.59	0.64					0.04	Service station
26 Neill St		0.31	0.39	0.44	0.50						Detached house
27 Neil St	0.39	0.41	0.44	0.48	0.52	0.10	0.12	0.15	0.19	0.23	Unspecified – retail trade
28 Neil St	0.46	0.50	0.58	0.64	0.71						Detached house
30 Neil St	0.50	0.50	0.58	0.65	0.72						Detached house

Beaufort

It is suggested that this table be used in conjunction with the flood inundation maps

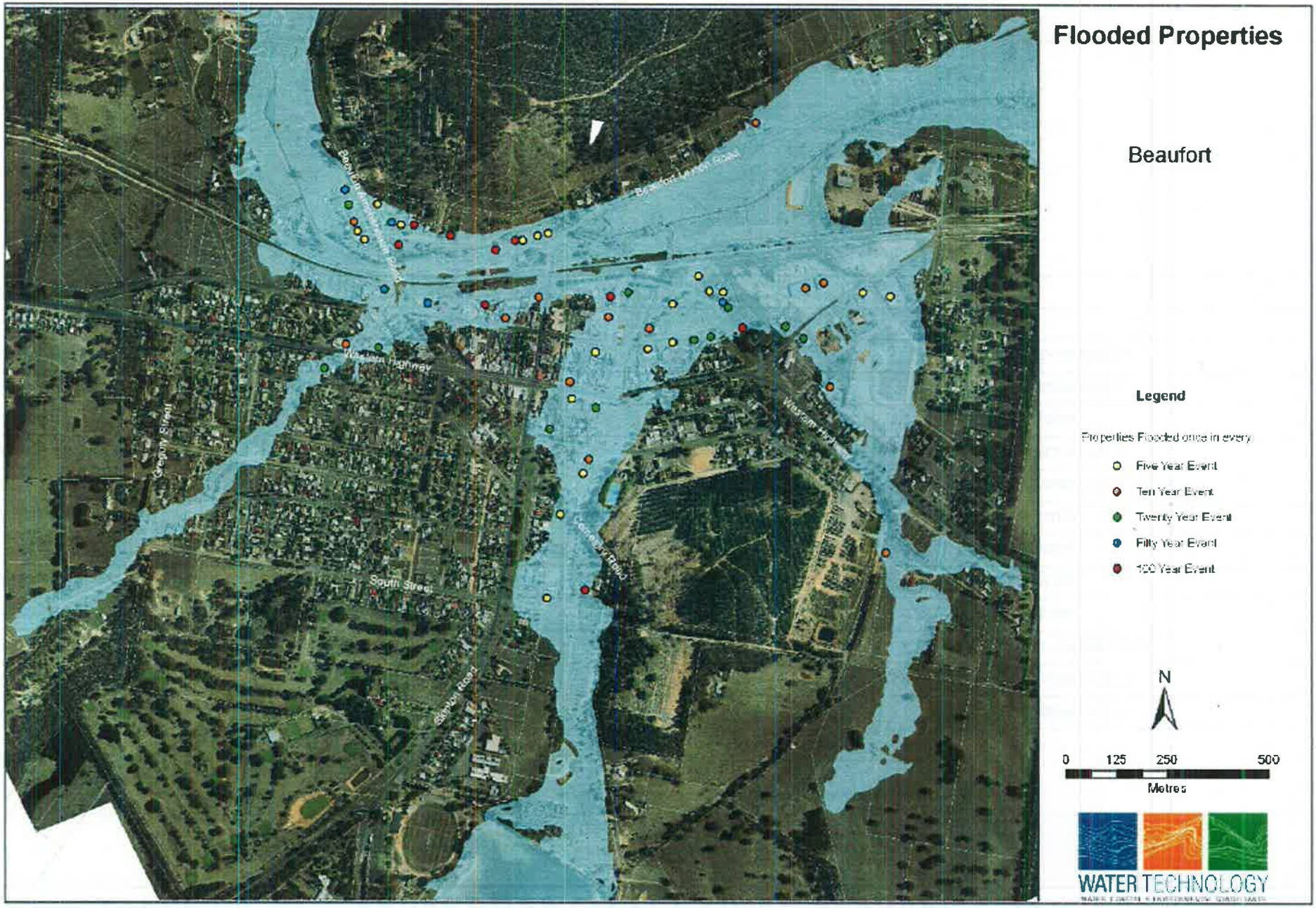
Location of House (Street Name & Number)	Depth of flooding at lowest part of property for selected severity of flooding					Depth of over floor flooding at property for selected severity of flooding					Comments
	5 yr	10 yr	20 yr	50 yr	100 yr	5 yr	10 yr	20 yr	50 yr	100 yr	
32 Neil St	0.62	0.59	0.64	0.70	0.76						Detached house
33 Neil St	0.40	0.40	0.44	0.47	0.52						Detached house
34 Neil St	0.46	0.46	0.52	0.59	0.66						Office
36 Neil St	0.43	0.47	0.53	0.59	0.66		0.01	0.07	0.13	0.20	Garage / Motor vehicle repairs
76 Neil St		0.44	0.49	0.52	0.55			0.05	0.08	0.11	Detached house
78 Neil St	0.54	0.60	0.56	0.69	0.72						Detached house
80 Neil St		0.93	0.99	1.03	1.07		0.02	0.08	0.12	0.16	Service station
85 Neil St	0.73	0.83	0.91	0.97	1.03				0.01	0.07	Detached house
38 Olinda St	0.89	0.96	1.04	1.11	1.17	0.11	0.18	0.26	0.33	0.39	Rural residential with house
1 Pratt St	0.98	1.15	1.28	1.34	1.40	0.08	0.25	0.38	0.44	0.50	Detached house
9 Pratt St	0.59	0.74	0.88	0.94	1.00			0.13	0.19	0.25	Detached house
15 Pratt St		0.17	0.22	0.28	0.35						Detached house
23 Pratt St		0.20	0.22	0.25	0.27		0.07	0.09	0.12	0.14	Hotel
25 Pratt St	0.16	0.18	0.22	0.25	0.27						Detached house
27 Pratt St	0.19	0.23	0.26	0.29	0.31						Senior citizens clubrooms
31 Pratt St		0.24	0.26	0.30	0.32						Detached house
35 Pratt St		0.23	0.26	0.28	0.31					0.01	Hotel
5 Racecourse Rd	1.32	1.49	1.63	1.68	1.73	0.08	0.25	0.39	0.44	0.49	Processing plant – No 1
5 Racecourse Rd		1.49	1.62	1.68	1.72		0.26	0.39	0.45	0.49	Processing plant – No 2
8 Racecourse Rd		0.35	0.36	0.36	0.37						Garage / Motor vehicle repairs
16 Racecourse Rd	0.53	0.58	0.60	0.62	0.64						Factory
24 Racecourse Rd	1.26	1.30	1.33	1.36	1.38	0.56	0.60	0.63	0.66	0.68	Factory / warehouse
28 Racecourse Rd	1.03	1.07	1.10	1.13	1.16	0.17	0.21	0.24	0.27	0.30	Store

APPENDIX B1 – PROPERTIES LIKELY TO BE FLOODED – BEAUFORT

Beaufort

It is suggested that this table be used in conjunction with the flood inundation maps

Location of House (Street Name & Number)	Depth of flooding at lowest part of property for selected severity of flooding					Depth of over floor flooding at property for selected severity of flooding					Comments
	5 yr	10 yr	20 yr	50 yr	100 yr	5 yr	10 yr	20 yr	50 yr	100 yr	
2 Ralphs St		0.59	0.59	0.60	0.61						Stop and dwelling – No 1
2 Ralphs St		0.78	0.80	0.81	0.82			0.01	0.02	0.03	Stop and dwelling – No 2
Willoby St	0.40	0.49	0.62	0.68	0.74		0.07	0.20	0.26	0.32	Unspecified – transportation
2 Willoby St	0.66	0.80	0.93	1.00	1.05		0.13	0.26	0.33	0.38	Detached house
3 Willoby St	0.40	0.47	0.57	0.63	0.70						Detached house
3A Willoby St		0.30	0.43	0.49	0.55		0.05	0.18	0.24	0.30	Detached house
5 Willoby St	0.33	0.40	0.50	0.57	0.64	0.15	0.22	0.32	0.39	0.46	Detached house
7 Willoby St	0.35	0.41	0.51	0.57	0.65						Detached house – No 1
7 Willoby St	0.33	0.39	0.50	0.56	0.63						Detached house – No 2
20 Willoby St		0.23	0.26	0.28	0.30		0.04	0.07	0.09	0.11	Detached house
28 Willoby St	0.23	0.32	0.36	0.39	0.41						Vacant commercial land
30 Willoby St		0.43	0.46	0.50	0.52						Unspecified – retail trade
36 Willoby St		0.16	0.18	0.20	0.23						Shop
38 Willoby St		0.23	0.24	0.24	0.25						Depot


Flooded Properties
Beaufort
Legend
Properties Flooded once in every
Five Year Event
Ten Year Event
Twenty Year Event
Fifty Year Event
100 Year Event
N
0
125
250
500
Metres
WATER TECHNOLOGY
Gregory Street
Western Highway
South Street
Canadian Road

1. General

While the formal records of flooding are relatively sparse, there is significant anecdotal evidence to suggest that flooding has been an issue in low-lying parts of Beaufort for a considerable period of time.

Flooding is believed to have occurred in Beaufort in:

- 15 September 1884
- May 1892
- 13 October 1894
- 15 April 1939
- 1956
- 1962
- February 1965
- 1966
- February 1973
- December 1978 – January 1979
- 1980
- 1990
- 5 December 1992
- 2001
- 2002
- 2003
- 2004
- 14 January 2011

Specific Storm Events by Date

14 January 2011

96.8mm of rainfall was recorded to 9am on 14 January at Beaufort. This was the highest daily rainfall recorded at Beaufort in 120 years of record. The previous highest 24 hour total, 85.6mm, was recorded on 21 January 1904.

The Beaufort Lake dam overtopped during event which led to some concerns regarding possible failure.

Up to 50 houses inundated in Beaufort and the Western Highway was closed for a period.

The Big Garage Antiques business premises were flooded.

Roads flooded included: Pratt St, Willoby St, Beggs St, Alfred St and Albert St.

The Glenelg Hopkins Catchment Management Authority has additional information on the characteristics and impact of this flood event.

APPENDIX D – FLOOD CLASS LEVELS

FLOOD CLASS LEVELS for river gauges relevant to Pyrenees Shire (example)				
River Station	**Minor**	**Moderate**	**Major**	**Gauge Zero**
xxxx River at location 1	x.xm	x.xm	x.xm	x.xxxmAHD
xxxx River at location 2	x.xm	x.xm	x.xm	x.xxxmAHD
xxxx River at location 3	x.xm	x.xm	x.xm	x.xxxmAHD
NOTE: list and negotiate with BoM for flood class levels as part of the Service Level Agreement				

NOTE 1: as extracted from the Bureau of Meteorology's website (www.bom.gov.au) on ***date***.

It is emphasised that the flood levels quoted in the table above refer to that part of the river where the flood effects can be related to the gauge reading.

The occurrence of a certain class of flooding at one point in a catchment will not necessarily lead to the same class of flooding at other points – for example along the main river and its tributary creeks or along the drainage network's overland flow paths. This is because the floodplain physiography and use (and thus flood impact) varies along the river or flow path and also because antecedent conditions combined with where and how rainfall occurs (both in time and space) will drive how a flood develops and progresses.

It is important to remember that flood impact is dependent on more than the peak height or flow. The rate of rise, duration, extent and season of flooding are also important. For this reason, flood class levels can only be considered as a guide to flood severity.

Definitions

Flood warning classification definitions can be found at www.bom.gov.au/hydro/flood/flooding

Observed River Height: Depth of water (in metres) at a river height measuring gauge. In most cases, a zero reading is the lowest water level that is reached during dry conditions. Gauge readings usually need to be converted to mAHD *(by adding the gauge zero value in the following table)* before they can be used with flood inundation maps or to estimate the actual depth of flood waters.

1. Control

2. Evacuations will be controlled by VICPOL in consultation with VICSES.

2. Phase 1 - Decision to Evacuate

3. VICSES should recommend evacuations to VICPOL under the following circumstances:

- Properties are likely to become inundated;
- Properties are likely to become isolated and occupants are not suitable for isolated conditions;
- Public health is at threat as a consequence of flooding and evacuation is considered as the most effective risk treatment;
- Essential services have been damaged and are not available to a community and evacuation is considered the most effective risk treatment.

Gauge height triggers for evacuation can be found in Appendix A.

The following should also be considered when planning for evacuation:

- Number of people requiring evacuation
- Current and future weather conditions
- Time of day
- Time to undertake evacuations
- Time available to undertake evacuations
- Modes of transport available
- Resources availability
- Special needs groups
- Closure of evacuation routes
- Availability of adequate shelter

Table below details time required to evacuate established sectors.

Sector	Likely time required for evacuation (including resource assumptions)

3. Phase 2 - Warning

Once the decision to evacuate has been made the at-risk community will be warned to evacuate. Evacuation warnings can be disseminated via:

- Radio and TV stations;
- Doorknocks by emergency service personnel;
- Public address systems from emergency service vehicles;
- Telephone;
- Two-way radio;
- The internet;
- Community meetings.

Evacuation warning messages will be developed and issued by VICPOL in consultation with VICSES as the control agency.

4. Phase 3 – Withdrawal

Evacuees will be encouraged to move using their own transport where possible. Transport for those without vehicles or other means will be arranged [***insert arrangements***]

Evacuation routes to be used:

Sector	Evacuation Route	Evacuation route closure point and gauge height of closure

Special needs groups will be identified and assisted where required. This can be done through community network organisations.

5. Phase 4 - Shelter

Relief (Evacuation) Centres will be established to meet the immediate needs of people affected by flooding. Any of the following sites maybe used as evacuation centres: [list]

Sector	Relief (Evacuation) Centre (inc address)	Comments

On arrival at relief centres evacuees will be registered. VICPOL is responsible for ensuring registrations are completed. This function is usually delegated to the Australian Red Cross.

Animal shelter compounds will be established for domestic pets and companion animals of evacuees. These facilities will be located at ***[enter locations]*** and coordinated by the Pyrenees Shire.

6. Phase 5 – Return

Once it is considered safe to do so, VICPOL will authorise the return of evacuees to their normal or alternative place of residence. This decision will be made in consultation with appropriate officers in regard to matters such as public health.

Once it is considered safe to do so, VICPOL, in consultation with the control agency (VICSES) and appropriate council officers, will authorise the return of evacuees to their normal or alternative place of residence.

Flood Watches and Flood Warnings

Flood Watches are issued by the Bureau of Meteorology (BoM) to notify the Victorian community of the potential flood threat from a developing weather situation. They are based on an assessment of developing weather situations and indicators of current catchment wetness and provide a 'heads up' of likely flooding.

Flood Watches are issued for specific regions (eg. metropolitan streams) and provide generalised statements about the developing weather situation including expected forecast rainfall totals, describe the current state of the catchments within the target area and indicate the streams at risk from flooding. Instructions for obtaining rain and stream level observations and access to updated Watches and Warnings are also included.

Normally, the BoM would issue a Flood Watch 24 to 36 hours in advance of any likely flooding and issue updates as required. If at any time during this period there is an imminent threat of floods occurring, the Flood Watch would be upgraded to a Flood Warning.

Flood Warnings are firm predictions of flooding based on actual rainfall measurements and stream flow based models of catchment behaviour that take account of likely future rainfall. Flood warnings for streams within Melbourne Water's area of responsibility are prepared by Melbourne Water in conjunction with the BoM and issued by the BoM.

Flood Watches and Warnings are issued by the BoM to the media, VICSES and a range of other stakeholder organisations including the Pyrenees Shire. Council will receive a follow up communication from VICSES. This flow of information is shown in diagram form at Appendix G.

Council has the responsibility for alerting individuals within the community including activation of flood warning systems if they exist. Council is also expected to monitor the situation and take appropriate action within its areas of responsibility, ensuring that at all times, VICSES as the Control Agency for flood, is kept appraised of developments and that any actions taken accord with the overall strategy adopted by VICSES to respond to the event and as reflected in this Plan.

Flood Watches and Warnings, along with all available rain and river level / flow data (updated hourly), radar and satellite imagery and other related information, are also posted to the Bureau's website.

Riverine Flooding

Flood warnings are firm predictions of flooding.

Note 1: The term "local flooding" or "flash flooding" may be used for localised flooding resulting from intense rainfall over a small area.

Note 2: The term "significant rises" may be used in the early stages of an event when it is clear that stream levels will rise but it is too early to say whether they will reach flood level.

Additional information (eg. weather radar and satellite images, updated rain and river level information, details of current watches and warnings) can be obtained from the BoM's website (www.bom.gov.au/hydro/flood/vic) and the VICSES website (www.ses.vic.gov.au) or for the cost of a local call on ☎ 1300 659 217.

The BoM does not provide a flood warning service for the creeks around Beaufort.

Flash Flooding

Flash flooding[4] is often associated with severe thunderstorms or small scale weather systems that are locally intense and slow moving. The BoM can forecast the environment in which these sorts of weather events may occur and provides a generalised service to that effect. As it is not yet scientifically possible to predict individual flash flooding events except on time scales of tens of minutes at the very best, the BoM does not provide warnings for flash flooding for specific creeks and locations.

Local Flood Warning System Arrangements

[4] The BoM's policy on the provision of flash flood warning services is enunciated in a document dated May 1996 (Bureau of Meteorology, 1996). Following a definition of flash flooding ("*flooding occurring within about 6 hours of rain, usually the result of intense local rain and characterised by rapid rises in water levels*"), the document describes the policy framework which underpins the flash flood warning service provided by the BoM. The 1987 working arrangements (Bureau of Meteorology, 1987) also refer to the provision of flash flood warning services and make it clear that the BoM does not have an exclusive role.

APPENDIX F – SERVICE LEVEL AGREEMENTS

Service Level Agreements do not currently exist for flood warning services provided for watercourses within the Pyrenees Shire.

Sometimes also referred to as a Flood Warning Service charter.

The aim of the agreement is to establish the parameters for delivery of flood forecasts for each location identified as in need of a specific forecast so that community and agency requirements (in terms of people / assets at risk and viable response actions and associated timings) drive service delivery rather than perhaps the other way around.

Requirements for forecast issue (and reissue) times and frequencies, forecast locations, forecast lead times (ie. the time required between forecast issue and flooding to implement an effective response and therefore perhaps different for increasing flood severity), provision of raw rain and river level / flow data and so on need to be identified / negotiated as part of the process of establishing the Agreement.

Further, as part of that process, all flood class levels should be reviewed for representativeness and adequacy with particular attention to those areas / locations where structural flood mitigation measures or other works affected flood characteristics have been implemented since levels were originally established.

It is likely that (in time) the Agreement will provide a basis for routine post-event evaluations of flood forecast and warning system performance on a location by location basis. Any gaps between what is required and service delivery on each of the total flood warning system components could be documented and form the basis for longer term upgrade plans.

The Agreement could be accompanied by relevant supporting information. This could include details of the roles and responsibilities of each stakeholder entity with due regard for all elements of the total flood warning system. These will have their genesis in the legislation, policies, procedures and other arrangements that comprise the framework for flood warning service delivery within Victoria but be stated in terms specific to the catchment(s) being considered.

Pyrenees Shire to decide whether to retain or delete this Appendix.

APPENDIX G – INFORMATION FLOW CHARTS

No flow charts currently available.

Include a copy of (updated) Flood Warning System Information Flow Charts for all flood warning systems within the Municipality. While this may not be able to be populated at present, it is suggested that this Appendix should be retained.

APPENDIX H – WARNING DISSEMINATION LISTS

Agencies, organisations or entities	Provided by	Delivery method

The *Emergency Management Manual Victoria* (page 7-2) identifies the Department of Sustainability and Environment (DSE) as the Control Agency responsible for *"dam safety, water and sewerage asset related incidents"* and other emergencies.

Water Corporations perform a support agency role. In addition to prevention / mitigation / risk reduction activities, the response activities include: *"implementing incident and emergency management plans when the authority's assets fail to perform their function"*

A Water Corporation's support role vis-à-vis DSE during water and sewerage infrastructure emergencies is described in the *Emergency Response Notification Protocol between DSE and Victorian Water Authorities* (DSE, 2007) which states (p5):

1. *For incidents involving water and sewerage infrastructure, the initial response must be conducted by the water authority that owns the asset impacted.*
   - *For the initial response where DSE is the Control Agency, the water authority CEO (or delegate) is appointed to the role of Incident Controller.*
   - *Unless and until a replacement appointment is made, the CEO (or delegate) must remain the Incident Controller.*
2. *For emergencies involving dams:*
   - *Where a dam is owned by a water authority, the CEO of the water authority is the Incident Controller in the same way as for water and sewerage emergencies.*
   - *Where a dam is privately owned, the responsibility rests with Melbourne Water or the local rural water authority, whichever is the licensing authority for the private dam involved. The Incident Controller will be the CEO (or delegate) from that authority.*

1. Flood Inundation Maps – Beaufort

The flood inundation maps prepared as a result of the Beaufort Flood Study (Water Technology, 2008) are listed below. These maps are available in hard copy form and as PDF digital copies at the Pyrenees Shire Council MECC.

No.	Drawing
	5 year Average Recurrence Interval Flood Event - Flood Depths and properties impacted (1 sheet)
	10 year Average Recurrence Interval Flood Event - Flood Depths and properties impacted (1 sheet)
	20 year Average Recurrence Interval Flood Event - Flood Depths and properties impacted (1 sheet)
	50 year Average Recurrence Interval Flood Event - Flood Depths and properties impacted (1 sheet)
	100 year Average Recurrence Interval Flood Event - Flood Depths and properties impacted (1 sheet)
	Probable Maximum Flood Event - Flood Depths and properties impacted (1 sheet)

Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000), Standing Committee on Agriculture and Resource Management (SCARM) Report No 73: *Floodplain Management in Australia, Best Practice Principles and Guidelines.*

Bureau of Meteorology (1987): *Flood Warning Arrangements - Papers prepared for discussions with Victorian Agencies, December 1987.*

Bureau of Meteorology (1996): *Bureau of Meteorology Policy on the Provision of the Flash Flood Warning Service.* May 1996.

Department of Infrastructure (DoI) (2000a): *Victoria Planning Provisions (VPPs).*

Department of Infrastructure (DoI) (2000b): *Victoria Planning Provisions Practice Notes: Applying the Flood Provisions in a Planning Scheme, A Guide for Councils.*

Department of Infrastructure (DoI) (2000c): *Victoria Planning Provisions Practice Notes: Applying for a Planning Permit under the Flood Provision, A Guide for Councils, Referral Authorities and Applicants.*

Department of Natural Resources and Environment (DNRE) (1998a): *Victoria Flood Management Strategy.*

Department of Natural Resources and Environment (DNRE) (1998b), Floodplain Management Unit: *Advisory Notes for Delineating Floodways.*

Department of Natural Resources and Environment (DNRE) (2000): *Flood Data Transfer Project* – – Flood Data and Flood Planning Maps as well as Flood Mapping and River Basin Reports.

Department of Sustainability and Environment (DSE) (2007): *Water and Sewage Infrastructure Emergencies: Emergency Response Notification Protocol between DSE and Victorian Water Authorities*; Version 4.00.

Department of Sustainability and Environment (DSE) (2008): *Victoria Caravan Parks Flood Emergency Management Plan Template and Guidelines.* (Two documents) March 2008

Emergency Management Australia (EMA) (1999a): *Managing the Floodplain.* Australian Emergency Manual Series Part 3 (Emergency Management Practice) Volume 3, Guide 3.

Emergency Management Australia (EMA) (1999b): *Flood Response.* Australian Emergency Manual Series Part 3 (Emergency Management Practice) Volume 3, Guide 6.

Emergency Management Australia (EMA) (1999c): *Flood Warning – 2nd edition.* Australian Emergency Manual Series Part 3 (Emergency Management Practice) Volume 3, Guide 5.

Emergency Management Australia (EMA) (1999d): *Flood Preparedness.* Australian Emergency Manual Series Part 3 (Emergency Management Practice) Volume 3, Guide 4.

Emergency Management Australia (EMA) (1999e): *Emergency Management Planning for Flood Affected by Dams.* Australian Emergency Manual Series Part 3 (Emergency Management Practice) Volume 3, Guide 7.

TGM group (2004): *Beaufort Flood Scoping Study.* Consulting report prepared for Glenelg Hopkins Catchment Management Authority, November 2004.

Victoria State Emergency Service (VICSES) (2007): *State Flood Emergency Plan for Victoria.* Version 1.4, November 2007.

Water Technology (2008): *Beaufort Flood Study.* Consulting report (J558/R04) prepared for the Pyrenees Shire, June 2008.

Water Technology (2011): *Beaufort Floodplain Management Plan Study Report.* Consulting report (1222-01/R02V02) prepared for the Pyrenees Shire, May 2011.

APPENDIX D COMMUNITY ALERTING AND NOTIFICATION

1. Background

According to Rogers and Sorensen (1988), warning people of impending danger encompasses two conceptually distinct aspects—alerting and notification. Alerting deals with the ability of emergency officials to make people aware of an imminent hazard. Alerting frequently involves the technical ability to break routine acoustic environments to cue people to seek additional information. In contrast, notification focuses on how people interpret the warning message: it is the process by which people are provided with a warning message and information.

2. Available Alerting and Notification Tools and Technologies

2.1 Discussion

There are a number of alerting and notification tools and technologies available, some of which both alert and notify. Molino et al (2002) provide a summary worth considering in the context of Beaufort and flash flooding. Only those that can very quickly provide property owners and occupiers with an alert or notification have been considered herein due to the rapid response time associated with the creeks that impact on Beaufort.

A summary of available tools / technologies and their applicability to Beaufort is provided below.

- Those that alert only:
  - Sirens / alarms – good for small areas but do not alert those who live outside the immediate area
  - Aircraft – impractical due to time, weather and noise limitations
  - Modulating electrical supply voltage – frequent false alarms
  - Modulating electrical supply frequency (eg. NZ MeerKat system) – unlikely to be cost effective
  - Coded visual signals (cf. fire danger signs) – not practical due to rapid onset of flooding
  - Laser lights – health risks and high potential for theft of equipment
- Those that alert and notify:
  - Personal notification – impractical due to rapid onset of flooding and resources needed
  - Fixed and mobile public address systems – only serves immediate area
  - Tone alert radios – not cost effective for a small area
  - Dial-out systems and related technologies – worth considering
  - Enhanced dial-out system – similar to above but more expensive and reliant on local power supply
  - Paging and mobile phones – potential if local community is flood aware
- Those that provide notification only:
  - Mass media (radio, television) - already used, for example ABC radio (1026AM and 774AM)
  - Internet – Bureau website displays warnings[5] and data from rain and river sites[6] (not Beaufort specific)
  - FM-88 with community awareness program – wide application, needs to be managed and maintained

From the above it can be seen that while information about flooding is available to the community through the internet there is need to, as a minimum, alert the Beaufort community to the likely on-set of flooding so that they can obtain the necessary notifications.

The need to alert communities to flash flooding is not restricted to Beaufort. While a number of flash flood warning systems have been installed in NSW, the community alerting task in Victoria is a VICSES responsibility and, when time permits, is usually achieved via local radio announcements combined, when required, with an Emergency Alert (see below). Active alerting is only undertaken occasionally and generally involves door knocking and loud hailer street announcements.

In South Australia and Queensland, the Bureau of Meteorology alerts and notifies selected stakeholder agency staff using an SMS message system provided by StreetData. Within Victoria, many of the Councils involved in flood warning system upgrades in recent years have implemented Premier Global Services' Xpedite

[5] While the Bureau does not provide a flash flood warning service for the creeks in and around Beaufort, it does issue severe storm and thunderstorm warnings, phenomena that often lead to flash flooding in similar catchments.

[6] Rain and water level data from sites in adjacent catchments are updated approximately every hour or more frequently.

VoiceREACH system to alert and notify residents and property owners in flood-prone urban areas. Melbourne Water are piloting an in-house developed SMS alerting system for residents in an area subject to flash flooding alongside Brushy Creek in the City of Maroondah which is triggered by the exceedance of rain or water level alarm criteria[7].

Both Xpedite (www.premiereglobal.com.au/voicereach/voicereach_broadcasting.htm) and StreetData (www.streetdata.com.au) are available and operational within Victoria. Both use existing technology, are quick and effective, are relatively cheap to implement and maintain, but require good quality broadband internet access from the host computer. For either to be truly effective, the at-risk or target community needs to be flood aware.

A further system that has potential for application across a wide range of emergency situations, particularly flooding, is the (National) Emergency Alert (System). The system allows a user (eg. an emergency manager) to deliver a voice and text message to all telephone subscribers (landline and mobile) within an area[8], selected dynamically and in real-time. The Emergency Alert was used to good effect by VICSES to alert threatened communities during the January 2011 floods in Victoria.

2.2 Expedite VoiceREACH

A number of Councils within Victoria have had to address the issue of how best to alert their flood–prone urban communities to the on-set of flooding. In all cases (City of Greater Shepparton for Shepparton and Mooroopna, Latrobe City for Traralgon, Strathbogie Shire for Euroa, City of Benalla for Benalla, City of Maribyrnong for Maribyrnong Township, City of Greater Geelong for Moolap and Moira Shire for Nathalia) Premier Global Services' Expedite VoiceREACH system was selected to perform the alert and notify task. A formal flood warning service exists for all communities except Moolap. Moolap is a relatively small mixed residential and industrial area in Geelong which is subject to flash flooding. Some parallels can be drawn between Beaufort and Moolap.

VoiceREACH is simple to set up, implement, use and maintain. When flooding is likely, a message is scripted by Council staff and, following log-in (from any computer with broadband internet access) to the VoiceREACH website, is read into a file by the user. The message is confirmed via playback and either edited or accepted for transmission. On acceptance for transmission, VoiceREACH delivers the voice message almost simultaneously to all telephone numbers in the user-managed telephone number file[9] located on the VoiceREACH website.

VoiceREACH provides a message despatch report and delivers (by email to the user) a delivery success or failure report for each number in the telephone number file. This provides a template for follow-up door knocking or other personal approaches.

All Councils currently using VoiceREACH for flood alert and notification activate it manually. This could be a disadvantage to its use for Beaufort. While not confirmed, it is understood that VoiceREACH message delivery could be initiated by Environmon[10] through delivery of a pre-formatted voice file on triggering of a field station sensor alarm level. Environmon has the capability. The issue is whether VoiceREACH requires real-time interaction with the user. If not, automatic activation driven by river and rainfall alarms should be possible.

VoiceREACH has the potential to be used in a similar manner to alert at-risk residents and property owners in other areas of the Shire subject to periodic flooding or other hazards.

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[7] Melbourne Water and the City of Maroondah are also working with VicSES on the roll-out of a StormSmart program for residents affected by flash flooding along this reach of Brushy Creek. This has included helping pilot area residents develop personal residential flood response plans and the supply of fully equipped household flood kits.

[8] Landlines and mobiles where the billing address is in the affected area. The system is not yet able to send messages or calls to mobiles based on their actual physical location.

[9] The telephone number file is established and managed by the user. Numbers can be added and deleted online.

[10] Enviromon is a software package supplied and maintained by the Bureau of Meteorology. It runs on a local base station for a network of event report rain and / or stream gauge stations.

2.3 StreetData

StreetData offers an SMS delivery service[11]. The disadvantage of StreetData that it can only deliver an SMS message. This means that unless a telephone handset recognises SMS protocols, only mobile phone owners can receive the message[12]. Further, there is no guarantee of delivery, delivery is not necessarily immediate and there is no confirmation that the message has been received: it is essentially a "fire and forget" system.

When coupled with a network of event reporting rain (and steam) gauges and a local base station running the Bureau of Meteorology supplied and maintained Enviromon software package, StreetData can deliver a pre-scripted SMS message to a local user-maintained list of telephone numbers on the exceedance of alarm criteria on each sensor reporting into the base station. The alarm system operates on filtered rather than raw data which reduces but does not eliminate the opportunity for errors.

To set up the system, alarm criteria are set for each sensor, message scripts are develop and loaded to Enviromon and a StreetData account is opened. The Bureau has established a streamlined procedure with StreetData that makes this last step very easy. Essentially, all that is required is a credit card with which to purchase initial credits.

Enviromon can be set up to send the message to StreetData with a single, block of or all listed telephone numbers[13]. The Bureau recommends however that the message is sent to StreetData for each telephone number. This reduces the risk of message loss as, if there is a failure, only single, rather than many recipients fail to receive the message.

Enviromon can be configured to automatically drive the alerting process. It will monitor data from each sensor at each site[14] and can drop real time data into the pre-scripted messages.

StreetData credits expire at the end of 12-months unless further credits are purchased in which case they roll-over for a further 12-months. StreetData send a reminder email when credits are about to expire.

The Bureau is in the process of finalising documentation for the use of StreetData with Enviromon[15].

2.4 FM-88

FM-88 is used by a number of Councils to broadcast flood related warnings and information. The message is recorded from a normal PC onto a memory card which is then slotted into a control box at the FM-88 site. Control is then switched from the normal broadcast to the new memory card. A first step in initiating an FM-88 alerting system is to determine the availability of a local licence. Hardware, software, installation and commissioning follow.

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[11] There are a number of alternative SMS message service providers. Generally, these either have a higher minimum monthly spend or are domiciled outside Australia. StreetData has a flexible credits program that accommodates low usage without imposing a high cost and is fully based in Australia.

[12] This gap could be covered if flood wardens were appointed and given the responsibility of passing on information to groups of people without a mobile phone. Robyn Betts (OESC) suggested that flood wardens could also assist other community members in interpreting messages. Lack of time coupled with liability and other issues may mitigate against appointment of and utility of wardens.

[13] There is a limit of 250 telephone numbers per message.

[14] This enables both data and system alerts to be generated. For example, if any pre-set alert criteria were exceeded an SMS message could be sent to the Duty Officer to prompt activation of Xpedite to alert the community to potential (or actual) flooding. An SMS message could also be sent to the Duty Officer if there was no activity on a sensor over a set period, thereby assisting the Shire's monitoring of system integrity.

[15] Enviromon can accommodate other programs that initiate other actions provided that an interface is available or developed. This means that if the Pyrenees Shire wished to initiate a siren (say) on exceedance of alarm criteria, provided there was a program available to activate the siren and provided that an interface was prepared, the Enviromon alarm function could be used to sound the siren.

3. Considerations

There are a number of matters that would need to be addressed if a community alerting and notification system was to be established at Beaufort.

- A total system approach is required. The initiation of a community alerting and notification system would need to have regard for how other elements of the Total Flood Warning system are to be addressed.
- An on-going flood awareness program would be required. The Shire should consider discussing opportunities for a partnership for roll-out and maintenance with VicSES, perhaps in the context of StormSmart or FloodSmart.
- Recipients must understand the message they receive and be able to interpret it for the alerting and warning system to be effective. This extends to appreciating that responsibility for non-receipt of alerting messages rests with the individual and using all available information – environmental indicators, information on individual risk, Bureau warnings, etc.
- Community and Duty Officer awareness of flood risk and of system alerts would need to be established and maintained. This would include acceptance of responsibility within the community for individual flood damage reducing actions.
- Any alerting system established should be "opt-in"[16].
- If a telephone database was established it would need to be maintained. A process to assist this would need to be developed and implemented. Responsibility for this should, as much as possible, reside with individuals.
- There would need to be a routine test (monthly, annually?) of the system to confirm system integrity, ensure telephone numbers are correct and that the list is complete, and to maintain public awareness of flood risk and system alerting[17].
- Experience suggests that if the system is integrated with an event reporting data network, there would be some false alerts. While Enviromon tests filtered data against the alarm criteria some erroneous data is not flagged as such until after receipt of new data. This would only occur after alerts had been sent out. There would need to be an understanding of and process for handling false alerts, within Council, VicSES and the community.
- Flood risk cannot be eliminated. Promote good examples (eg. NSW FloodSafe program for businesses and for residents, Brisbane City Council's BeFloodWise, etc) of community level risk management strategies.

4. References

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[16] The Greater City of Shepparton, Latrobe City, City of Greater Geelong and Moira Shire initiated robust "opt-in" processes, any of which would work well for Beaufort.

[17] The most recent system test at Shepparton was preceded by a letter and questionnaire aimed at reminding people about the system, alerting them to the test and soliciting information about their reaction to the test and system.