Beaufort Linear Park Master Plan

Concept Design

August 2024

Pyrenees Shire Council

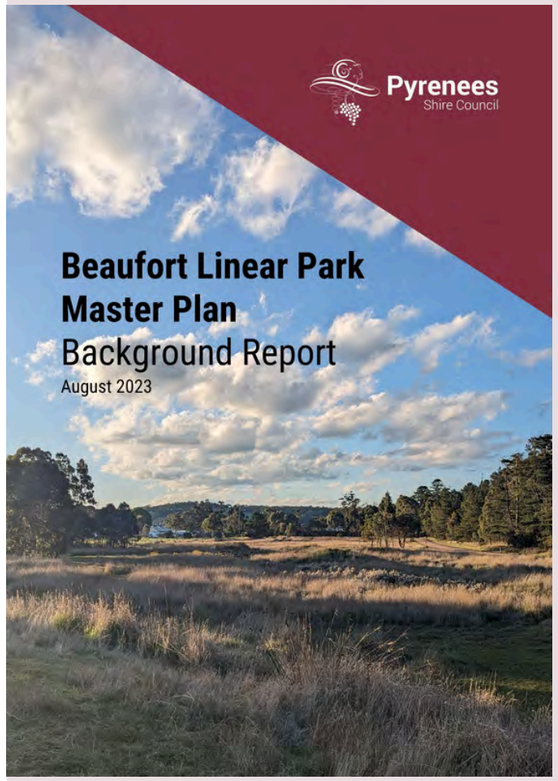
The Pyrenees Shire is located on the traditional lands of the Wadawurrung, Dja Dja Wurrung, Wotjobaluk and Eastern Maar Peoples. Beaufort is located on Wadawurrung country which stretches from the Great Dividing Range of Ballarat, to the coast from the Werribee River to Mangowak (aireys Inlet), including Djilang (Geelong).

We pay our respects to the customs, traditions and stewardship of the land by the Elders past and present and emerging leaders, and the people of these tribes.

Pyrenees Shire Council

emerge ASSOCIATES

Contents



Background Report

This masterplan should be read in conjunction with the Background Report.

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Location

Lexton

Beaufort-Lexton Rd

Yam Holes Creek

Camp Hill

Ararat

Ballarat

Western Highway

Trawalla State Forrest

Beaufort Reservoir

Skipton Rd

Skipton Rd

Skipton

Major road

Access points

Site extent

Creekline

Railway line

Executive Summary

The Project

Develop a Master Plan for a new linear park along the Garibaldi Creek which runs north-south from Beaufort Lake in the south to the railway line in the north.

The project has been initiated by Pyrenees Shire to improve the township and natural environment of Beaufort and provide opportunities for the local community and tourists to walk, cycle, learn and gather along the restored waterway.

The location of the creek and open space corridor provides an exciting opportunity to draw visitors into the regenerated environment, celebrate the waterway and connect to other destinations including the town center and Camp Hill.

An extensive hydrological analysis comparing the existing and proposed conditions has been conducted as part of the master planning process to ensure the recommendations in the master plan are achievable and have a positive influence on biodiversity and habitat values without compromising the risk of flood. The proposed condition hydrology report shows an opportunity to reduce flood risk at the old school oval.

See Appendix A hydrological report

Partnering with Traditional Owners

The project has been designed with a commitment to Traditional Owner engagement. Wadawurrung Traditional Owerns Aboriginal Corporation has been intrinsic to the successful outcome of the masterplan; representatives were involved with the project control group (PCG) meetings as well as providing insight into biodiversity and land management challenges for the site.

Partnering with the Community

The project has been designed along side the community and there have been multiple opportunities for stakeholders to provide their ideas for for the site. These opportunities included -

- online surveys
- pop ups at the playground and the local supermarket
- walking tour
- community workshop
- discussions with traditional owners
- meetings with local businesses, schools and service clubs
- informal drop in conversations in the town center

For more detail refer Background Report

What we heard

Key Themes

Keep a natural feel and improve the environment

Flooding is a concern for the area

Walking and cycling trails are very important and can also connect to surrounding destinations

Make sure it is safe and well maintained

We need good signs to direct residents and visitors

We need somewhere for dogs off leash (although some feedback opposed a designated area)

We like to see art in the landscape and to draw people to a destination

What about other recreation activities like a pump track, disc golf or an obstacle course

We'd like to see mostly native vegetation

Attract visitors to appreciate and learn about the environment

Objectives

Vision

To create an ecological and recreational corridor along the course of the Garibaldi Creek to connect Beaufort, improve water quality, biodiversity, community health and wellbeing.

Principles

Four principles have been identified as key values that apply across all directions, objectives and actions.

- Community health and wellbeing
- Collaboration with Traditional Owners
- Community parnerships
- Sustainability

Directions

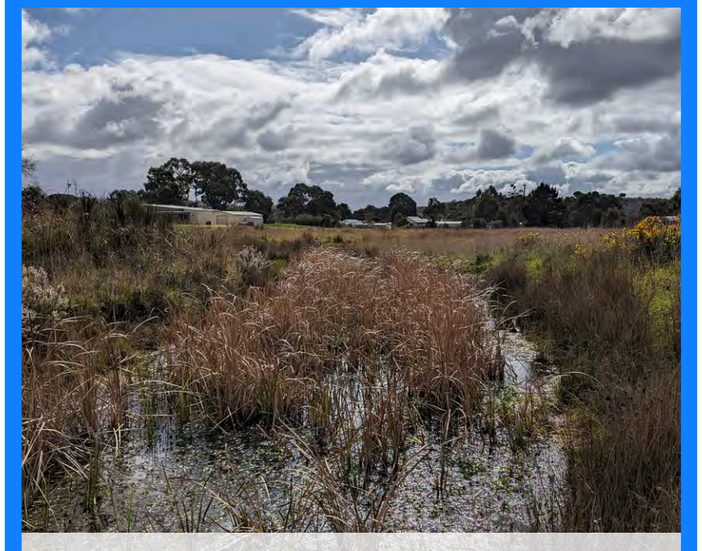
Improved connectivity and movement

- Clear wayfinding and sense of arrival
- Strong walking and cycling connections
- Improved access and safety

Enhanced landscapes

- Sustainable management
- Strengthen local environment & sense of place
- Encourage social and nature connection

Healthy and valued waterways



- Celebrate the Garibaldi Creek and its catchment
- Improve biodiversity and water quality
- Mitigate and adapt to flooding

Masterplan Concept Design

Pyrenees Shire Council

Masterplan Overview

The Beaufort Linear Project is a unique opportunity for Beaufort to engage with Integrated Water Management (IWM) practices and work towards a more sustainable and climate-resilient future.

The master plan unites the community's needs for connectivity and improved well-being with the environment's needs to enhance water quality and improve wildlife habitat. In the past, we saw urban waterways as drains and wastelands; the Beaufort Linear Project embraces the waterway as a valued part of the community, a place to play, relax, and ride, while connecting with the cycles of nature. The design expands on the path network and leisure activities of the Goldfields Reserve and builds a direct link to the playground and skate park.

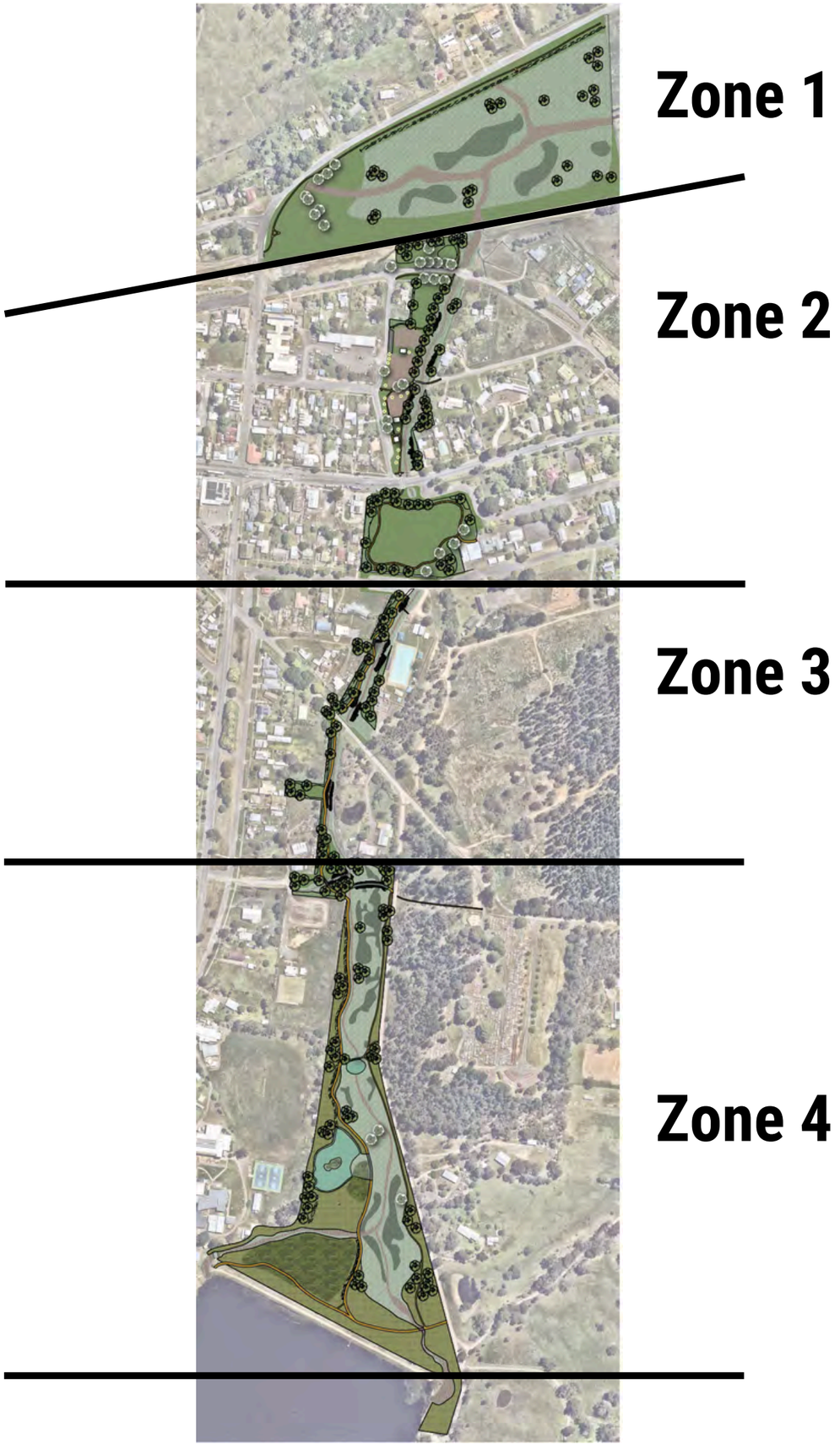
The master plan is divided into four design zones:

Zone 1
Regeneration of the Yam Holes Creek and flood plain creating a welcoming entrance to the town from Albert Street.

Zone 2
Activity hub with improved play and skate facilities

Zone 3
Habitat link and pedestrian/cycle corridor (linking north with south).

Zone 4
Regeneration of the Garibaldi Creek and connection to the Goldfield Recreation Reserve



Zone 1


Small picnic grounds
Albert Street
Boardwalk
Rail line
Connection to town / Camp Hill
Swale
Gravel Paths (Shared Path 3m/ Pedestrian Path 1.5m)
Low Flow (creek centre line)
Waterway
Wetlands (low depressions)
Rough Mown (native grass)
Road crossing to be considered in detail design (traffic engineer)
Existing Tree
Local Indigenous Tree
Exotic Tree
0 10 20 30 40 50 M

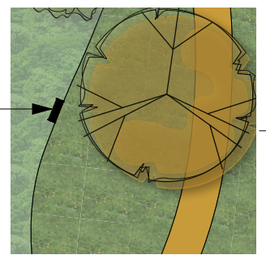
Zone 2

Existing shed to be repurposed as a shelter and seating area.
Vic Rail to be consulted on this option.

Proposed Parking

Existing shelter

Existing toilet



Bench seating located away from paths (to relax and take in the views)

Old school oval to be regraded and drained to form effective passive irrigation to open space

0 10 20 30 40 50 M

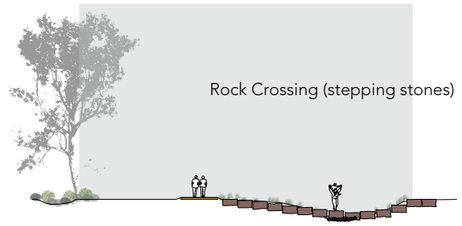
- Swale
- Proposed Play Space
- Gravel Paths (Shared Path 3m/ Pedestrian Path 1.5m)
- Concrete path (link to existing path network)
- Low Flow (creek centre line)
- Waterway
- Mix Shrub Planting
- Rough Mown (native grass)
- Concrete Crossovers (high flow water coverage)
- Mudstone embankment stabilisation
- Road crossing to be considered in detail design (traffic engineer)
- Existing Tree
- Recent Tree Planting
- Local Indigenous Tree
- Exotic Tree

Dog Off Lead Options

Option A Positioned on the councils land is an advantage of this option. However, it is adjacent to private property (not ideal due to noise and dog ownership). This location also reduces the lawn area and openspaxce available for general use.

Option B Utilising land that is currently underused and its position at the northern most end of the site ensures that the dog park will not encroach on other park uses. However, the land is under Vic Track ownership and will require agreements to the negotiated with council

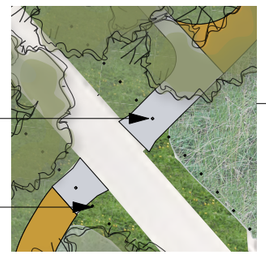
Zone 3



Rock Crossing (stepping stones)

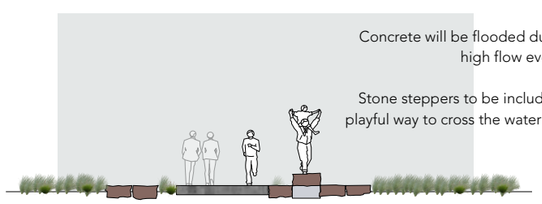
Pedestrian Bridge

Concrete path (link to existing path network)



Removable bollard for maintenance access

Timber Bollards



Concrete will be flooded during high flow events.

Stone steppers to be included a playful way to cross the water way.

Pocket Park - care to be taken to endure passive surveillance including sight lines and lighting

Pedestrian Bridge

- Swale
- Gravel Paths (Shared Path 3m/ Pedestrian Path 1.5m)
- Concrete path (link to existing path network)
- Low Flow (creek centre line)
- Waterway
- Mix Shrub Planting
- Rough Mown (native grass)
- Concrete Crossovers (high flow water coverage)
- Mudstone embankment stabilisation
- Road crossing to be considered in detail design (traffic engineer)
- Local Indigenous Tree

0 10 20 30 40 50 M

Zone 4

Pedestrian Bridge

Rural (6 wire strand) fencing to delineate school grounds Lineal Project

Existing dam

Rock seating / gathering Place

- Water Body
- Swale
- Gravel Paths (Shared Path 3m/ Pedestrian Path 1.5m)
- Concrete path (link to existing path network)
- Low Flow (creek centre line)
- Waterway
- Wetlands (low depressions)
- Woodland
- Mix Shrub Planting
- Rough Mown (native grass)
- Existing Tree Planting
- Concrete Crossovers (high flow water coverage)
- Mudstone embankment stabilisation
- Road crossing to be considered in detail design (traffic engineer)
- Existing Tree
- Local Indigenous Tree

Key Directions

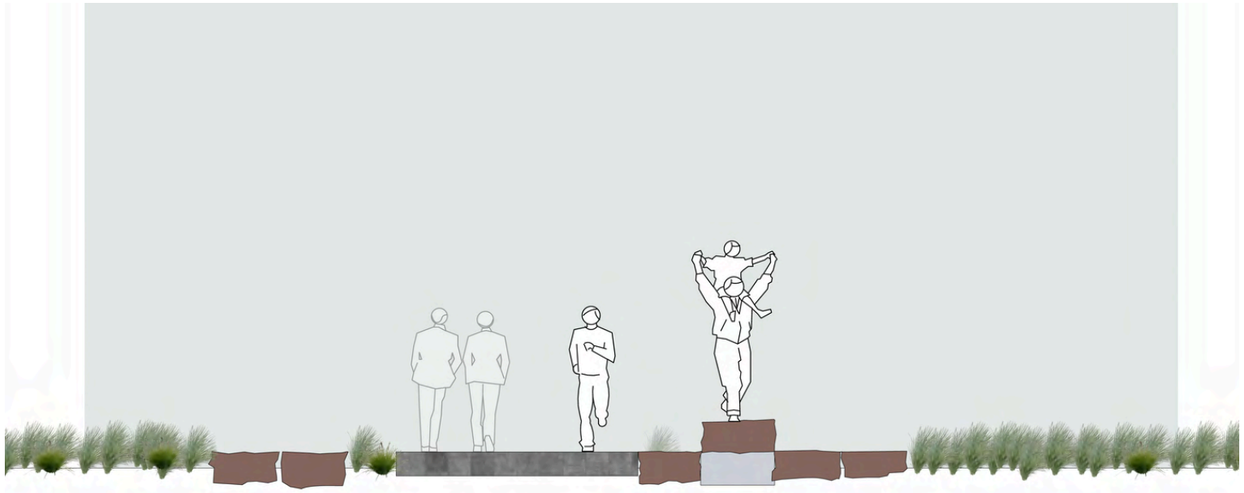
Pyrenees
Shire Council

Improved connectivity and movement

Improved access and safety

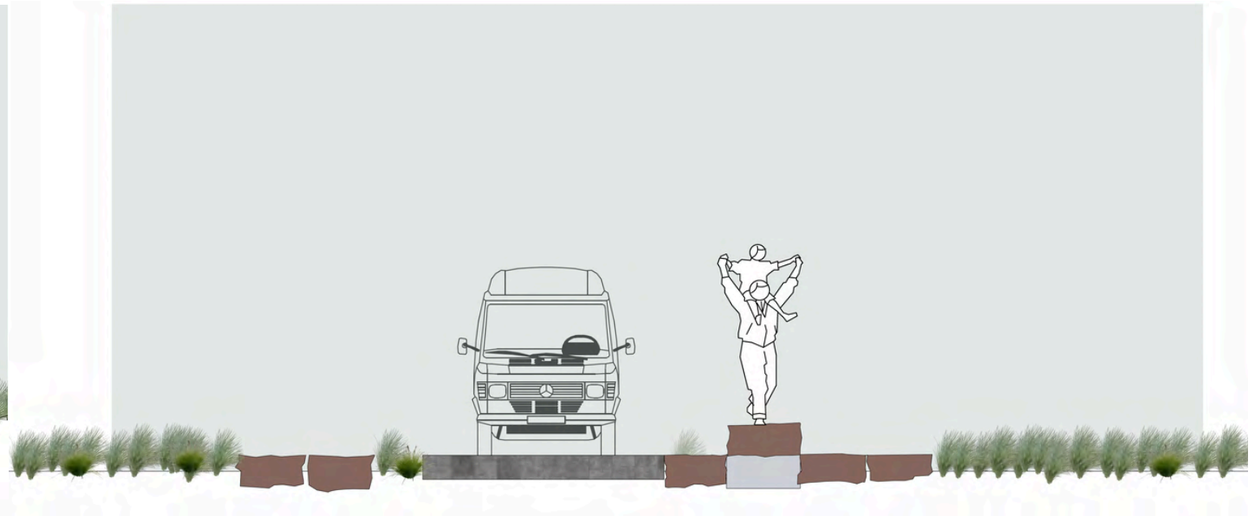
Currently the site has no path access, is poorly maintained and feels unloved and potentially unsafe for visitors.

The master plan recommends landscaping and trails that respond to the characteristics of the site. The proposed trails have been designed to ensure there is a clear line of site with appropriate adjacent vegetation including mown zones and absence of bushy shrubs where appropriate. Transitioning the overgrown drainage line, that lies at the back of properties, into a popular walking/cycling destination will bring activity, surveillance and safety for the community.



Concrete floodways are used to cross areas of frequent flooding
Stepping stones provides a playful way to cross the waterways

The use of wide shared paths within isolated sections of the project maintain clear sight-lines, improving safety and surveillance.



Extra wide shared paths allow for safe use and movement for multiple users including cycling, mobility scooters, jogging and pedestrians. The width also provides access for service and maintenance vehicles to ensure ease of site maintenance.

Strong walking and cycling connections

The master plan aims to provide a clear walking and cycling connection not only through the subject site but also to other trails further afield including the existing trails around the reservoir, Camp Hill trails, Beaufort town centre and Trawalla State Forest. There are some significant physical barriers that the master plan proposes to address, to improve connectivity such as intersection of the highway through the park, the railway line and highway to the north of the site.

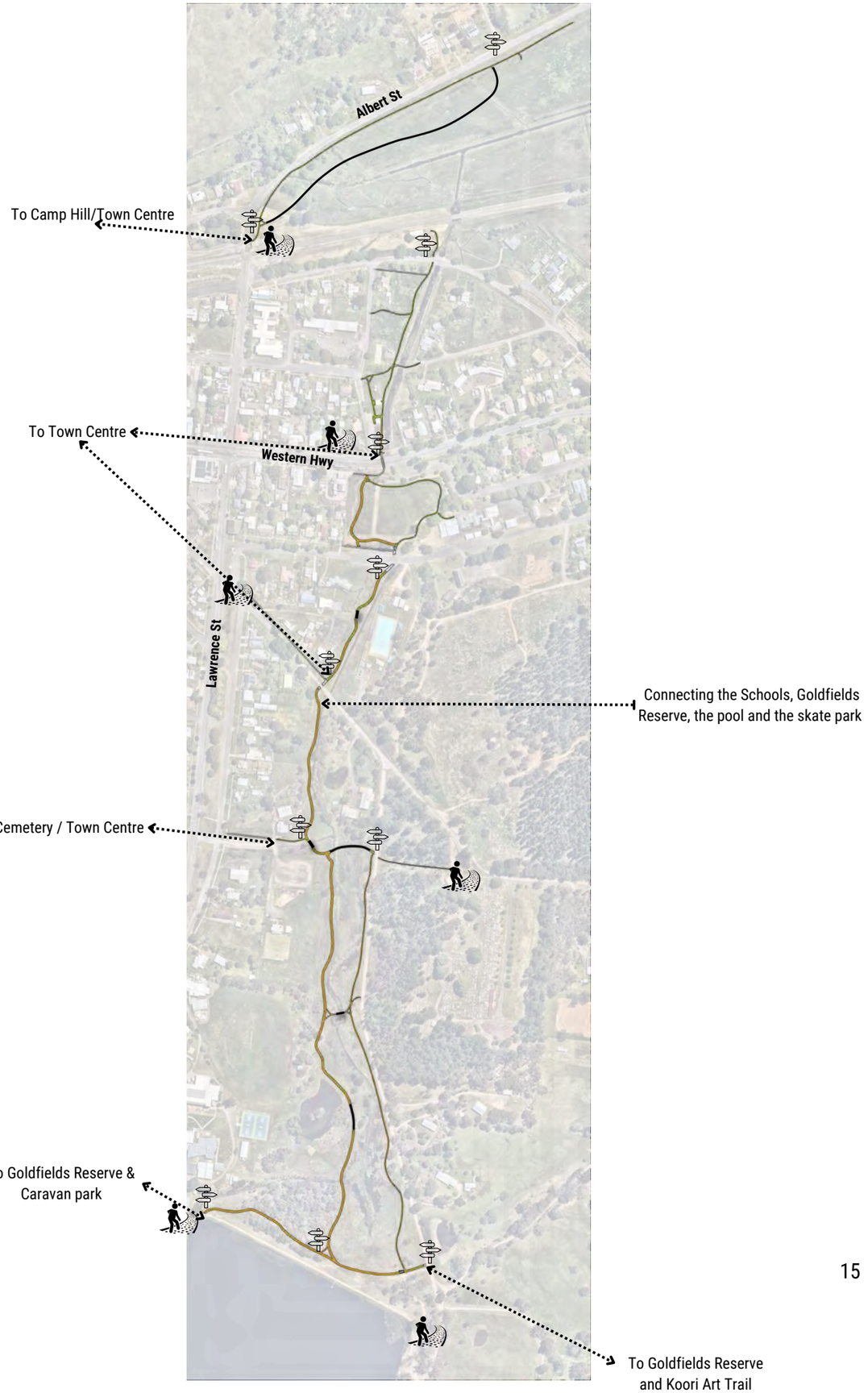
The proposed trails have been designed to respond to the sensitivities of the site with wider trails where increased activity is predicted and narrower trails where alternatives routes for cycling are available.

Clear wayfinding and sense of arrival

The master plan guides opportunities to articulate the location of the linear park, the activities available and the broader connections. The design concept highlights the arrival points to the linear park.

Way finding information to include but not limited to -

- Directions and distance to key attractions
- Interpretive signage - on plants and wildlife
- Interpretive single on history and heritage
- Alternative routes



Enhanced landscapes

Sustainable Management

The master plan acknowledges the challenges of numerous land owners and management models along the subject site. The structure of the masterplan, with identified landscape types, provides an opportunity for all land owners and managers to work together to revitalise this valuable site, improve the environment and bring the community together.

All recommended actions are underpinned by environmentally sustainable design principles and reflect policy directions already identified in existing Council strategies. The design reflects these principles and has not recommended new infrastructure where it is not important. Materials, species and approaches selected have low ongoing maintenance requirements. Regenerative approaches to landscape management, in landscape types 1 and 2, are designed to minimise weed incursion, and will be largely self sustaining after establishment.

Collaborative management is vital to the park's ongoing success. A collaborative management team; including Council staff, the local community, bush regeneration practitioners, and Traditional Owners is critical.

Encourage Social and Nature Connection

The proposed design will create spaces for the community to play, experience nature, get together to socialise or celebrate, and for exercise such as walking or cycling.

In the areas identified as landscape type 3, the master plan proposes improved play opportunities including an expanded skate park, new junior pump track, and eventually, a refurbished playground. These expanded facilities will be supported by social seating and comfortable gathering spaces.

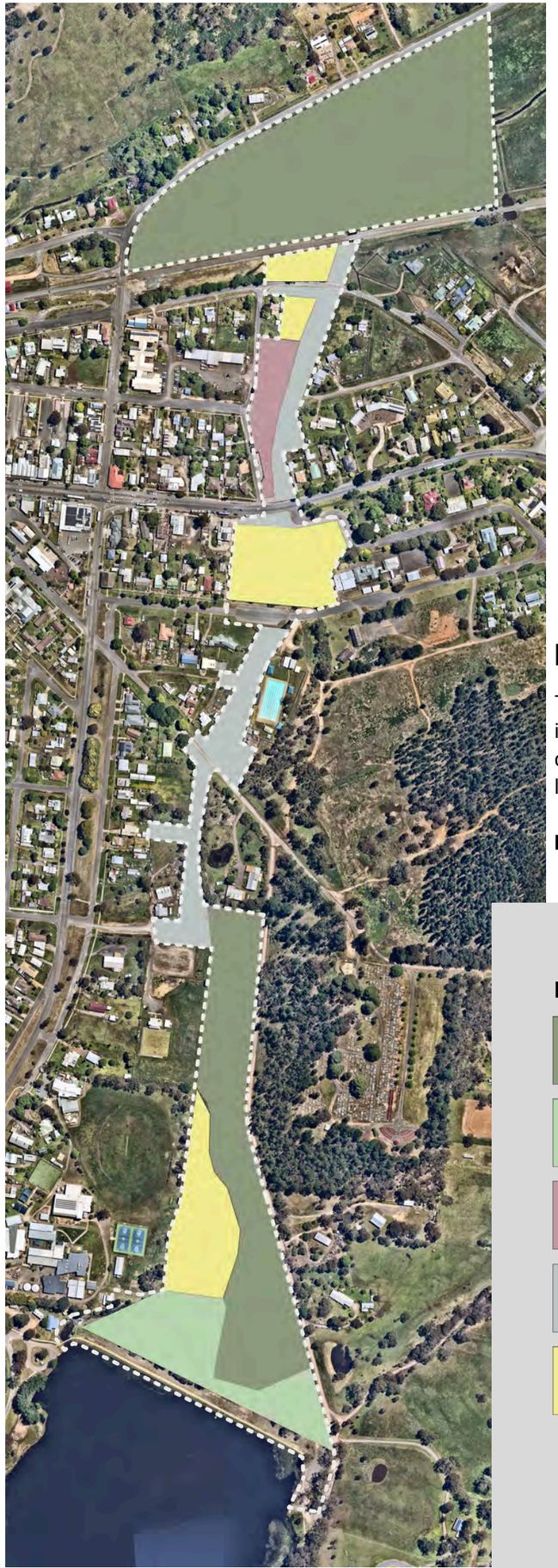
The natural areas throughout the site will be welcoming to the community to explore and connect with nature. The landscape type 4 area, in particular, focuses on bringing people into the landscape and restored waterway.

The special use areas (landscape type 5) have been identified specifically to create opportunities for collaborative placemaking. These spaces offer flexibility for the community to use the space as they need, and collaborate to determine their use on an ongoing basis. The plan proposes consideration of an area for off-leash dogs, and a space for events, as examples of potential uses. This approach seeks to create a sense of ownership of the space and connection within the community.

Strengthen Local Environment and Sense of Place

The master plan proposes a uniquely Beaufort approach to revitalise the site, which is currently underutilised and in poor condition. The creek, a regionally significant waterway, also runs through the middle of the town connecting the lake the town centre.

Species, materials and designs proposed in the master plan reflect the local community and the history and landscape of the surrounding area. This approach, when established, will make a significant positive contribution to the town of Beaufort. A lush, green, natural landscape will be woven through the town in a way which invites people to explore, move and enjoy.



Landscape Types

To create a uniquely Beaufort landscape and to clearly identify the approach, design and ongoing requirements of the different spaces within the site, five different landscape types have been identified.

Each landscape type is described on the following pages.

Legend

- ***Landscape Type 1***
  Regeneration - Damp Sand - Herb rich woodland
- ***Landscape Type 2***
  Regeneration - Lower Slopes/Hills Woodlands (grassy)
- ***Landscape Type 3***
  Recreation Activity Area
- ***Landscape Type 4***
  Natural recreational waterway
- ***Landscape Type 5***
  Special Use

Landscape Type 1

Regeneration Damp Sand - Herb rich woodland

Overview

Within the natural flood plains of Beaufort, the pre-colonial vegetation type was a Herb Rich Woodland with riparian vegetation growing adjacent to the waterways (Garibaldi Creek).

The vegetation is typified by the open woodland canopy of Manna and Swamp Gum, a shrub layer and a rich ground layer of herbs, grasses, and orchids. Remnant examples of this vegetation type can be found within the adjacent Goldfield Recreation Reserve.

Rationale

The Garibaldi Creek receives increased stormwater runoff from the hard surfaces of the town (roads, paths, and roofs). The excess water increases the flow of the creek, and the surrounding soil remains wet for longer. In areas where the soil remains moist for extended periods, riparian vegetation is most appropriate, and will thrive in these conditions.

Strengthen Local Environment and Sense of Place

The intention for the landscape type 1 is to regenerate the landscape to resemble a pre-colonial condition and if practical propagate from local plants to preserve genetic makeup of local populations.

Encourage Social and Nature Connection

The regeneration areas provide the community and visitors with an opportunity to engage with nature, though walking and cycling, places to sit, as well as take part in the activity of bush regeneration. Regenerating and healing the landscape is an ongoing commitment that requires the community to work with council, Landcare groups and Traditional Custodians to develop a sense of stewardship of the waterway.

Sustainable Management

The regeneration process includes two main phases; initiation and perpetual.

Initial phase 2-5 years

- Control of existing invasive plant species – with minimal disturbance to soil and native vegetation
- Revegetation of local indigenous species – if practical genetic stock to be selected local to the Beaufort region

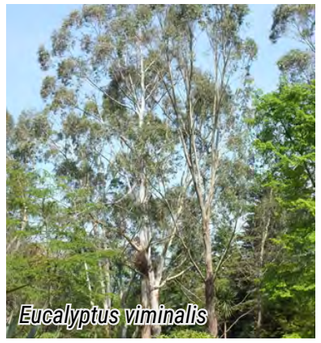
Perpetual phase

- Control of new invasive species as required (expected to be minimal)
- Custodianship activities that may include:
  - Cool burning (patchwork)
  - Slashing (patchwork)
  - Repair / revegetation after significant disturbance events

Species


Herb Rich Grassy Understory


Acacia verticillata


Eucalyptus viminalis


Pultenaea gunnii


Brunonia australis


Thelymitra macrophylla


Pimelea humilis


Juncus pallidua

Materials

Landscape Type 2

Regeneration - Hills Woodlands (grassy)

Overview

The vegetation in landscape type 2 is similar to the grassy woodland of Camp Hill and characterised by a sparse shrub layer and a rich ground layer of herbs, grasses, and orchids.

Rationale

The areas adjacent to the water way will remain slightly dryer, the plants of the Hills Woodlands are adapted to short periods of inundation and long periods of drought. By using plant species that respond to the location, climate resilience is built into the landscape.

Strengthen Local Environment and Sense of Place

The intention for the Landscape Type 2 is to regenerate the landscape to resemble a pre-colonial condition and if practical propagate from local plants to preserve genetic makeup of local populations.

Encourage Social and Nature Connection

The regeneration areas provide the community and visitors with an opportunity to engage with nature, though walking and cycling, places to sit, as well as take part in the activity of bush regeneration. Regenerating and healing the landscape is an ongoing commitment that requires the community to work with council, Landcare groups and Traditional Custodians to develop a sense of stewardship of the water way.

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- Control of new invasive species as required (expected to be minimal)
- Custodianship activities that may include:
  - Cool burning (patchwork)
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  - Repair / revegetation after significant disturbance events

Species


Pultenaea pedunculata

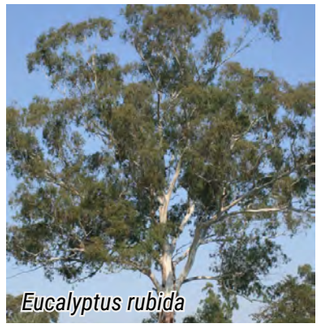

Acacia melanoxylon


Melaleuca


Pimelea humilis


Ozothamnus obcordatus


Leptospermum continentale


Eucalyptus rubida


Drosera Whittakeri

Materials

Landscape Type 3

Recreation Activity Area

Overview

Landscape type 3 is a traditional active recreation park area. There is an existing fenced playground with an adjacent picnic area/shelter and public toilets. Further north there is a skate park and play equipment for older children.

Rationale

The master plan builds on the existing character and proposes upgrades to the play and skate infrastructure as well as the addition of a junior pump track. The design and layout of the additional infrastructure will ensure that there are flexible open spaces for picnics or informal lawn games along with the connecting trails.

Strengthen Local Environment and Sense of Place

Species have been selected to compliment the park and play style landscape with a mixture of exotic and native species that provide shade and amenity while ensuring passive surveillance sight lines.

Sustainable Management

This area will continue to be managed by Council as part of the standard park, playground, skate and public toilet maintenance regime including regular audits and inspections. Lawn areas will be mown and trees pruned in line with standard park landscape maintenance.

The proposed additional pump track and expanded skate park are low maintenance, hard surface amenities which are not anticipated to increase the maintenance requirements substantially.

Encourage Social and Nature Connection

This area will continue to attract families and children of all ages to gather, play and participate in challenging activities such as skateboarding or biking. This area will have something for everyone and will continue to attract groups for parties or neighbourhood get togethers. The connecting trails will allow families to walk or ride to this active recreation node.

Species


Eucalyptus sp


Ozothamnus obcordatus


Eucalyptus sp


Eucalyptus sp

Community Use

Materials

Landscape Type 4

Natural Recreational Waterway

Overview

The waterway will be ‘naturalised’ from it’s current state as an open drain. The edges of the channel will be softened with riparian vegetation and constructed rocky outcrops. Sections will be widened to allow for temporary pooling during storm events. The adjacent path network will wind its way along the creek to activate and provide access to the waterway with pause points to sit and enjoy the landscape.

Rationale

Naturalising the channelised waterway will improve water quality though vegetation filtration and aeration, and water flow rates will be slowed to increase soil absorption and mitigate flash flooding. A reconstructed Garibaldi Creek provides opportunities for improved habitat and ecology, providing visitors and the Beaufort community with an opportunity to connect with nature.

Strengthen Local Environment and Sense of Place

The intention for the landscape type 4 is to regenerate the landscape to resemble a pre-colonial condition and, if practical, propagate from local plants to preserve the genetic makeup of local populations.

Encourage Social and Nature Connection

The regeneration areas provide the community and visitors with an opportunity to engage with nature, though walking and cycling, places to sit, as well as take part in the activity of bush regeneration and waterway management. Regenerating and healing the landscape is an ongoing commitment that requires the community to work with council, Landcare groups and Traditional Custodians to develop a sense of stewardship of the water way.

Sustainable Management

The regeneration process includes two main phases; initiation and perpetual.

Initial phase 2-5 years

- Control of existing invasive plant species – with minimal disturbance to soil and native vegetation
- Revegetation of local indigenous species – if practical genetic stock to be selected local to the Beaufort region

Perpetual phase

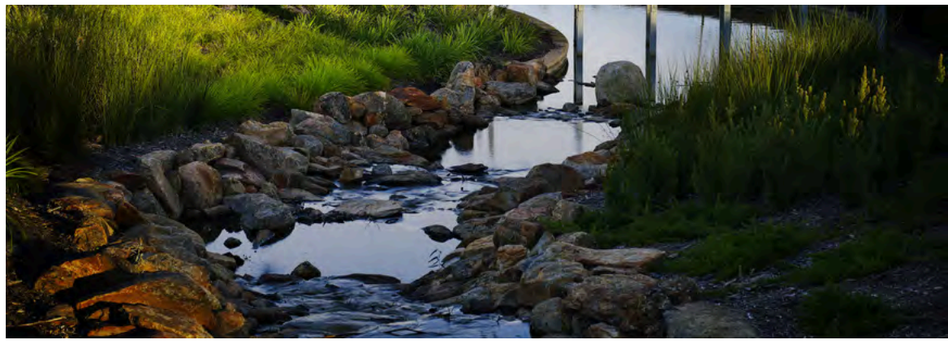
- Control of new invasive species as required (expected to be minimal)
- Custodianship activities that may include:
  - Cool burning (patchwork)
  - Slashing (patchwork)
  - Repair / revegetation after significant disturbance events

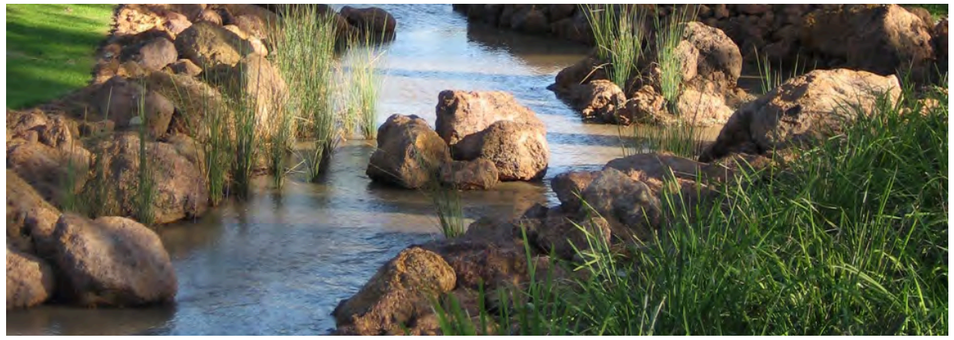
Species


Poa labillardierei


Xerochrysum palustre


Carex appressa






Craspedia paludicola


Ficinia nodosa

Materials

Landscape Type 5

Special Use

Overview

These areas have been identified for multipurpose community and special event use. To allow for maximum flexibility the space is to be open, largely grassed, with few trees, and mostly flat to gently undulating. The grass to be a rough mown, biodiverse mix of native grasses with buffer planting of mixed native and/or exotic shrubs (woody meadow type planting to reduce maintenance and increase biodiversity).

Rationale

Apart from sporting ovals, Beaufort lacks open grassy areas to host community gatherings and events including farmers markets, festivals, concerts and for informal activities such as Disc Golf. The aim of the special use areas are to provide opportunities for future uses to be explored and community lead placemaking to take place.

The special use areas have an additional storm water management role. The scale of the open space and the proximity to Garibaldi Creek allows for flash flood events to spread out across the landscape in a controlled way to mitigate flooding in built up areas.

Strengthen local environment and sense of place

The grass to be rough mown, biodiverse mix of native grasses with buffer planting of mixed native and/or exotic shrubs (woody meadow type planting to reduce maintenance and increase biodiversity). This approach will create a softer, more natural look, which is similar to the landscapes surrounding Beaufort, including at the Camp Hill lookout.

Encourage Social and Nature Connection

The special use areas are to encourage the local community to take part in 'place making' providing them with the flexibility to use they space as they need, providing a sense of ownership of the landscape and connection with the community.

Sustainable Management

The open grassy areas are to be managed though slashing and when appropriate the slashing may be suspended to allow for the native grasses to set seed.

The intention of the shrub buffer plantings is to be as low maintenance as possible and utilise a combination traditional park management with regenerative practice including coppicing.

Potential Functions

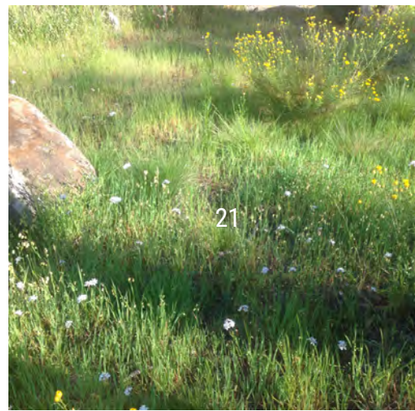

Biodiverse rough mown grass


Ozothamnus obcordatus


Eucalyptus sp


Eucalyptus sp

Materials



Healthy and Valued Waterways

Improve Biodiversity and Water Quality

Swales

Swales are shallow, vegetated open channels that convey and treat stormwater. They are typically planted with grass or sometimes more dense vegetation to filter runoff.

Swales initially immobilise pollutants by binding them to organic matter and soil particles, then remove them by settling, filtration and infiltration into the subsoil. Certain pollutants, such as hydrocarbons, may be digested and processed by soil microorganisms in the ground as the water filters through.

The park site already has an extensive network of swales. The proposal is to revegetate these, turning them into 'vegetated swales' or 'bioswales' where appropriate.

Vegetated Swales

A vegetated swale is an open channel with sloping sides which has been planted with native wetland and damp land species.

Vegetated swales are utilised in the master plan to:

- Protect paths from washing out during storm events
- Provide passive irrigation to the surrounding landscape by holding water in the soil and distribute it to adjacent trees and vegetation.

Bio Swales

Bio-swales are similar to vegetated swale but have been constructed to manage a higher volume of storm water through installation of underground filtration structures and soils.

Bioswales are utilised in the master plan to:

- Mitigate flash flooding of the Garibaldi Creek by diverting and delaying stormwater from reaching the creek during severe storm events
- Improve water quality by allowing plants and soil organisms to filter out pollutants and purify storm water before reaching the waterway.

Wetlands and Waterways

Wetlands are shallow water bodies permanently or periodically inundated. Many areas throughout Beaufort Linear Park currently act as wetlands.

Revegetated Wetland

Additional vegetation will help these areas to retain much of the stormwater flow before slowly discharging it through natural aquatic vegetation to reduce sediment and improve water quality.

Revegetated wetlands are utilised in the master plan to:

- Improve water quality by allowing plants and soil organisms to filter out pollutants and purify storm water before reaching the waterway
- Slow water velocity to increase infiltration
- Mitigate downstream erosion and flash flooding
- Increase habitat for wetland and riparian species

Naturalised Waterway

Beaufort Linear park currently has extensive open drains running the length of the site connecting Yam Holes Creek to the Beaufort Reservoir.

Re-naturalising the channels will restore the creek meander, slow storm water velocity, reduce erosion, aerate and improve water quality and create habitat. This process involves the construction of low flow rock line creek and rock bank stabilisation as well as revegetation and will:

- Improve water quality, by aerating the water as it flows over and between the rocks
- Slow water velocity, to increase infiltration and reduce erosion
- Provide habitat for small fish, insects and invertebrates
- Stabilise and protect the bank at constructed meander points
- Increase the meander of the creek to slow velocity
- Make the creekline look more attractive, welcoming for people, and create an opportunity to use the creek as a recreation experience (nature play)

Mitigate and Adapt to Flooding

Detention Basin

Detention (or 'retarding') basins are dam-like depressions designed to detain large stormwater flows immediately after a storm, then release it slowly downstream. The proposed basins do not hold water for long periods, but they do help to prevent flash flooding and to protect assets after storms.

Location of WSUD elements

Zone 1

Note: In isolation the WSUD elements do not have a measurable effect on flood risk, however work with flood mitigation measures to assist in climate resilience.
For an example of flood mitigation opportunities see Appendix A

Swales (including Bio-swales)

-Increase soil infiltration of surface runoff
-Provides passive irrigation to adjacent landscape
-Mitigates down stream flash flooding (disrupt the stormwater flow and velocity reaching Yam Holes creek)
-Protects gravel paths from washing out from surface runoff

Low Flow (creek centre line)

-Rock lining - reduce flow velocity, increase flow aeration and increase habitat
-Increased meander - slow flow velocity and improve the natural aesthetic of the creek

Waterway

-Increase meander Increased meander, slow flow velocity and improve the natural aesthetic of the creek
-Regenerative planting of riparian species, improves water quality and habitat

Mudstone Embankment Stabilisation

-Bank stabilisation
-Increase water aeration
-Provide habitat

Wetlands (low depressions)

-Existing depressions act as functioning natural wetlands
-Vegetation improves water quality, slows runoff and improves habitat
-Natural depressions mitigate down stream flash flooding

Passive irrigation (old school oval)

Re-grading the old school oval to slow runoff will provide passive irrigation to the lawn area and proposed trees and garden beds

Zone 2

Location of WSUD elements

Zone 3

Swales (including Bio-swales)

-Increase soil infiltration of surface runoff
-Provides passive irrigation to adjacent landscape
-Mitigates down stream flash flooding (disrupt the stormwater flow and velocity reaching Yam Holes creek)
-Protects gravel paths from washing out from surface runoff

Low Flow (creek centre line)

-Rock lining - reduce flow velocity, increase flow aeration and increase habitat
-Increased meander - slow flow velocity and improve the natural aesthetic of the creek

Waterway

-Increase meander Increased meander, slow flow velocity and improve the natural aesthetic of the creek
-Regenerative planting of riparian species, improves water quality and habitat

Concrete Crossovers (high flow water coverage)

-Provide vehicle and pedestrian access during dry periods.
-Allows unimpeded flow during high flow and flood events

Mudstone Embankment Stabilisation

-Bank stabilisation
-Increase water aeration
-Provide habitat

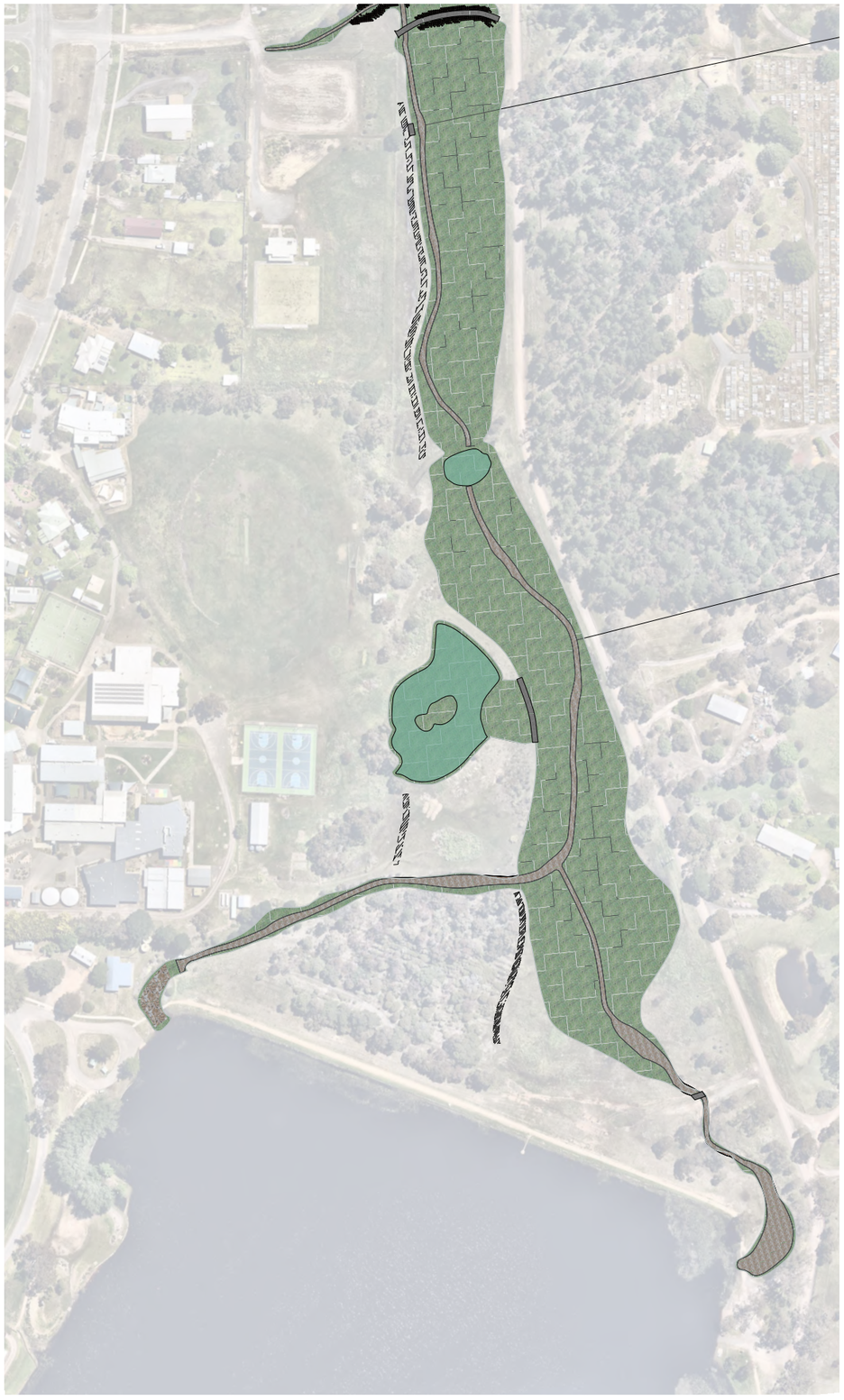
Wetlands (low depressions)

-Existing depressions act as functioning natural wetlands
-Vegetation improves water quality, slows runoff and improves habitat
-Natural depressions mitigate down stream flash flooding

Existing Dams

-Capture and hold stormwater runoff
-Migrate down stream flash flooding
-Aesthetic feature

Zone 4

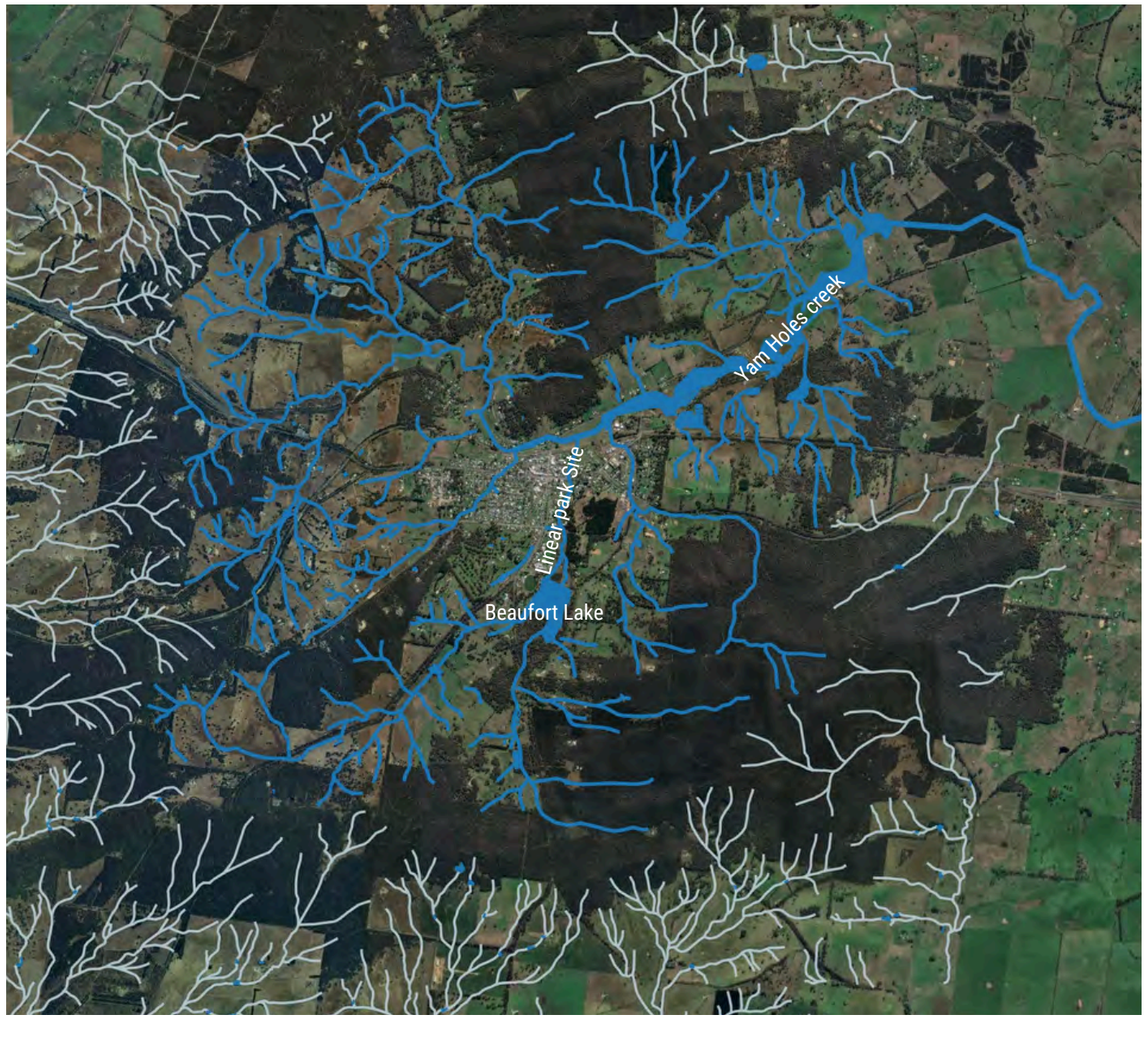


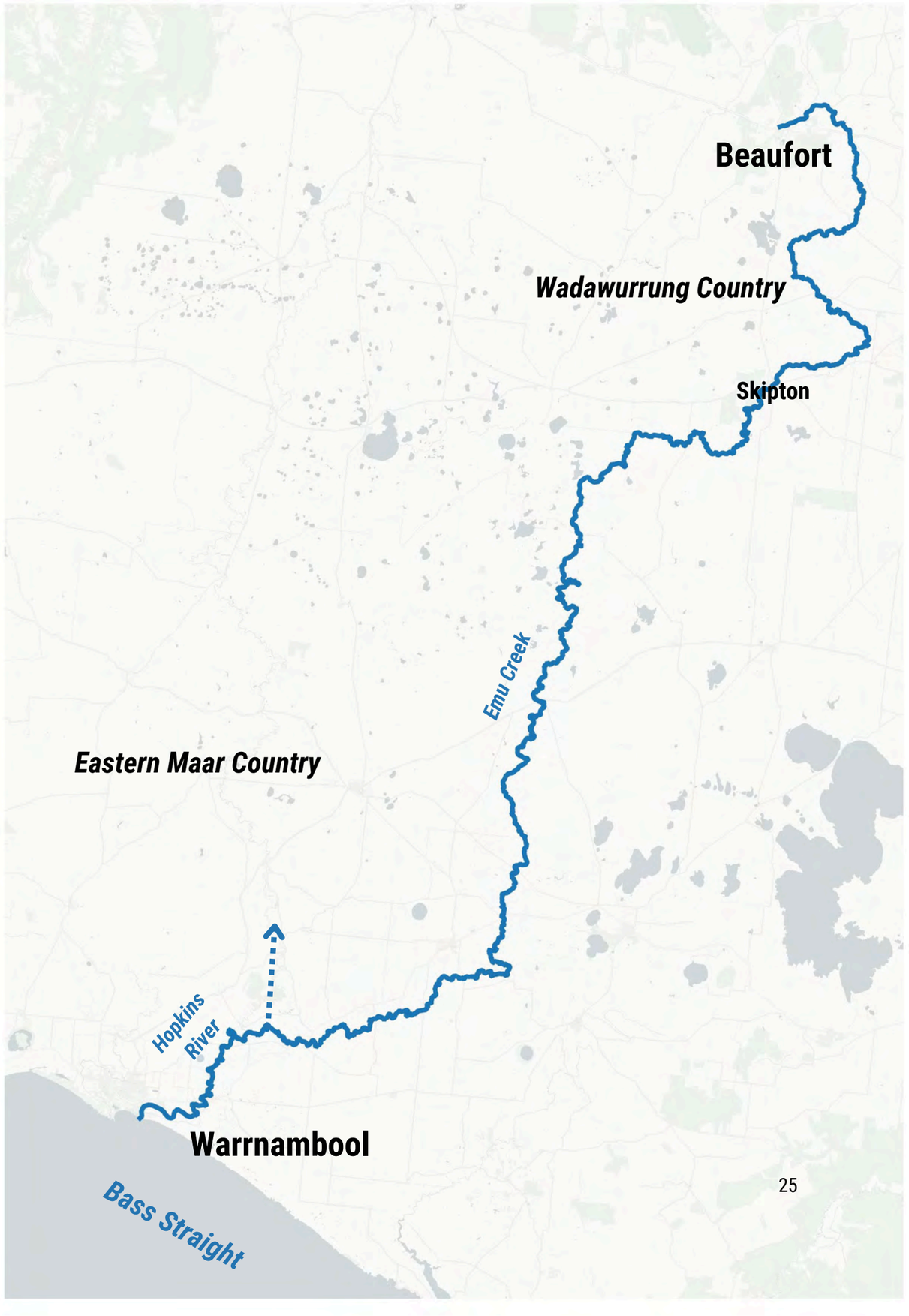
Celebrate the Garibaldi Creek and the Broader Catchment

The Garibaldi Creek is part of a much larger network of creeks flowing through the Yam Holes creek and towards Emu Creek.

Green blue infrastructure along the Beaufort Linear Park site is important and will increase the climate resilience of Beaufort, however a wholistic approach is needed across the entire Beaufort catchment and township to capitalise on the benefits of Integrated Water Management (IWM)

Water Sensitive Urban Design can be incorporated into the streetscapes, parks and private property to include rain gardens, swales and passive irrigation. Connecting the Beaufort catchment with an IWM system will vastly improve the towns resilience against both drought and flood.





Flood risk and the complexity of the Garibaldi Creek

The Garibaldi is one of three significant creeks within a small bowl-shaped catchment with a small outlet via Yam Holes Creek. Therefore, the Lineal Park project offers limited capacity to affect considerable flood mitigation measures across the town. The primary concern from the community and stakeholder groups is the chance of increased flood risk due to the landscape treatments along the creek. The initial planning and concept stages of the Masterplan considered findings from the Beaufort Flood Study Report 2008 and Beaufort Floodplain Management Plan Study Report 2011 and took steps to design the new paths and layout of the Masterplan to ensure minimal changes to the channel and to ensure any landscape works would have a nil effect on flood risk.

To support the methodology and claims of the Masterplan, Pyrenees Shire Council, enlisted the services of the Emerge Associates Hydrologists to conduct a flood report. The report aimed to show the effect of proposed landscape treatments on flood risk; initially, the report compared Scenario 1 (existing condition) with Scenario 2 (post-construction condition). Option 3 was added to the report to provide the Council with a scenario with the most significant **localized** benefit to mitigate flooding.

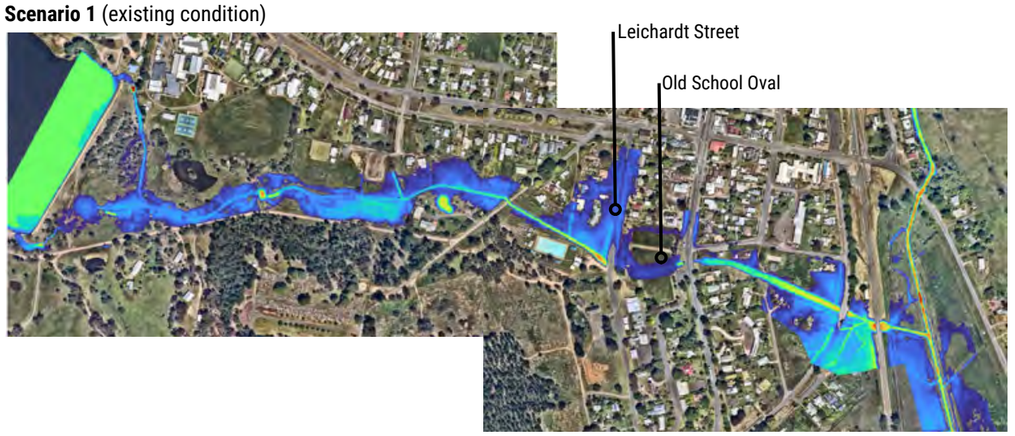
Report summary – see full report Appendix A

Scenario 1 (existing condition)
It shows the existing flood risk to the areas south and west of the Leichardt Street culvert and the area south of the Havelock Street culvert. The scenario also shows the flooding of the wetland area north of the lake, which poses no risk to property, as well as flooding to the open space north and east of Beggs Street Park, where private property is affected.

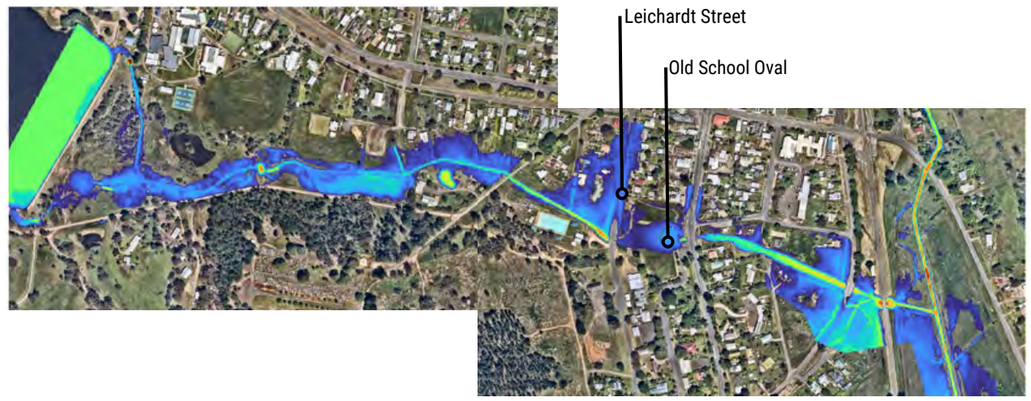
Scenario 2 (post construction condition)
The proposed minor adjustments to the meander and naturalization of the creek line have nil effect on flood risk. The proposed use of the old school oval as a detention basin offers nil mitigation of flooding south and west of Leichardt Street. However, passive irrigation benefits the proposed conversion from an oval to a grassed park.

Scenario 3 (localized flood mitigation)
Civil works to double the capacity of the box culvert at Leichardt Street and beneath the old school oval, as well as building a swale (15m wide and 500mm deep channel) through the old school oval. This scenario will maximize the localized mitigation of regular flood events to the area south and west of the Leichardt Street culvert. However, there has been no investigation on the positive or negative effects of increased flows to Yam Holes Creek. The proposed flood study, to be completed by Glenelg Hopkins Catchment Management Authority, will confirm if this scenario pushes the flood risk further downstream.

Scenario 1 (existing condition)



Scenario 2 (post construction condition)



Scenario 3 (localized flood mitigation)

Climate Adaptation v Climate Resilience

Climate adaptation and resilience are often interchangeable terms, as there is considerable overlap in the methodology and outcomes of both climate adaptation and resilience measures.

Climate adaptation Climate adaptation measures upgrade or build infrastructure to improve a site's ability to adapt to and generally avoid a specific climate change risk—for example, widening and deepening a channel to mitigate floods.

Climate resilience Climate resilience is a holistic approach that supports the landscape and community's ability to thrive during and bounce back after extreme climate events, including heat waves and prolonged droughts.

Green Blue infrastructure is featured extensively in the brief of the Linal Park Project and is the primary driver for funding for the linear park. Swales and detention treatments throughout zones 2,3 and 4 may have limited to nil effect on flooding. However, a climate-resilient future requires more consideration than focusing on flood mitigation alone. One of the remits outlined in the brief was to provide opportunities for passive irrigation – the swales and detention areas hold runoff in the landscape, recharging topsoil and passively irritating the adjacent landscape, providing drought resilience and enhancing the landscape's ability to bounce back after prolonged dry conditions.

Next steps

Glenelg Hopkins Catchment Management Authority is proposing to conduct an updated flood study for the Beaufort catchment; this study will provide an overview of the hydrology of the catchments and recommendations on flood risk and mitigation. As an opportunity to increase town-wide climate resilience, this study will be the first step. The study will show the adaptation measures needed to guard the town from flooding; however, flooding will not be the only risk to the town in a climate-change future. Studies have shown that climate adaptation measures occasionally negatively affect climate resilience; the example of Beaufort is that flood mitigation measures may negatively impact the town's ability to cope with and bounce back from drought.

Climate resilience study and Masterplan

Before acting on the Hydrological recommendation in scenario 3, it is recommended that the town conduct a Climate Resilience study and master plan for the catchment and town. The Climate Resilience study would provide valuable insight into the town's readiness and level of resilience to the effects of climate change.

Considerations for the Climate Resilience Study should include but not limited to

- Health and well-being implications of flood, drought, and excessive heat
- Community and individual psychological implication of climate change
- Bushfire risk
- Tree canopy cover and heat-resistant species (catchment including public and private land)
- Passive irrigation – stormwater diversions including Kerb cuts, rain gardens, and swales
- Urban ecology and biodiversity study – climate resilience increases with ecological complexity

Beaufort is not unique and will form a test case for other small Central Victorian towns that have evolved since the gold rush. The findings of a comprehensive climate resilience study will provide valuable insight to Beaufort and guidance on how all communities can work towards a climate-ready future.

Progressing the Linear Park

In general, the Beaufort Linear Park project can progress to the next stage of planning and construction – the master plan includes provisions for climate resilience, including swales for passive irrigation and landscape types to support biodiversity. Therefore, the Beaufort Linear Park works will dovetail with recommendations and actions from the Climate Resilience report. The only exception is the old school oval site, where further understanding of the downstream implications is required before a final decision can be made – interim works that include boundary planting and gravel paths can go ahead without affecting flood risk or possible future climate adaptation and resilience works.

Action Plan

Pyrenees
Shire Council

Action Plan Overview

The Action plan is designed to be funded by grants and partnership as they become available.

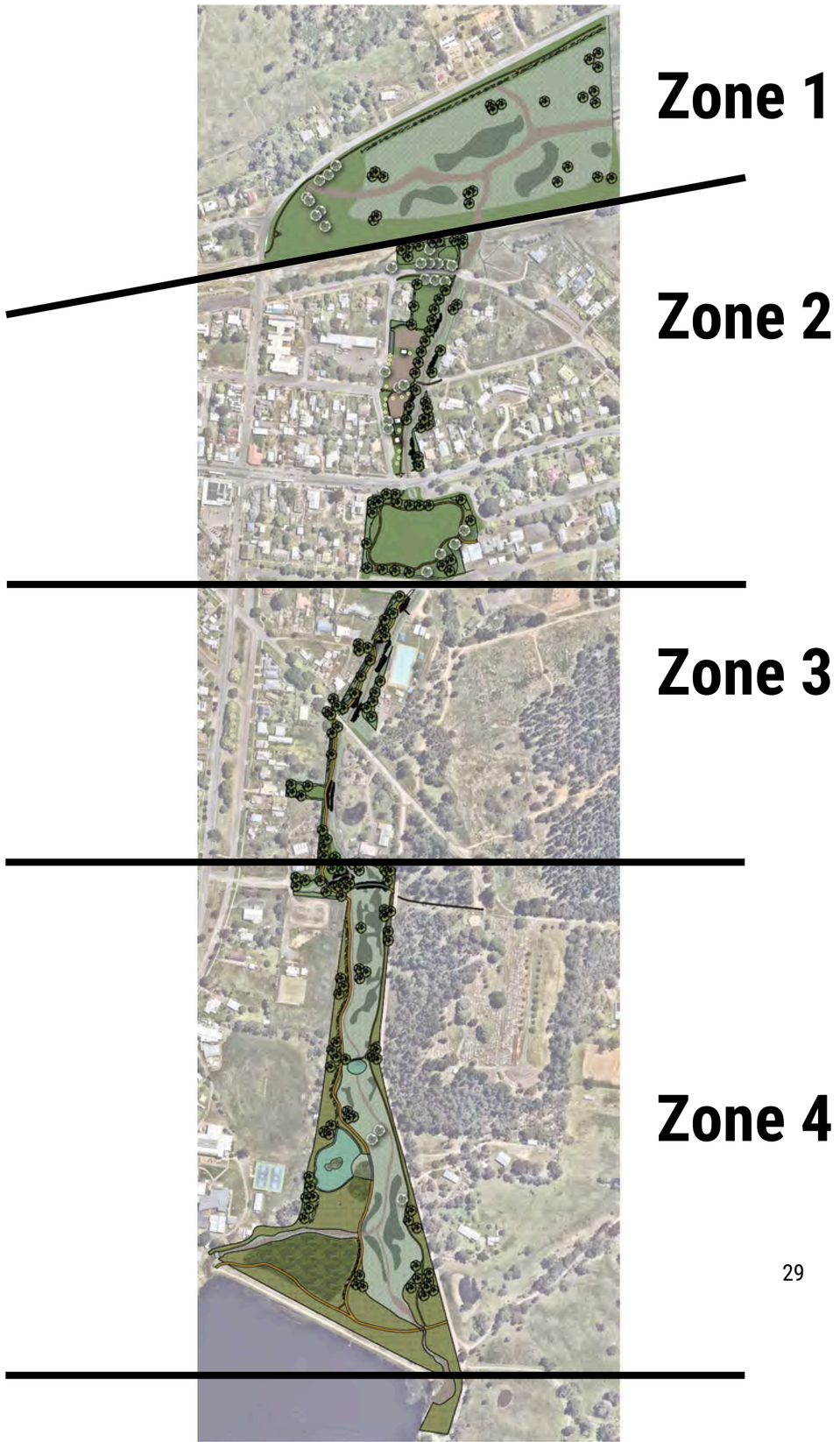
Actions are staged and costed by zone and by anticipated time frame.

*NOTE: costs estimated here are approximate and current as of November 2023. Costs are expected to increase per year at a rate higher or equal to the Australian Bureau of Statistics' Producer Price Index for Non-Residential Building Construction in Victoria. For example, over the past twelve months (Sept 2022-Sept 2024), non-residential building construction prices rose 5.7%.

Timing of the works is currently unknown. Estimated costs do not included predicted escalation.

Zone	Nov 2023* Predicted Costs
Total Zone #1	$1M
Total Zone #2	$920-40K
Total Zone #3	$460-70K
Total Zone #4	$760-80K
Total project costs	**Approx $3M**

Project Timing	Nov 2023* Predicted Costs
Total Short Term Projects (1-3 years)	$460-70K
Total Medium Term Projects (4-6 years)	$520-30K
Total Long Term Projects (7-10 years)	$1.5K
Total for regeneration over the first 10 years	$739-40K



Implementation Actions

**NOTE: costs estimated here are approximate and current as of November 2023. Costs are expected to increase per year at a rate higher or equal to the Australian Bureau of Statistics' Producer Price Index for Non-Residential Building Construction in Victoria. For example, over the past twelve months (Sept 2022-Sept 2024), non-residential building construction prices rose 5.7%.*

#	Zone	Activities	Description	Cost*	Timeframe
1	1	Detailed design and preliminary works for a new welcoming entry to Beaufort (Zone 1)		$20-30,000	7-10 Years
2	1	Picnic area and parking at a new welcoming entry to Beaufort	Install entry picnic grounds. Proposed works include a small seating area with accessible furniture, access path shade structure and grass area.	$63-68,000	7-10 Years
3	1	Boardwalk and interpretive signage at a new welcoming entry to Beaufort	Install a boardwalk and pathways to connect visitors from the picnic area along the regenerated creek and on to Beaufort Linear Park and into Beaufort. Use Water Sensitive Urban Design elements including swales along Albert Street, and naturalised wetland and creek line to improve water quality and ecosystem health.	$730-750,000	7-10 Years
4	1	Additional trees along Albert Street at a new welcoming entry to Beaufort	Plant an avenue of exotic trees to define the entry to the township and provide a colourful welcome for visitors and residents	$25-35,000	7-10 Years
5	1	Regeneration of the Yam Holes Creek flood plain and planting in swales (Zone 1)	Initial bush regeneration of waterway including weed control, revegetation. The commencement of patchwork disturbance regime including grazing (goats), cool burning and slashing.	$250-$260,000 establishment cost.	7-10 Years
6	2	Detailed design and preliminary works for the Beggs Street Recreation Activity Area Enhancement (Zone 2)		$34-38,000	7-10 years
7a	2	Beggs Street Recreation Activity Area Enhancement	Expand and upgrade existing recreation node to cater for all ages and abilities and provide a meeting, play and recreation space for the local community and visitors. Including: - Expand the skate park to cater for a wider range of ages and abilities - Develop a new junior pump track to provide the community with biking skill development - Upgrade the play space to improve play opportunities for all ages and to integrate with the neighbouring skate park and pump track - New small car parking area - New shade structure between the pump track and skate park	$270-320,000	7-10 years
7b	2	Special Use Area- Off Leash Dog Park	Create a new area for dog off leash use including fenced areas for large and small dogs and a seating area shaded by trees. Repurpose the existing shed to create a shelter and seating area. *Subject to community engagement (see Action 25)*	$60-65,000	7-10 years
8	2	Rocks, embankment stabilisation and grading to create a naturalised creek line	Undertake site grading, and install rocks and mudstone flats to change the open drain into a creek line formation. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek.	$60-70,000	7-10 years
8	2	Pathways connecting Western Highway through to Pratt Street and the existing bridge for access from Willoby Street.	Install gravel pathways (1.5m width) around and through the Beggs Street Recreation Activity Area.	$20-25,000	7-10 years
9	2	Trees and a rough mown lawn area of native grasses in the recreation activity zone.	Prepare and install of rough mown areas with native grass species, garden beds with low maintenance woody meadow species and trees to maintain an area of grassy open space for informal lawn activities and events.	$55-65,000	7-10 years
10	2	Establishment weed control and revegtatative planting of the newly reshaped waterway (Zone 2)	After site grading and reformation of the open drain to create a naturalised waterway formation, undertake establishment weed control and revegetation planting. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek.	$30-35,000 establishment cost.	7-10 years
11	2	Pathways and grassy open space detention basin at the old School Oval site	Re-grade the site to form a detention basin and grassy open space including buffer plantings (woody meadow) to provide critical flood mitigation function. Remove the existing school fence to open the site for community use and increase drainage. Install pathways around the detention basin area with seating to rest and enjoy the view of the site. Utilise extra wide shared paths (3m) to allow for safe use and movement for multiple users including cycling, mobility scooters, jogging and pedestrians. The width also provides access to service and maintenance vehicles to ensure ease of site maintenance.	$160-170,000	4-6 years
12	2	Flood mitigation measures at Leichardt Street	Scenario 3 works as outlined in Hydrology report Appendix A	$190-200,000	7-10 years
13	3	Detailed design and preliminary works for habitat link and pedestrian/cycle corridor (linking north with south) (Zone 3)		$25-30,000	1-3 years

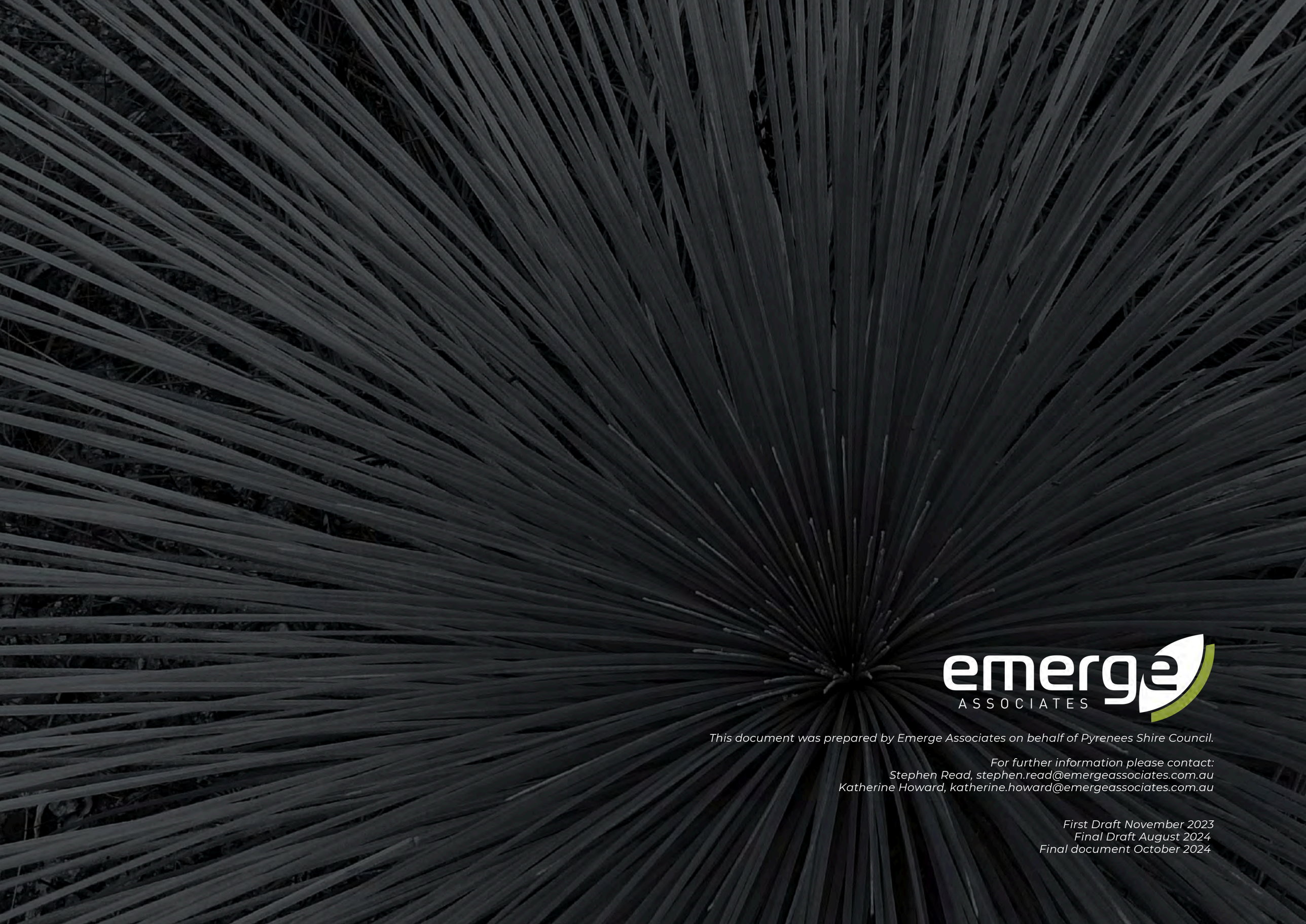
Implementation Actions

**NOTE: costs estimated here are approximate and current as of November 2023. Costs are expected to increase per year at a rate higher or equal to the Australian Bureau of Statistics' Producer Price Index for Non-Residential Building Construction in Victoria. For example, over the past twelve months (Sept 2022-Sept 2024), non-residential building construction prices rose 5.7%.*

#	Zone	Activities	Description	Cost	Timeframe
14	3	Rest and observation nodes along the pathway to provide comfortable access to the natural, recreational waterway	Install seating, bins, bicycle hoops, drinking fountain and wayfinding/interpretive signage along the recreational waterway path and at the entrance to the pocket park (just South of Cemetery Road).	$28-32,000	1-3 years
15	3	Pathways and a pedestrian bridge for walking and cycling along the recreational waterway, protected by water sensitive urban design features and embankment stabilisation to manage stormwater and create a naturalised creek line	Undertake site grading, and install rocks and mudstone flats to change the open drain into a creek line formation. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek. Install swales (and bioswales where required) alongside the route of the new pathway to protect it from washing away during storm or flood events. Establish a new pathways network using extra wide shared paths (3m) to allow for safe use and movement for multiple users including cycling, mobility scooters, jogging and pedestrians. The width also provides access to service and maintenance vehicles to ensure ease of site maintenance. Provide bollards (including removal/droppable) bollards at the Cemetery Road crossover to allow for vehicle access to the path when required. Improve access to the public swimming pool by installing a new low-maintenance pedestrian bridge (recycled plastic) and positioning creek line rocks to create stepping stones across the new waterway.	$300-320,000 Excluding the concrete path into town North of Cemetery Road (walkability project)	1-3 years
16	3	Native grasses and densely planted woody meadow areas in a new pocket park space and along the natural recreational waterway area to buffer adjoining properties and the pool	Prepare and install rough mown areas with native grass species, garden beds with low maintenance woody meadow species, planting to the newly installed swales and shade trees. Utilise high volume, densely planted woody meadow species to establish low maintenance buffers to adjoining private land owners and improve the interface with the pool.	$63-68,000	1-3 years
17	3	Establishment weed control and revegtatative planting of the newly reshaped waterway (Zone 3)	After site grading and reformation of the open drain to create a naturalised waterway formation, undertake establishment weed control and revegetation planting. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek.	$36-40,000 establishment cost.	1-3 years
18	4	Detailed design and preliminary works for habitat link and pedestrian/cycle corridor (linking north with south) (Zone 3)		$25-35,000	4-6 years
19	4	Rest and observation nodes along the pathway to provide comfortable access to the school and the wetland area	Install seating, bins, bicycle hoops, drinking fountain and wayfinding/interpretive signage along the recreational waterway path and create a circular seating area with local rocks to provide opportunities for an outdoor classroom.	$33-38,000	4-6 years
20	4	Pathways and and a floodable crossover with stepping stones for informal/playful crossing to Audus Lane, protected by water sensitive urban design features and embankment stabilisation to manage stormwater and create a naturalised creek line.	Undertake site grading, and install rocks and mudstone flats to change the open drain into a creek line formation, where required while maintaining existing wetland and dam areas. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek. Install swales (and bioswales where required) alongside the route of the new pathway to protect it from washing away during storm or flood events. Provide pathways to connect through the zone and to Goldfield Recreation Reserve and cycle loop onto lake road and beyond. Pathways on the western side of the site are wide (3m) to allow for safe use and movement for multiple users including cycling, mobility scooters, jogging and pedestrians. The width also provides access to service and maintenance vehicles to ensure ease of site maintenance. Pathways on the eastern side of the site are designed to be pedestrian only (1.5m wide) as cyclists can cross over to Lake Drive. Install a floodable concrete road crossing to allow access across the site at Audus Lane (east-west). Designed-in stepping stones will soften the look at the crossing (especially when not flooded), provide an alternative options for crossing during wetter months, and encourage playful interactions with the creek.	$260-310,000k	4-6 years
21	4	Regeneration of the Garibaldi Creek wetland areas and waterway and adjacent woodland (Zone 4)	After site grading, swale installation and reformation of the open drain to create a naturalised waterway formation, undertake establishment weed control and revegetation planting. The works will naturalise the existing open drain to add aquatic and riparian ecological values and create a waterway which mimics a natural creek. Utilise denser planting in woodland areas to help to buffer visibility to the school.	$ 400-405,000 establishment cost. Custodian management of the site is ongoing.	4-6 years

Management Actions

	Activities	Timeframe
22	Establish maintenance protocols for the site which respond to the unique characteristics of the linear park, by managing the landscape in line with landscape types 1-5, including: • Control existing invasive plant species with minimal disturbance to soil and native vegetation • Source local indigenous species for revegetation. If practical genetic stock to be selected local to the Beaufort region • Choose shrub species for buffer plantings, which will be as low maintenance as possible (Woody Meadow style planting and management) • Utilise a combination of traditional park management with regenerative practice including coppicing • Establish a patchwork disturbance regime including grazing (goats), cool burning and slashing • Monoculture lawn to be avoided to reduce irrigation and maintenance cost and replaced with the establishment of rough mown grassy areas - a biodiverse mix of native grass and flowering species to increase biodiversity and climate resilience	Initial phase 2-5 years, then ongoing
23	Partner with Wadawurrung, Dja Dja Wurrung, Wotjobaluk and Eastern Maar Peoples to regenerate and heal the landscape as a long term commitment to ongoing management of the landscape	Ongoing
24	Partner with community groups including Landcare to develop a sese of ownership and commitment to the ongoing regeneration of the waterway and linear park. Custodianship activities that may include: ◦ Cool burning (patchwork) ◦ Slashing (patchwork) The open grassy areas are to be managed though slashing and when appropriate the slashing may be suspended to allow for the native grasses to seed ◦ Repair / revegetation after significant disturbance events	Ongoing
25	Undertake community engagement regarding the potential dog off leash area (Beaufort Linear park Zone 2) to determine level of community support and if supported, it's final design.	Within the next 12 months
26	Engage a specialist hydrologist to review concept drawings and model the proposed water management approaches to confirm: • capacity and grading of detention basin (old school oval) • if bioswales are required in areas of greater stormwater runoff volume (or if basic swale drains are sufficient throughout the project)	Within the next 12 months



This document was prepared by Emerge Associates on behalf of Pyrenees Shire Council.

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First Draft November 2023
Final Draft August 2024
Final document October 2024

Appendix A
Hydrology Report

TECHNICAL MEMORANDUM

Pyrenees Shire – Garibaldi Creek Design - Hydrological Support

PROJECT NUMBER	EP24-036(01)	**DOC. NUMBER**	EP24-036(01)—002 FMH
PROJECT	Garibaldi Creek Design Support	**CLIENT**	Pyrenees Shire
AUTHOR	FMH	**REVIEWER**	DPC
VERSION	001	**DATE**	August 2024

1 INTRODUCTION

A Masterplan for the new linear park along Garibaldi Creek (and within the central POS area) as well as the revitalised Garibaldi Creek is being prepared by Emerge Associates. The design of the Creek is proposed to be revised to assist managing the frequent rainfall event. The objective of this hydrological assessment is to support the design of Garibaldi Creek and to demonstrate that the design does not pose any further flooding risk for the adjacent properties and to provide increased usability of open spaces and biodiversity within the waterway corridor.

This technical memorandum presents the methodology adopted by Emerge Associates to develop a hydrological and hydraulic model to support the changes to the Garibaldi Creek and its current alignment. The Creek runs south to north through the Beaufort townsite prior discharging into Yam Holes Creek.

To understand the hydraulic behaviour of the Garibaldi Creek the assessment took the following steps:

- Assess existing flood studies to fully understand what information already exists, so that any assessment undertaken builds on existing and accepted knowledge.
- Source and analyse available topographical data to enable a detailed assessment of local contributing catchments and the flood behaviour of the Creek in response to small/frequent rainfall events.
- Undertake a 1D modelling assessment to determine the overall design requirements of the streamline (i.e. base width, side slopes and depth) – based on previous hydrological studies.
- Utilise initial modelling results to develop design guidelines for the Garibaldi Creek to manage the frequent rainfall event

The above steps facilitate a more detailed assessment and comparison of the hydraulic behaviour of the existing Creek with the proposed modifications using a 2D modelling approach. This is able to graphically show the flooding extent along Garibaldi Creek in response to a frequent rainfall event.

2 MODELLING METHODOLOGY AND PROCEDURE

2.1 Modelling methodology

Previous flooding risks assessments, flood plain management plans and emergency plans have been prepared for the Garibaldi Creek and downstream areas (including Yam Holes Creek) and these have characterised the flood extent and risk to the Beaufort Townsite. The documentation relevant to the Garibaldi Creek has been reviewed and adopted as a base line to inform the hydraulic assessment of and support the design of the streamline. This documentation includes:

- Beaufort Flood Study Report (Water Technology 2008)
- Beaufort Floodplain Management Plan Study Report (Water Technology 2011)
- Pyrenees Shire Flood Emergency Plan (Pyrenees Shire Council 2020).

The hydrological and numerical hydraulic models which include the Townsite and surrounding flood plain were developed as part of the above investigations for the 5, 10, 20, 50, 100 year average recurrence interval (ARI) storm events. These have been reviewed to derive the frequent event peak flows using a logarithmic regression, as further detailed in the following sections.

The likely rainfall and inundation has previously been investigated in the Beaufort Flood Study developed by Water Technology (2008). The modelling methodology adopted by Emerge has sought to adopt key parameters/assumptions from this study where appropriate. The method for the various components are further discussed later in this document.

XPSWMM hydrological and hydraulic modelling software was used to calculate the surface water runoff volumes/flow rates generated within the contributing catchments across Beaufort Townsite, including all pervious and impervious areas (i.e. residential and commercial roads, and road reserves).

In order to undertake a preliminary assessment and to determine the design parameters for the Garibaldi Creek (e.g. overall cross section and maximum water depth) a 1D XPSWMM model was developed to mimic the existing hydraulic and topographical conditions including the upstream and downstream invert levels of the Garibaldi Creek. This was based on the previous studies undertaken over the Beaufort Townsite and which included Garibaldi Creek using the methodology described above. The process also included incorporating localised catchments (further described in **Section 2.2.1**), as well as all culvert crossings from the Beaufort Reservoir downstream to the discharge into Yam Holes Creek.

2.2 Contributing catchment

2.2.1 Beaufort Town catchment areas

LiDAR data was used the generate a digital elevation model (DEM) of Beaufort Townsite. This then allowed a catchment analysis to determine any additional local inflows into the Garibaldi Creek from the Townsite downstream of the Beaufort Reservoir. This analysis was based on the available DEM for the site, town drainage infrastructure and aerial imagery. A total of 13 catchments were identified as contributing to the Garibaldi Creek as shown in **Plate 1.**

The land uses were analysed and classified as:

- Pervious areas such as remanent vegetation, golf course and public open spaces (POS) – these were assumed to be 100 % pervious.
- Residential and commercial lots – these were assumed to be 50% impervious (e.g. roof and paved areas) and 50% pervious (e.g. back of lot and garden areas)
- Road reserves were assumed to be 40% impervious (bitumen/paved) and 60% pervious (to represent road verges).

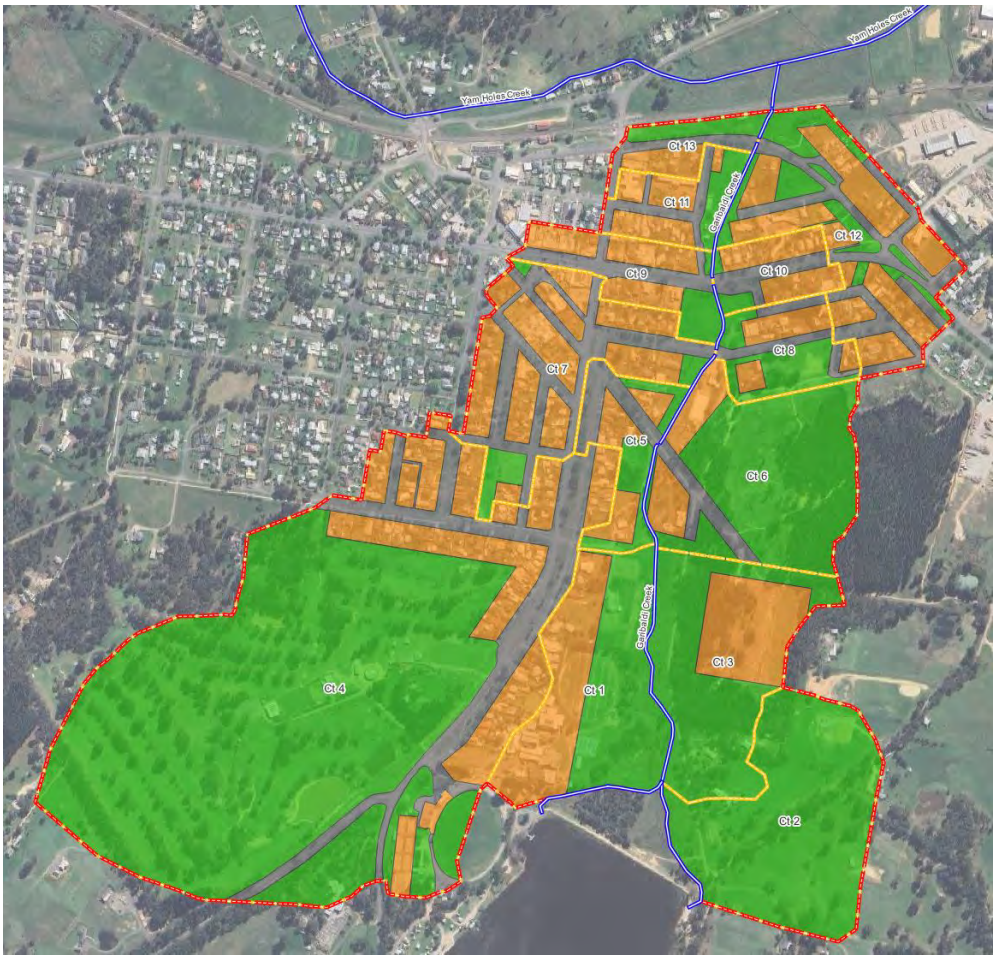


Plate 1: Contributing catchment areas across Beaufort Townsite.

2.2.2 Upstream catchment areas

The contributing upstream catchments and respective inflows to the Garibaldi Creek were developed using a RORB model and documented within the Beaufort Flood Study developed by Water Technology (2008), and therefore no further detail is provided in this document. It is noted that the upstream catchments and design inflows to the Garibaldi Creek from this study have been adopted.

2.3 Upstream Inflows

Inflows entering the Garibaldi Creek (downstream of the Beaufort Reservoir) in the frequent rainfall event were derived from the existing Beaufort Flood Study developed by Water Technology (2008). It is noted that as part of the Flood Study the Cemetery Creek West and the Cemetery Creek East (now referred as Garibaldi Creek East/West) were identified as both converging at the Beaufort Reservoir prior to continuing north through Beaufort and ultimately discharging into Yam Holes Creek.

In order to determine the peak flows entering the Beaufort Reservoir from both Garibaldi Creek East and West and then flowing through the main Garibaldi Creek, a logarithmic regression of the 5 year ARI to the 100 year ARI (with duration 36 hour) peak flows was adopted (from the Beaufort Flood Study (Water Technology 2008)) to derive the frequent rainfall event (1 year ARI). Based on the logarithmic regression (further shown in **Plate 2**), it was determined that the peak inflows in the

frequent rainfall event entering the Garibaldi Creek from the East and West branches are 2.72 m³/s and 3.39 m³/s respectively, equating to an adopted design peak inflow of 6.11 m³/s for the frequent rainfall event.

The modelling undertaken by Emerge assumed that the upstream catchments are pre-wetted and that the Beaufort Reservoir is at 100% capacity. Whilst conservative, this is considered appropriate to inform design of a flood prone waterway. On this basis, in the event of a frequent rainfall event there will be no losses nor detention within the reservoir resulting in all runoff being conveyed via the Garibaldi Creek. It is noted that these assumptions are also consistent with the Beaufort Flood Study (Water Technology 2008).

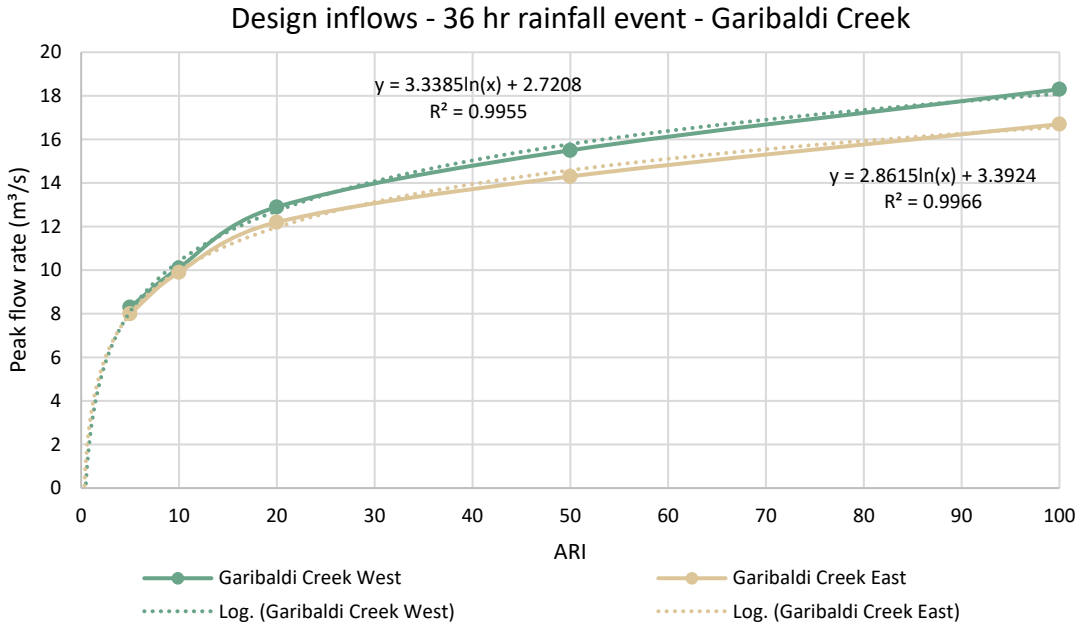


Plate 2: Logarithmic regression of design inflows entering the Garibaldi Creek

2.4 Rainfall

The intensity of the frequent rainfall event (1 event per year (1EY), which approximates the 1 year ARI)) was obtained from the Bureau of Meteorology (BoM 2024). Together with the temporal patterns (storm ensembles) from the Australian Rainfall and Runoff (AR&R) Data Hub (AR&R 2019), these were used for the rainfall analysis for the contributing catchments across Beaufort Townsite (refer to **Plate 1**). Following the process suggested by AR&R (Ball J *et al.* 2019), the highest mean duration resulting from the 10 storm ensembles was selected as the critical duration, and for the 1 EY this is the 63.2% AEP ensemble 4.

2.5 Infrastructure

Existing culvert crossings adopted in the 1D XPSWMM model are based on the drainage data information facilitated by the Pyrenees Shire. Where data was incomplete or not available, topographical data was extracted from the DEM, culvert crossing information was obtained from the Appendix B of the Beaufort Flood Study (Water Technology 2008) or derived from observation of aerial photography. The key culvert information adopted is described as:

- Culverts under Havelock/Cemetery Street (C4 - C5) and Pratt Street (C60) were obtained from the Shire drainage database.
- Culverts under Leichardt St, Western Hwy were adopted from the information provided on Appendix B of the Flood Study.
- Culvert under the POS (between Leichardt St and Western Hwy) was assumed to be 2.4 m x 1 m with a total length of 118.7 m.
- Railway crossing culvert adopts a quadruple 2400 x 1200 box culvert based on a combination of the recommendations outlined in the Floodplain Management Plan (Water Technology 2011) and aerial imagery.

2.6 Tailwater condition

A representation of the downstream condition of the Garibaldi Creek needs to be assumed to ensure the flows act in accordance with the downstream hydraulics. To determine the tailwater conditions at Yam Holes Creek, a long section of the Yam Holes Creek as well as a typical cross section was extracted from the DEM and included as part of the 1D XPSWMM hydraulic model. The modelled section of Yam Holes Creek was extended 500 m downstream to ensure the stability of the tailwater condition and minimise boundary effects. Inflows for the frequent rainfall event relevant to the Yam Holes Creek were quantified similar to the Garibaldi Creek using a logarithmic regression (refer to **Plate 2**). On this basis, it was determined that peak inflows being conveyed by Yam Holes Creek in the frequent rainfall event are 5.28 m³/s for the Yam Holes Creek north and 4.27 m³/s for the Yam Holes Creek south, with a total combined flow rate of 9.55 m³/s.

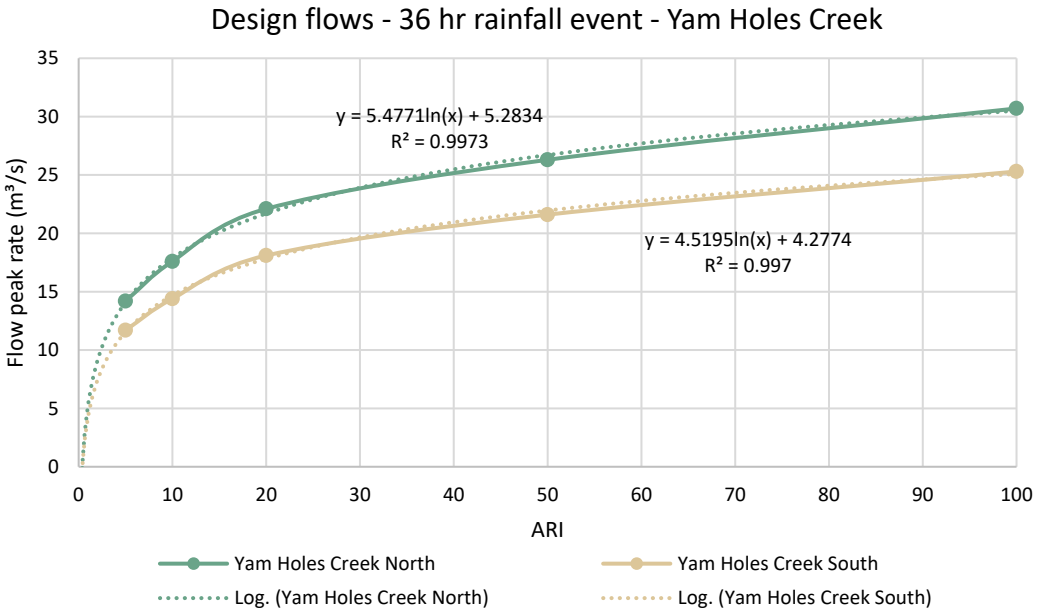


Plate 3: Logarithmic regression of design flows being conveyed by Yam Holes Creek

2.7 Rainfall losses for urban catchments

An initial loss-continuing loss model was adopted to account for the losses across the identified urban catchment. The land types and losses values were based on aerial imagery and previous

investigations which indicate that the catchment generally has low permeability. **Table 1** summarises the loss parameters adopted to account for rainfall losses across the urban (Townsite) catchments.

Table 1: Urban catchment losses

Land uses	Initial loss (mm)	Continuing loss (mm)
Impervious areas (i.e. Road surface, roof areas)	1	0.1
Pervious area (i.e. road verges and garden areas)	9	1.5
POS and Forest	15	3

3 MODELLING RESULTS

3.1 1D Modelling assessment

As previously indicated, an initial 1D assessment was undertaken to determine the overall hydraulic configuration of the streamline. To do so, the Garibaldi Creek was divided into segments generally between culvert crossings and/or between discharge locations. This segmentation allows the direct connection of contributing catchments, the introduction of the existing culvert crossings within the hydraulic model, allows any flow restrictions posed by the culverts to be considered, and to stabilise the tailwater condition at the discharge into Yam Holes Creek. **Plate 4** shows the 1D model of Garibaldi Creek.

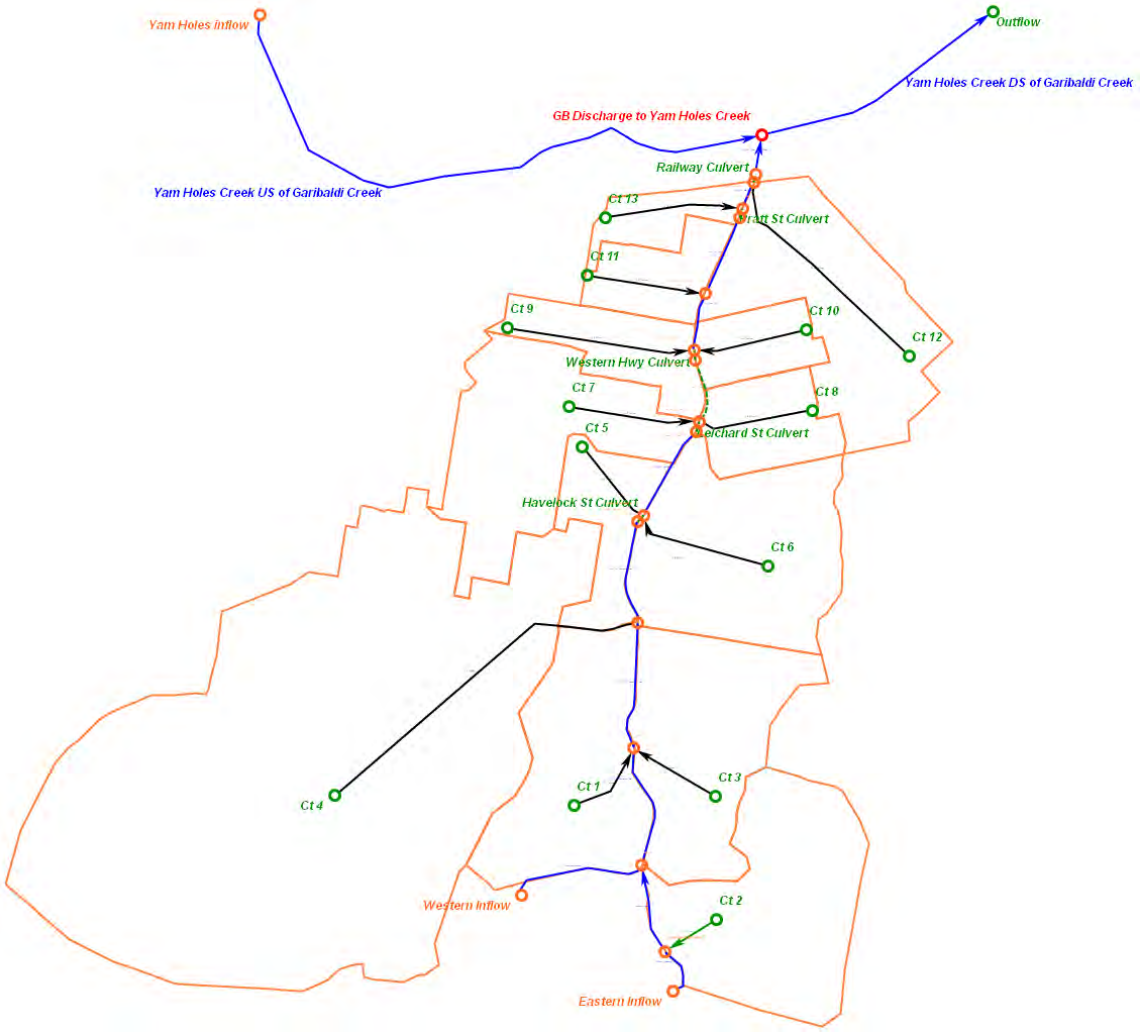


Plate 4: 1D XPSWMM link-node diagram of the Garibaldi Creek.

As shown in **Plate 4** all segments of the Garibaldi Creek and the Yam Holes creek have been represented in the 1D XPSWMM model by blue links and culvert crossings by green links. The following approaches were adopted in the model:

- Hydraulic links have been given the approximate spatial lengths to represent actual catchments
- Upstream/downstream invert levels are based on the DEM and/or Pyrenees Shire drainage information
- A Mannings roughness coefficient (n) of 0.035 is adopted in order to represent naturally occurring vegetation, natural obstructions and vegetation which could potentially be adopted as part of the revitalisation.

Upstream inflows for both the Garibaldi Creek and Yam Holes Creek have been introduced in the model as a nodal input with hydrographs inflows being consistent with the peak flows identified in **Section 2.3.**

The initial 1D modelling assessment indicates that in order to convey the frequent rainfall event (1EY) the Garibaldi Creek channel should be at least 1 m to 1.4 m deep, have a base width of 3 m to 4 m and have side slopes of 1:3. Adoption of these design parameters should safely manage the frequent rainfall event within the channel whilst being consistent with contemporary approaches for revitalised waterways. It is noted that adopting a channel configuration to match this is idealistic and may not be practical when localised site conditions are considered.

It is noted that POS bounded by Leichardt Street and Western Highway has been assumed to maintain the existing culvert running through the entirety of the POS area. In order to ensure conveyance of the storm water across the POS area and to avoid ponding upstream (and resulting in overland flows flowing west along Leichardt Street), an overflow swale was adopted through the POS area, with the same alignment as the existing culvert. An overflow corridor across the POS is recommended to be at least 15 m wide and nominally 500 mm deep which could be achieved in the form of a low depression across the POS running from end to end. The actual flood depth will only be 210 mm in a frequent storm event, however the additional freeboard would provide some design flexibility and additional capacity (e.g. in the event of partial culvert blockage. The overall design parameters for the Garibaldi Creek based on the 1D assessment are detailed in **Plate 5** and **Plate 6,** and **Plate 7** shows a long section of the model creek line.

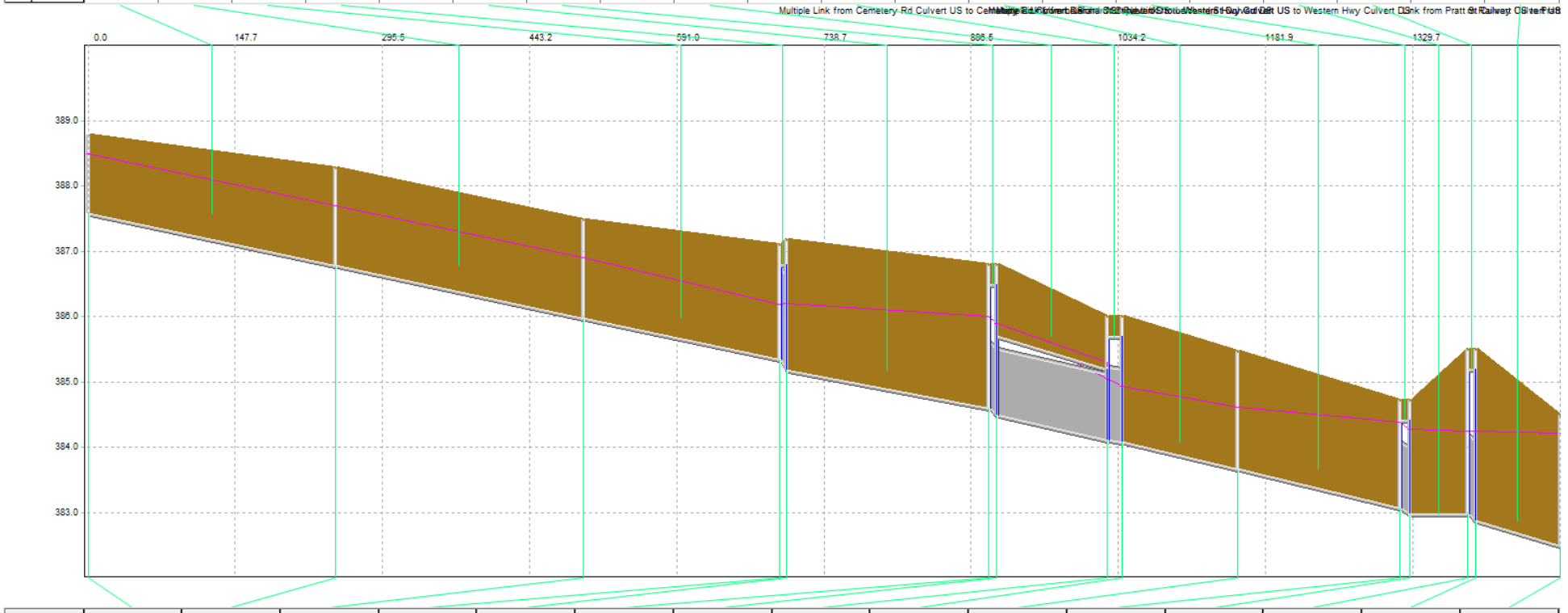
Plate 5: Design parameters from Beaufort Reservoir down to Havelock Street

Plate 6: Design parameters from Havelock Street down to the Railway crossing

Pyrenees Shire – Garibaldi Creek Design - Hydrological Support

Garibaldi Creek Design Support

	GB US of Ce	GB US of Ce	GB US of Ce	Havelock BC	Havelock Rd	GB US of Leic	Leichard St B	Leichard St R	Culvert	Overland flo	Western Hwy	Western Hwy	GB US of Prat	GB US of Prat	Pratt BC	Pratt St Flow	GB US of Rail	Railway Culv	Railway overl	GB US of Ya
Storm	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1	SSM_63pct_1
Max Flow	6.104	6.097	6.094	6.100	0.000	6.086	6.080	0.000	4.404	1.735	6.078	0.000	6.077	6.077	6.079	0.000	6.080	6.081	0.000	6.083
Max Velocity	1.153	1.151	1.158	1.687	0.000	0.860	2.167	0.000	1.813	0.567	2.174	0.000	1.086	0.882	2.168	0.000	0.637	0.550	0.000	0.717
Max Depth	0.920	0.924	0.924	1.032	-0.588	1.400	1.416	-0.594	1.416	0.206	0.942	-0.768	0.949	1.316	1.316	-0.134	1.296	1.368	-9e+99	1.736
Design Full Flo	7.244	7.240	7.242	12.412	0.117	18.792	6.548	0.164	2.847	9.382	3.155	0.164	9.338	9.342	5.427	0.169	2.023	6.992	0.164	10.491
Length	248.896	248.872	196.420	7.500	7.200	202.215	8.500	8.500	110.200	110.200	15.600	15.600	115.858	162.700	9.000	10.000	58.244	8.000	8.000	84.417



	EW Join	EW Join.1	EW Join.1.1	Cemetery Rd Culv	Cemetery Rd Culv	Leichard St Culver	Leichard St Culver	Western Hwy Cul	Western Hwy Cul	Western Hwy Cul	Pratt St Culvert US	Pratt St Culvert D	Railway Culvert U	Railway Culvert D	GB Discharge to Y
Storm	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4	SSM_63pct_1hr_4
Subcatchment															
Ground Elevati	388.780	388.280	387.481	387.100	387.180	386.800	386.800	386.000	386.000	385.468	384.720	384.720	385.500	385.500	384.490
Invert Elevatio	387.580	386.780	385.981	385.350	385.180	384.600	384.490	384.120	384.090	383.666	383.070	382.990	382.980	382.880	382.490

Plate 7: Garibaldi Creek 1D cross section from Beaufort Reservoir to discharge into Yam Holes Creek

3.2 2D Modelling Assessment

In order to understand the changes in the flooding extent as a result of the proposed upgrades a 2D modelling assessment has been undertaken. This assessment combines the Beaufort Townsite DEM and existing drainage infrastructure along the Garibaldi Creek previously described in **Section 2.5** from the Beaufort Reservoir down to the Railway crossing. It is noted that all upstream inflows, townsite contributing catchments, rainfall and tailwater conditions described in **Section 2** are consistent between the preliminary 1D and 2D modelling assessment.

Three different scenarios have been undertaken to visually differentiate the flood extent changes in the frequent rainfall event. These are described in the following sections.

3.2.1 Scenario 1 - Existing Garibaldi Creek alignment

The existing alignment of the Creek based on the DEM and culvert information was utilised to develop a 2D modelling scenario that shows the current extent of flooding across the Beaufort Townsite in the frequent rainfall event. The current flooding extent shown in **Plate 8** and **Plate 9** establish a baseline for comparison of the proposed changes.

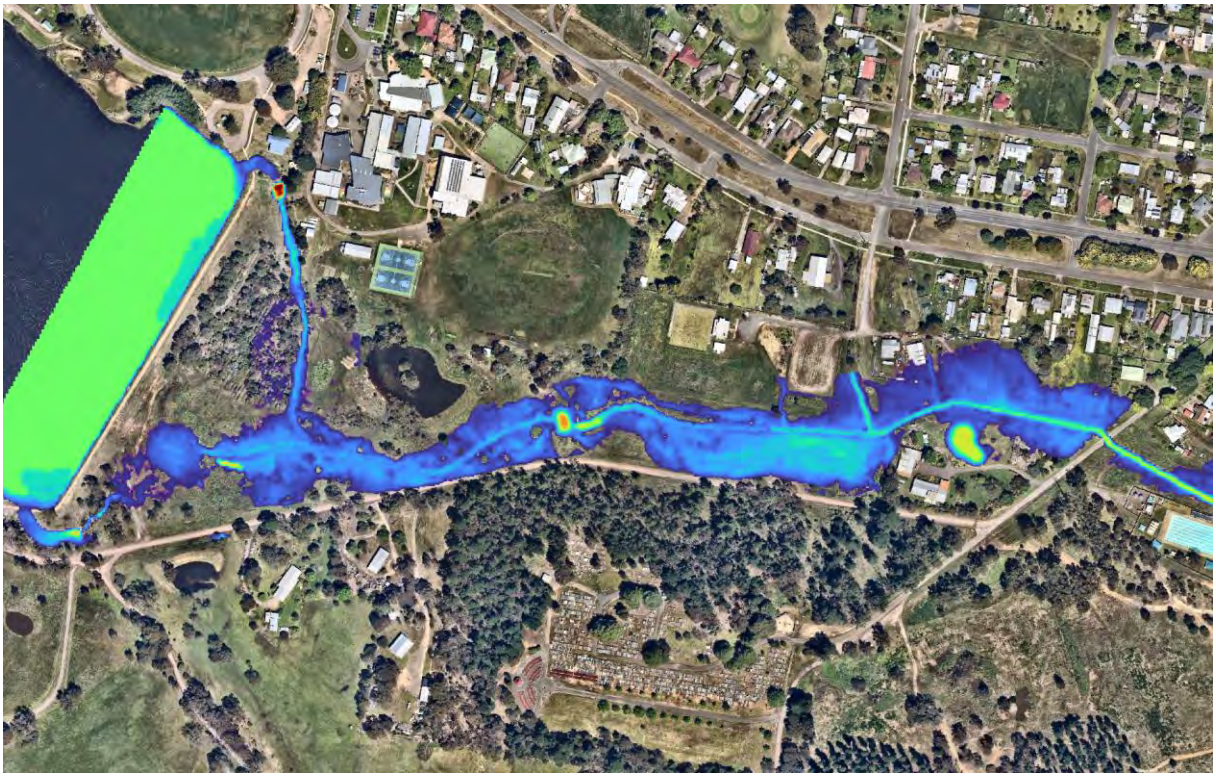


Plate 8: Scenario 1 – Existing flooding extent in the frequent rainfall event (1EY) upstream of Havelock Street

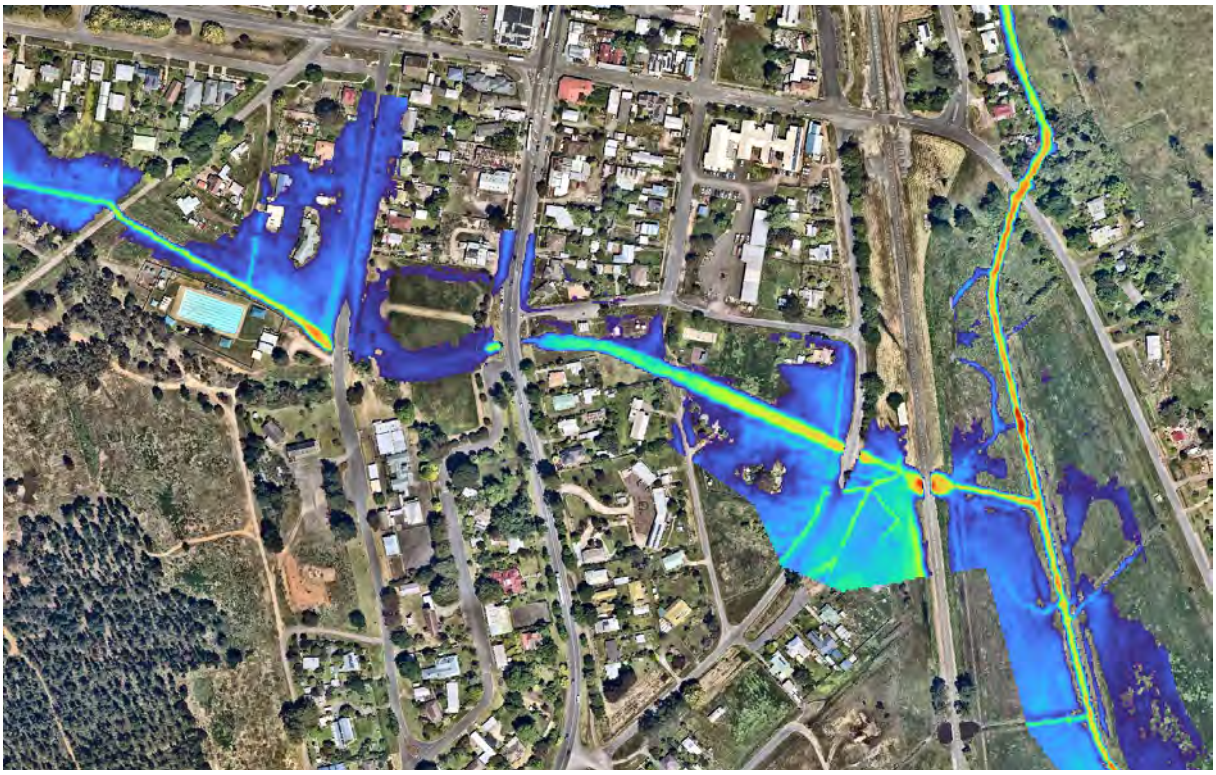


Plate 9: Scenario 1 – Existing flooding extent in the frequent rainfall event (1EY) downstream of Havelock Street

3.2.1 Scenario 2 – Modified Garibaldi Creek alignment and conveyance swale in central POS

Based on the design parameters identified in the 1D analysis previously described in **Section 3.1**, minor widening of the streamline within its existing flood plain (show in red in **Plate 10**) and topographical changes within the central POS area (shown in green in **Plate 10**) were included within the 2D modelling assessment. Widening of the Creek in the four proposed areas aimed to improve localised flooding to the adjacent areas and to partially improve localised detention. Modifications to the topography within the central POS intends to provide greater conveyance to the upstream flows that generally runoff west along Leichardt St rather than continuing flowing north as overland flow over the POS.

Plate 10: Proposed modifications to the Garibaldi Creek (i.e. changes to alignment in red and changes to topography in the central POS in green)

The modelling results of Scenario 2 shown in **Plate 11** and **Plate 12** indicate that the proposed changes to the alignment and elevations within the POS does not have a negative impact in the flooding extent upstream or downstream. Whilst it provides a modest amount of localised detention, it also does not alleviate surface runoff flowing west along Leichardt Street. Conversely, whilst some detention is provided in the POS, this is observed as an increase to the extent of inundation within the POS.

Plate 11: Scenario 2 – Flooding extent in the 1EY upstream of Havelock Street based on proposed changes to alignment and linear park within central POS

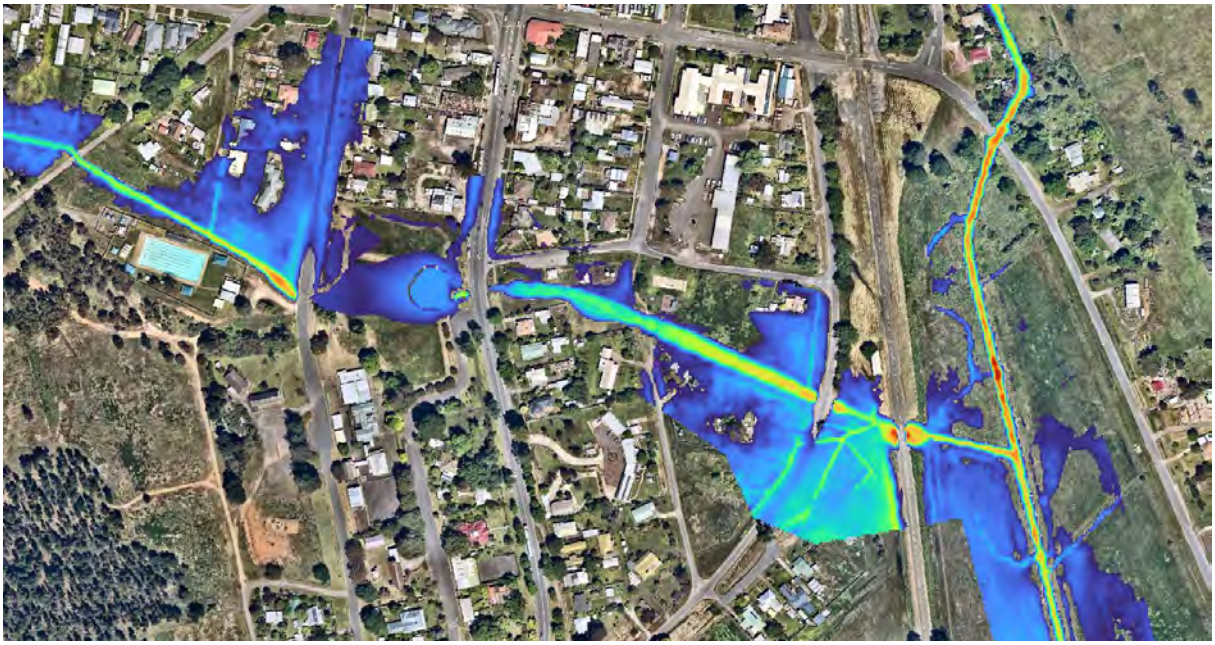


Plate 12: Scenario 2 – Flooding extent in the 1EY downstream of Havelock Street based on proposed changes to Garibaldi Creek alignment and linear park within central POS

3.2.1 Scenario 3 – Upgraded box culvert alignment along central POS

Based on the modelling results for Scenarios 1 and 2 it is noted that the existing culvert alignment underneath the POS (i.e. single 2.4 m x 1 m and 118.7 m long box culvert) does not have sufficient capacity to manage flows in the frequent rainfall event. Therefore, to improve the conveyance capacity of the Garibaldi Creek and to alleviate flooding extent upstream of the POS, Scenario 3 tests the increase in capacity (doubling) of the box culverts at the culvert crossing in Leichardt Street and beneath the POS, in addition to a conveyance swale through the POS. Proposed upgrades are shown in **Plate 13.**

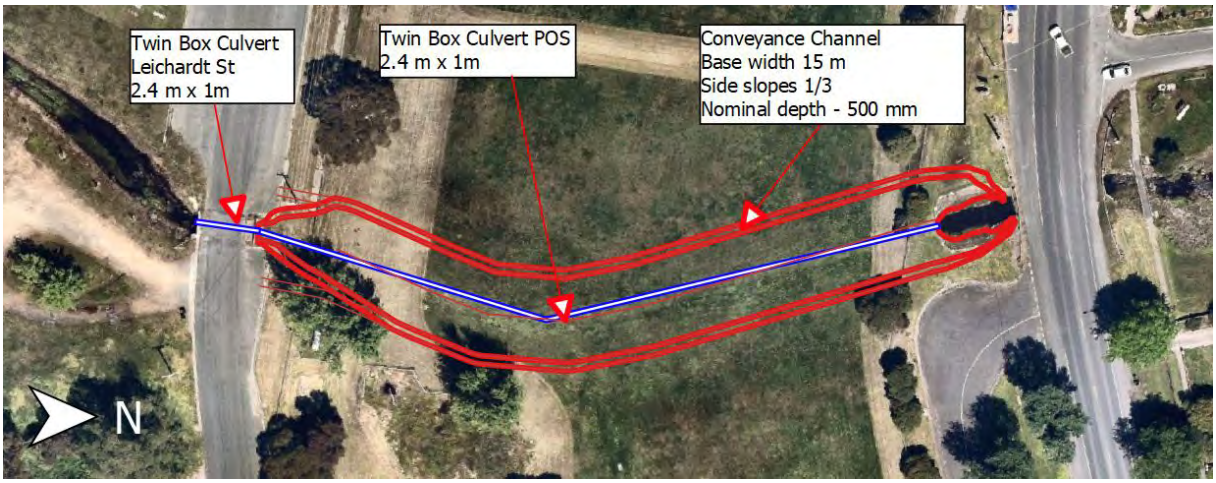


Plate 13: Propose upgrade to culvert configuration at Leichardt Street, beneath POS and conveyance swale

The results of the modelling shown in **Plate 14** and **Plate 15** indicate that increasing the culvert capacity does alleviate some of the flooding of surrounding properties upstream of the POS as well as reducing the amount of surface runoff flowing west along Leichardt Street, however inundation to surrounding properties is not completely avoided. Additional increases may see additional improvement in flooding of upstream properties, it is noted that this may shift the problem further downstream, with properties nearby Yam Holes Creek potentially further affected by flooding in a frequent rainfall event.

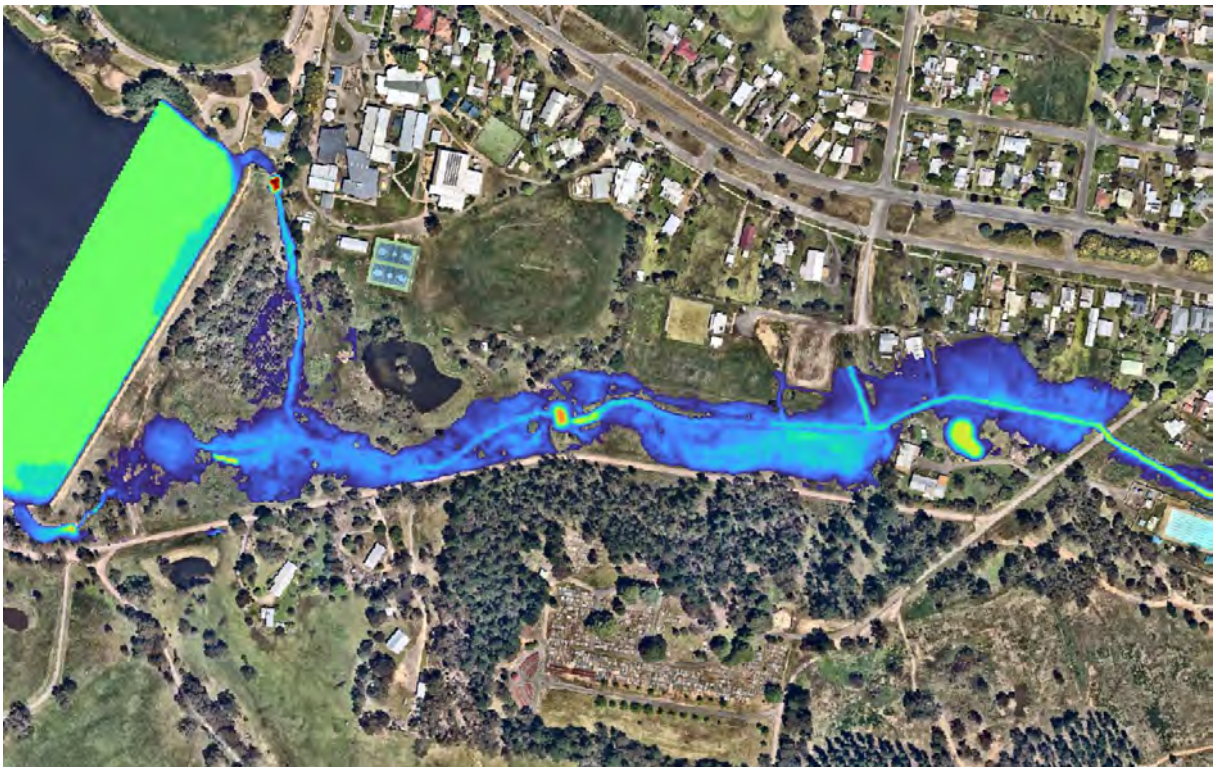


Plate 14: Scenario 3 – Flooding extent in the 1EY upstream of Havelock Street based on increase culvert size at Leichardt Street, underneath the central POS and conveyance channel

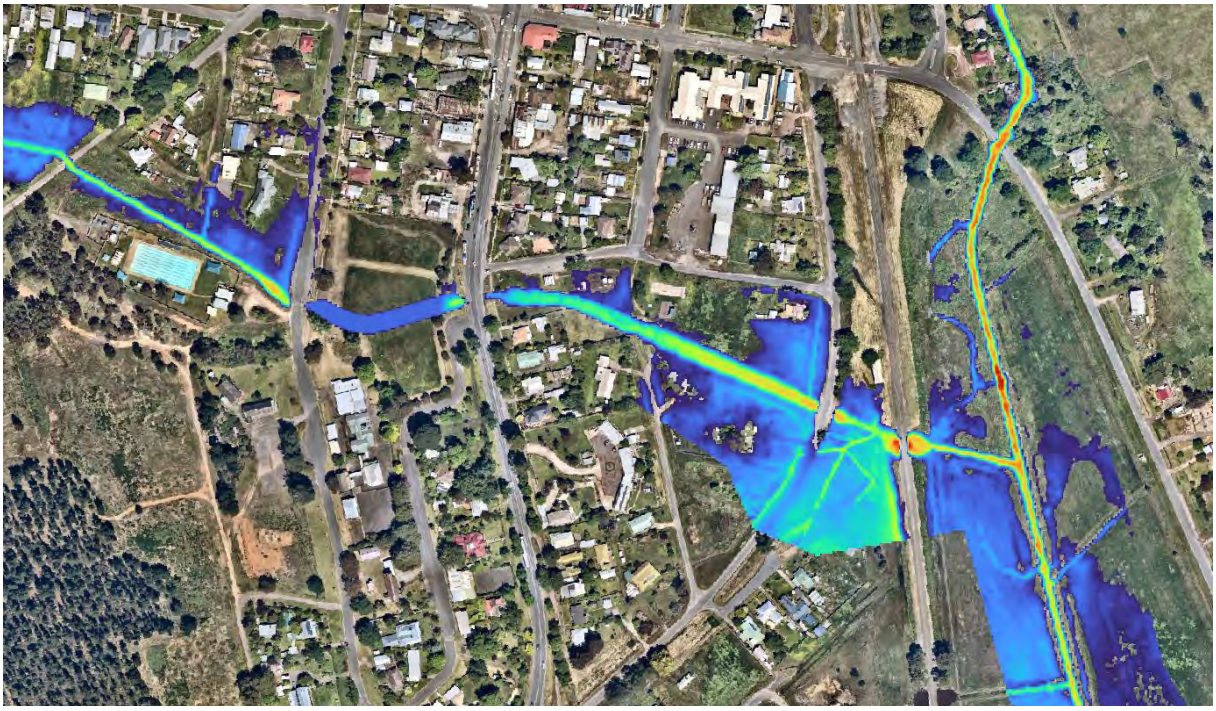


Plate 15: Scenario 3 – Flooding extent in the 1EY downstream of Havelock Street based on increase culvert size at Leichardt Street, underneath the central POS and conveyance channel

4 SUMMARY AND CLOSING

This technical memorandum details the hydraulic modelling assessment undertaken by Emerge Associates to support the landscape Masterplan for the revitalised Garibaldi Creek. In order to demonstrate that the proposed upgrades will not have a detrimental impact in the overall hydraulic behaviour of the waterway, the extensive existing work undertaken by others to characterise flood behaviour of Beaufort Townsite and relevant waterways was used to inform a site specific assessment of frequent rainfall events. An initial 1D hydraulic model was developed to determine the general design requirements for management of the frequent rainfall event, which then it was used to develop the design parameters recommended for the concept Masterplan for the revitalised waterway.

The key design parameters that should be adopted in the design of Garibaldi Creek channel include:

- Retain existing culverts and culvert inverts
- Garibaldi Creek channel should be at least 1 to 1.4 m deep (varies per the long section in Plate 7)
- Garibaldi Creek channel should have a base width of 3-4 m
- Garibaldi Creek channel should have side slopes no greater than 1:3.
- POS between Leichardt Street and Western Highway should have a 15m wide 500mm deep overflow channel with the same general alignment as the existing/retained culvert.

Based on the design parameters indicated by the 1D modelling assessment, design changes were developed based on what could be practically achieved in the Creek and POS. A 2D model was developed to demonstrate the effect of the proposed upgrades do not increase the risk of flooding upstream/downstream areas. Three Scenarios were modelled to allow comparative analysis. Scenario 1 (existing environment) provides a baseline for comparing proposed amendments, Scenario 2 (Creek and POS amendments) shows potential changes resulting from design chances to the Creek and POS.

Based on the results of Scenarios 1 and 2, it was noted that the culvert beneath the POS appears to be a key constraint. Therefore, a third Scenario (Scenario 3 – upgraded culvert and a swale) was tested to provide an indication of the likelihood that this approach could alleviate flooding upstream/downstream.

In summary, Scenario 2 does not affect the flood inundation upstream/downstream of the POS, however the modification provides some additional detention capacity within the POS, increasing the flood extent in the POS. Scenario 3 was found to provide some measure of relief to flood inundation upstream of the POS area. Further culvert increases could see additional benefit, notwithstanding it is possible that this could also result in an increase in flood extents further downstream near Yam Holes Creek.

5 REFERENCES

5.1 General references

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