Creamery Road Development Services Scheme

FUNCTIONAL DESIGN REPORT (REVISED FINAL)

December 2022

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Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This draft report has been prepared by Alluvium Consulting Australia Pty Ltd for City of Greater Geelong under the contract titled 'Cowies Creek Stormwater Management Strategy'.

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Cover image: abstract river image, Shutterstock

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1 Introduction

As part of the Cowies Creek Stormwater Management Strategy, Alluvium, in collaboration with Water Modelling Solutions (WMS), has been engaged by City of Greater Geelong (The City) to prepare concept and functional drainage designs (Development Services Scheme) for the Creamery Road Precinct Structure Plan (PSP).

This report summarises existing conditions and issues as they pertain to stormwater management in the project area, as well as issues and constraints that may impact upon the implementation of future water management strategies in a post-development scenario. The aim of this report is to cover the analysis undertaken to develop stormwater management options to a functional design level.

This stormwater drainage strategy and functional design set of all stormwater related infrastructure required for the precinct will inform the Creamery Road PSP which will guide the future development of all land within the precinct; as well as inform the future Development Contributions Plan (DCP) which will identify and cost the suite of infrastructure required to support development of the land.

This report details the designs which have been developed to a functional level.

1.1 Location

The study area for this project is located within the Cowies Creek Catchment Management Unit (CMU) and Western Geelong Growth Area (WGGA). The Location is shown in Figure 1. The area of interest is bounded by the Geelong - Ballarat rail line to the north, the Geelong Ring Road (the Princes Freeway, M1) to the east, Ballarat Road (the Midland Highway, A300) to the south and the Geelong-Ballan Road (C141) to the west.

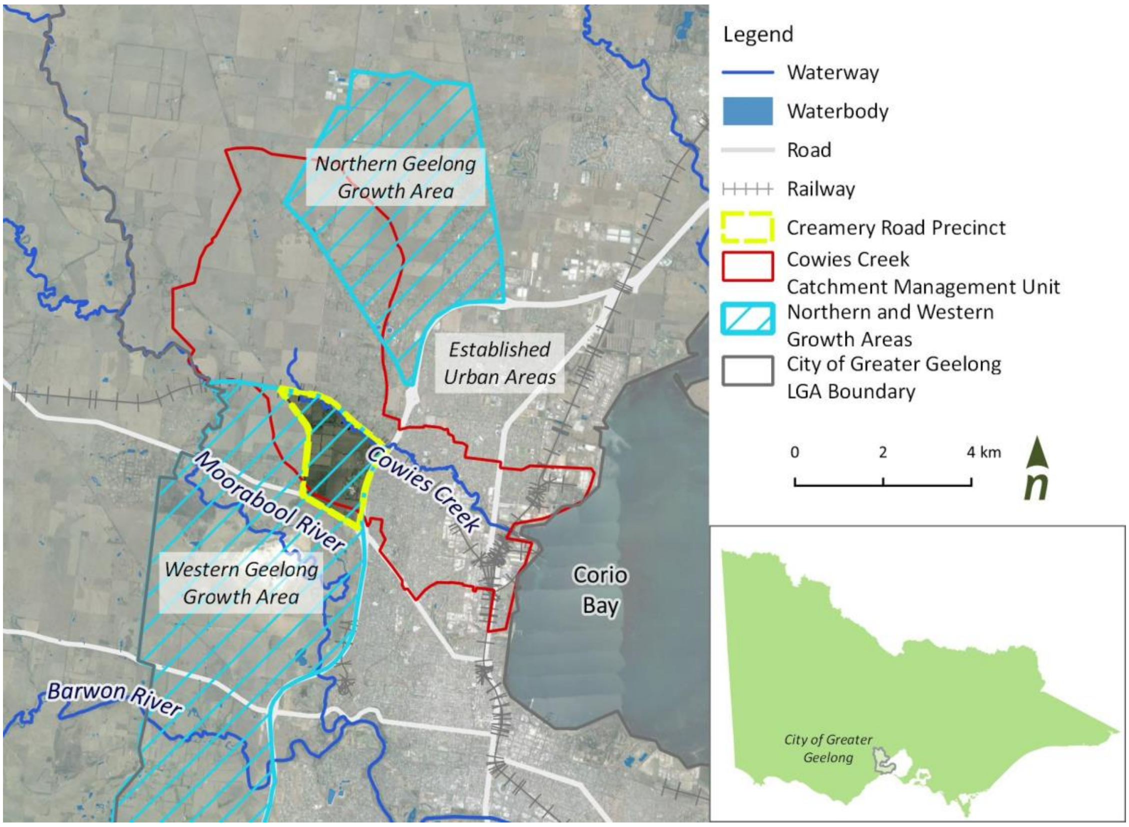


Figure 1. *Creamery Road Development Services Scheme within the Cowies Creek CMU and Western Geelong Growth Area*

1.2 Project background

Development Services Schemes (DSS) are prepared to plan for any required infrastructure to make sure new urban development meets appropriate standards for flood protection, water quality, and waterway health. DSSs also incorporate measures to protect natural systems along waterways and within the floodplain and recommend rehabilitation approaches where waterways and natural assets require improvements, or modifications to improve their health and function.

A DSS will incorporate a stormwater drainage strategy that will guide any resulting infrastructure, and the contributions in rates required to build and maintain them.

Two previous Stormwater Management Strategies (SWMS) have been proposed in the location:

- Stormwater Management Strategy and Flood Impact Assessment: Volume 1 Developed Conditions (Water Technology, May 2019)
  - covers the entire WGGA which informs the Northern and Western Geelong Growth Areas (NWGGA) Framework Plan
  - Creamery Road is part of the Cowies and Moorabool North area
- Western Geelong Growth Area – Creamery Road PSP (Cowies Creek) Alternate Drainage Strategy (Cardno, February 2020)
  - covering a portion of the site.

A review of these strategies has been completed by Alluvium and included in Appendix A. A review of the previous strategies was undertaken to ensure that the scheme was developed with new background information incorporated, project objectives and stormwater management requirements were met, and to ensure that best practice design was adopted.

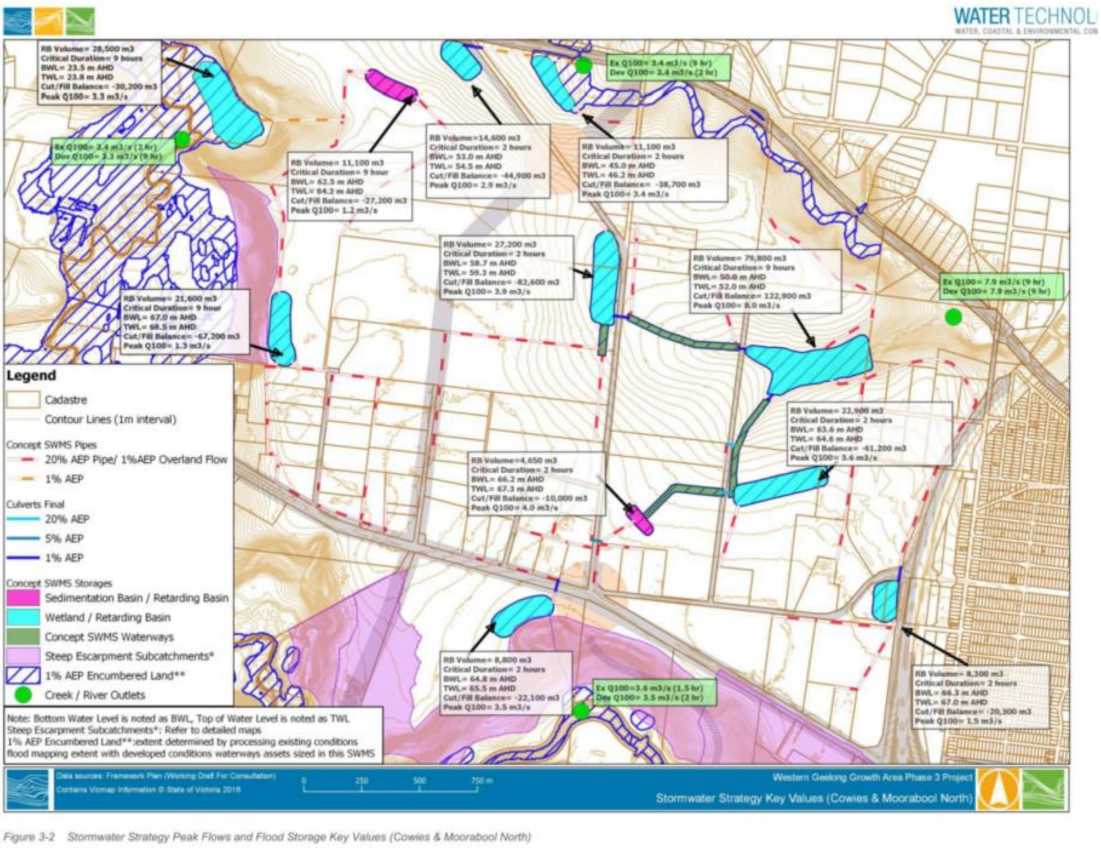


Figure 2. *Stormwater management layout (Water Technology, 2019)*

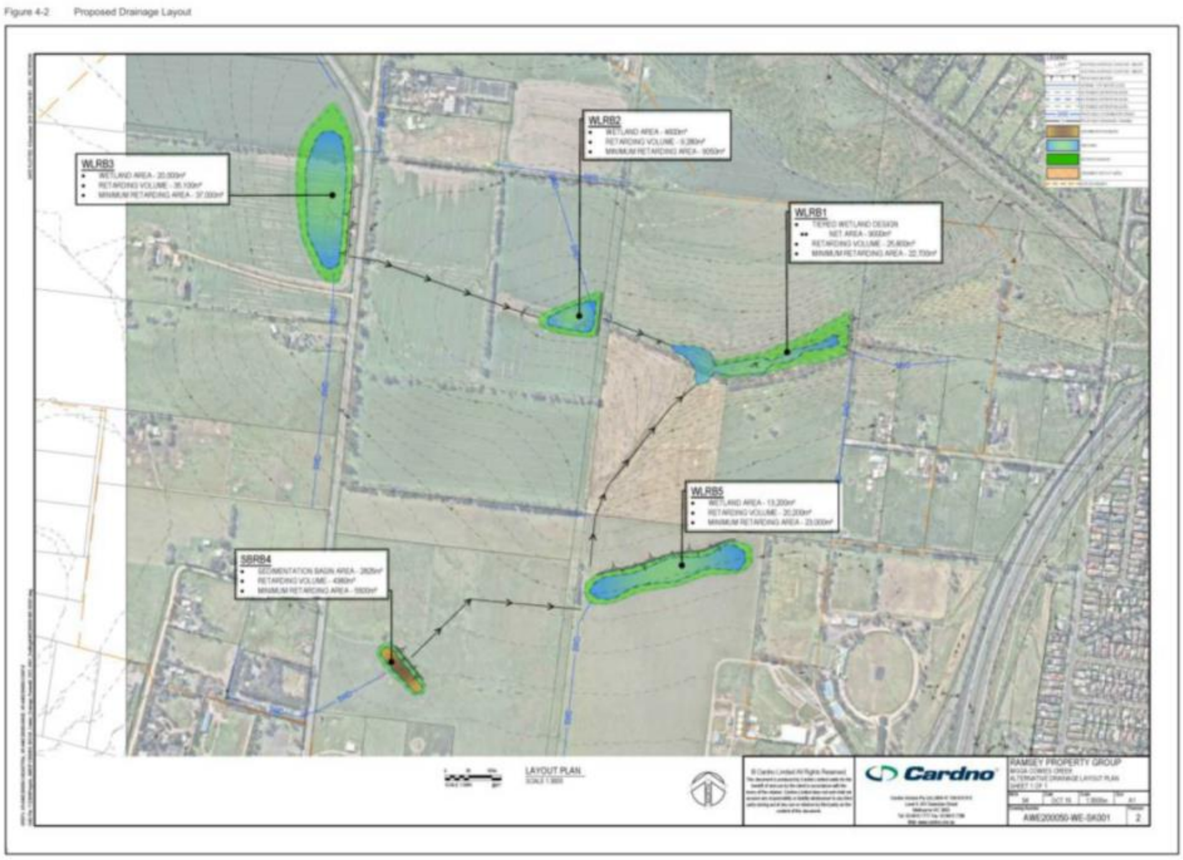


Figure 3. *Proposed alternate drainage layout (Cardno, 2020)*

1.3 Project Partners

The City is the local drainage authority for urban land in the region. There are numerous stakeholders to this study which include (but not limited to):

- The Victorian Planning Authority (VPA)
- Greater Geelong City Council (The City)
- Corangamite Catchment Management Authority (CCMA)
- Barwon Water
- Department of Environment, Land, Water and Planning (DELWP)
- Wadawurrung Traditional Owners Aboriginal Corporation (WTOAC)
- Developers
- Community (includes residents, landowners, businesses, community/Friends/Landcare groups etc.).

1.4 Project scope

This report is delivered as part of a larger catchment strategy for the Cowies Creek CMU. The scope of the DSS works is to:

- Review previous stormwater strategies
- Identify existing conditions (cultural heritage, flora and fauna, geomorphic, topography, catchments and hydrology, flood modelling)
- Undertake hydrologic modelling for existing and post-development scenarios
- Size retarding basin storages

- Undertake treatment modelling
- Develop concept designs and consult with stakeholders
- Develop functional design of all stormwater management (quantity and quality) assets
- Produce functional design drawings and cost estimates for the scheme.

This report details work undertaken up to the functional design stage. The functional designs follow on from final feedback and acceptance of the concept layout by Council.

1.5 Background information

For the scheme development, the following sources of information have been drawn on:

- Northern and Western Geelong Growth Areas Framework Plan (Final adopted - August 2020)
- Northern and Western Geelong Growth Areas IWM Plan (E2 DesignLab, March 2021)
- Clause 56.07-4 of the Victorian Planning Provisions (VPP) and Geelong Planning Scheme
- Infrastructure Design Manual (IDM)
- Urban Stormwater Best Practice Environmental Management Guidelines (BPEM, CSIRO 1999)
- Report on Geotechnical, Hydrogeological and Preliminary Environmental Study (Douglas Partners, May 2017)
- Existing Ecological Conditions: Northern and Western Geelong Growth Areas (Draft) (Ecology & Heritage Partners, 2021)
- Creamery Road PSP Aboriginal Cultural Heritage Impact Assessment (Unearthed Heritage, June 2021)
- Stormwater Management Strategy and Flood Impact Assessment: Volume 1 Existing Conditions (Water Technology, January 2019)
- Stormwater Management Strategy and Flood Impact Assessment: Volume 1 Developed Conditions (Water Technology, May 2019)
- Western Geelong Growth Area – Creamery Road PSP (Cowies Creek) Alternate Drainage Strategy (Cardno, February 2020)
- Stormwater Services Strategy 2020-30 (City of Greater Geelong, June 2020)
- City of Greater Geelong GIS layers
- Creamery Road Draft Concept Future Urban Structure (FUS) (City of Greater Geelong, August 2022 version)
- LiDAR Digital Elevation Model (2019, provided by The City)
- Cowies Creek – Hydraulics and Flood Intelligence Report (Water Modelling Solutions, August 2022)
- Melbourne Water MUSIC Guidelines (2018).
- City of Greater Geelong Stormwater Standard Drawings and Design Notes
- Melbourne Waterway Corridor Guidelines (2013)
- Melbourne Water Wetland Design Manual (2020)
- Melbourne Water Constructed Waterway Design Manual (2019).

1.6 Strategic drivers

Northern and Western Geelong Growth Areas Framework Plan (Final adopted - August 2020)
Geelong is Victoria's second largest city and is currently experiencing a significant economic boom, while facing associated development pressures to service a growing population for new residents and investors to the region.

In response to this challenge, the *Northern and Western Geelong Growth Areas (NWGGA) Framework* (2020) was developed to best guide the region's transition. The NWGGA is the largest greenfield planning project in regional Victoria and will be home for a further 110,000 new residents. The Framework is a high-level strategic document that guide's Greater Geelong's approach to sustainable urban growth that meets the aspirations of The City and its broader community. The Framework identifies the need for nine Precinct Structure Plans (PSPs) for the growth areas, with the first two priority PSPs now scheduled for preparation:

- Elcho Road East precinct, within the Hovells Creek CMU (parallel study)
- Creamery Road precinct, within the Cowies Creek CMU (this study).

The shared vision for Geelong's development future states (NWGGA Framework):

> *The Northern and Western Geelong Growth Areas will exemplify Geelong's transformation as a clever and creative city by building diverse, localised and sustainable neighbourhoods that prioritise self-sufficiency whilst maximising connections to the Geelong community, economy and identity.*

It is noted that large-scale developments are in demand in the Greater Geelong region and their implications in relation to the State Environment Protection Policy (SEPP - *Waters*) and need to comply with the EPA guidelines for best practice environmental management (BPEM) of urban stormwater is fundamental.

The Framework Plan urban development objectives of most relevance to the DSS development are:

- Create diverse and vibrant new urban communities: Plan for neighbourhoods that encourage community interaction by maximising public access and activity in high amenity destinations throughout the growth area.
- Integrate transport and land use planning: Deliver a comprehensive active transport network utilising the substantial river corridors and acknowledge the future potential of the rail corridor.
- Create growth areas with high amenity and character: Establish a district of lakeside and riverside neighbourhoods recognised for their healthy waterways and attractive open spaces that will enhance Geelong's local character.
- Protect biodiversity: Protect and regenerate biodiversity and cultural heritage values along the Barwon and Moorabool Rivers, Cowies Creek and the Dog Rocks Sanctuary and establish vegetated constructed waterways.
- Create integrated open space networks: Cultivate an exemplary open space network that links the Barwon and Moorabool Rivers to an iconic lake at the Batesford quarry and supports a network of recreation reserves and local parks.
- Plan for environmental sustainability: Create an integrated water management system based around the major catchments and prioritise active and public transport networks.

These objectives, along with numerous actions identified in the Framework, have been considered when developing up the assets throughout the precinct.

The long-term liveability of these precincts is critical, including how residents, visitors, businesses and workers to the region will be supported in terms of providing multi-functional and cost-effective infrastructure services that support accessibility to the natural environment (without compromising its values), movement and connectivity, while delivering resilience to climate change and urban heat stress. All of these elements can be enabled through a well-structured catchment management strategy for Cowies Creek CMU.

Plan 47 within the Framework Plan details the Creamery Rd Precinct. The plan shows the waterway corridors and drainage areas as per Water Technology's strategy.

Northern and Western Geelong Growth Areas IWM Plan (E2 DesignLab, March 2021)

Barwon Water engaged E2Designlab and Marsden Jacob Associates to deliver the Northern & Western Geelong Growth Areas IWM Plan in conjunction with the project funding partners - City of Greater Geelong Council and the Department of Environment, Land, Water and Planning (DELWP).

The project developed a clever and creative approach to IWM in the growth areas, which assists long-term liveability, climate resilience and cooler urban landscapes, and leadership in water sensitive cities thinking.

The IWM Plan sets out the vision and key objectives for IWM for the northern and western Geelong Growth Areas. It considers a range of possible IWM options that could support improved outcomes within the growth areas and for the broader region. A set of recommended infrastructure solutions and project initiatives are outlined in the Plan, including recommendations for the planning and staged delivery of recommendations within PSPs. These have been considered in the development of the concept designs for the Creamery Rd PSP.

The key IWM objectives include:

- Resilient and efficient water cycle
- Healthy waterways and aquifers
- Healthy landscapes and neighbourhoods
- A stronger community, economy and identity.

The recommended options directly relevant to the Creamery Road PSP and have informed the scheme include:

- Recycled water supply supporting growth
- Passively irrigated street trees
- Infiltration swales and billabongs
- Major waterway corridor enhancements (vegetation and canopy cover)
- Capture and transfer of treated stormwater from wetlands within developments to supplement regional water supplies
- Rainwater harvesting for non-potable demands in homes (if recycled water is not adopted)
- Stormwater harvesting for open space irrigation.

Stormwater Services Strategy 2020-30 (City of Greater Geelong, June 2020)

The City's *Stormwater Services (SWS) Strategy 2020-2030* provides a 10-year focus on the management of surface waters from flood mitigation to stormwater treatment for waterway health and using stormwater as a resource in the landscape through application of IWM principles and Water Sensitive Urban Design (WSUD) infrastructure solutions. The strategy's aim is to support Geelong's growth, health and liveability, through four goals:

Goal 1: Foster healthy and resilient communities

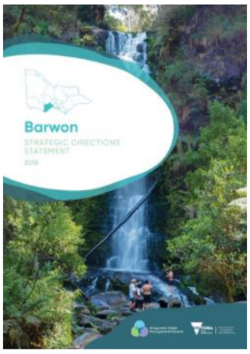
Goal 2: Support innovative and sustainable growth

Goal 3: Enhance built and natural environments

Goal 4: Create positive community experiences.

The following summarises key strategic documents that are directly relevant to, will influence, and/or align with key outcomes of this project.

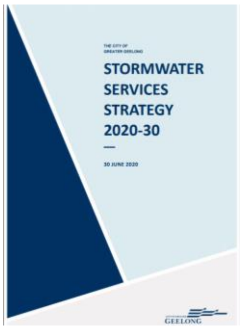
IWM Forum – Barwon Strategic Directions Statement (SDS)



The SDS has a region-specific vision, outcomes, objectives, and priority actions. Collaboration between Traditional Owners, Councils, Water Corps, CMAs, and DELWP, has led to shared ideas, buy-in, and momentum. Opportunities identified through this project will demonstrably align with the following outcomes:

1. Safe, secure and affordable supplies in an uncertain future
2. Effective and affordable wastewater systems
3. Avoided or minimised existing and future flood risks
4. Healthy and valued waterways and marine environments
5. Healthy and valued urban, agricultural, rural and green landscapes
6. Traditional Owner and community values reflected in place-based planning
7. Jobs, economic growth and innovation.

Stormwater Services Strategy 2020-2030 (Greater Geelong)



The stormwater services strategy aims to outline a clear pathway for managing Greater Geelong's stormwater into the future under pressures from increasing population and climate change. The mission is to lead the adaptation and integration of stormwater services to support the city's growth, health and liveability, which is supported by four goals:

1. Foster healthy and resilient communities
2. Support innovative and sustainable growth
3. Enhance the natural and built environments
4. Create positive community experiences

This strategy provides objectives and targets for the next 10 years and outlines priorities and actions to be undertaken.

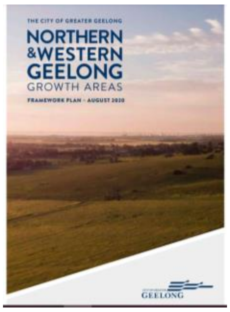
Flood Management Plan (Greater Geelong)

Flood Management Plan

The Flood Management Plan aims to lead in best practice flood management, with strong advocacy and partnerships with key stakeholders, and centralised knowledge base for flood risk management. It seeks to be adaptive in responding to future uncertainties in a changing environment.

Vision: As a clever and creative city, the city seeks to be knowledgeable, engaging and proactive in the management of riverine and stormwater flooding to develop a resilient community that is safe, prepared and informed.

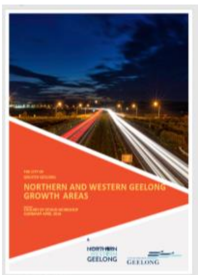
Northern and Western Geelong Growth Areas Framework (2020)



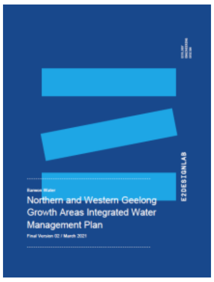
The City and the Victorian Planning Authority (VPA) developed the NWGGA Framework to provide a shared vision for the future of Geelong and guide the sustainable development of nine major development precincts. The N-W Growth Area is the largest greenfield development in regional Victoria and will service a further 110,000 new residents.

The Framework was adopted by The City and will be embedded into the Planning Scheme through Amendment C395. The first two PSPs to be developed are the Elcho Road East precinct and the Creamery Road precinct.

Northern and Western Geelong Growth Areas Enquiry by Design Workshops

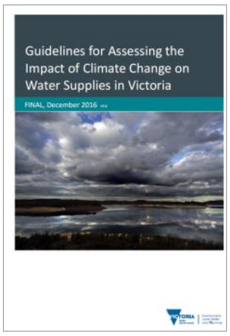


A series of workshops were held (2017-18) with a range of key stakeholders including landowners, educational institutions, emergency services, utility providers, water authorities, the CMA and a number of state depts (DELWP, DHS, DET, SV, VicRoads, etc) who came together to present and assess the preliminary urban structure plan for the northern and western Geelong growth areas, to refine and test the plan against an established vision and principles for urban development growth in the region. These findings helped inform the Northern and Western Geelong Growth Areas Framework (2020).



Northern and Western Geelong Growth Areas IWM Plan report

This IWM Plan sets the vision and key objectives for IWM for the entire Northern and Western Geelong Growth Areas. It considers a range of possible IWM options that could support improved outcomes within growth areas, and broader region. Recommended infrastructure/initiatives are provided along with planning and staged recommendations for delivery within Precinct Structure Plans. The Plan also recognises the dynamic nature of development, climate, economies, policy, and knowledge over a long delivery timeline. It sets out an adaptive pathways plan to build in future flexibility and resilience.



Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria (DELWP, 2016)

This document provides a guideline for planning for climate variability and climate change, translating Global Climate Models into projections for Victorian river basins. The document can inform the Cowies Creek SWMS through assessment of future system reliability, urban water strategy planning and drought preparedness. The combined decrease in rainfall and increase in temperatures will result in a larger impact on runoff of 15.6%. Aquifer recharge will also be impacted.

This modelling and DELWP's recommendations will guide our understanding of issues, particularly for systems that are at risk with a reduction to rainfall and runoff, and our considerations of the effectiveness of climate dependant alternative water sources (such as rainwater and stormwater harvesting).

2.2 Land use

Current land use is predominately farming with small scale grazing and cropping with some low-density housing. Covenant College, a K-12 private school, and Myers Reserve, a public park for active recreation are located along the eastern border.

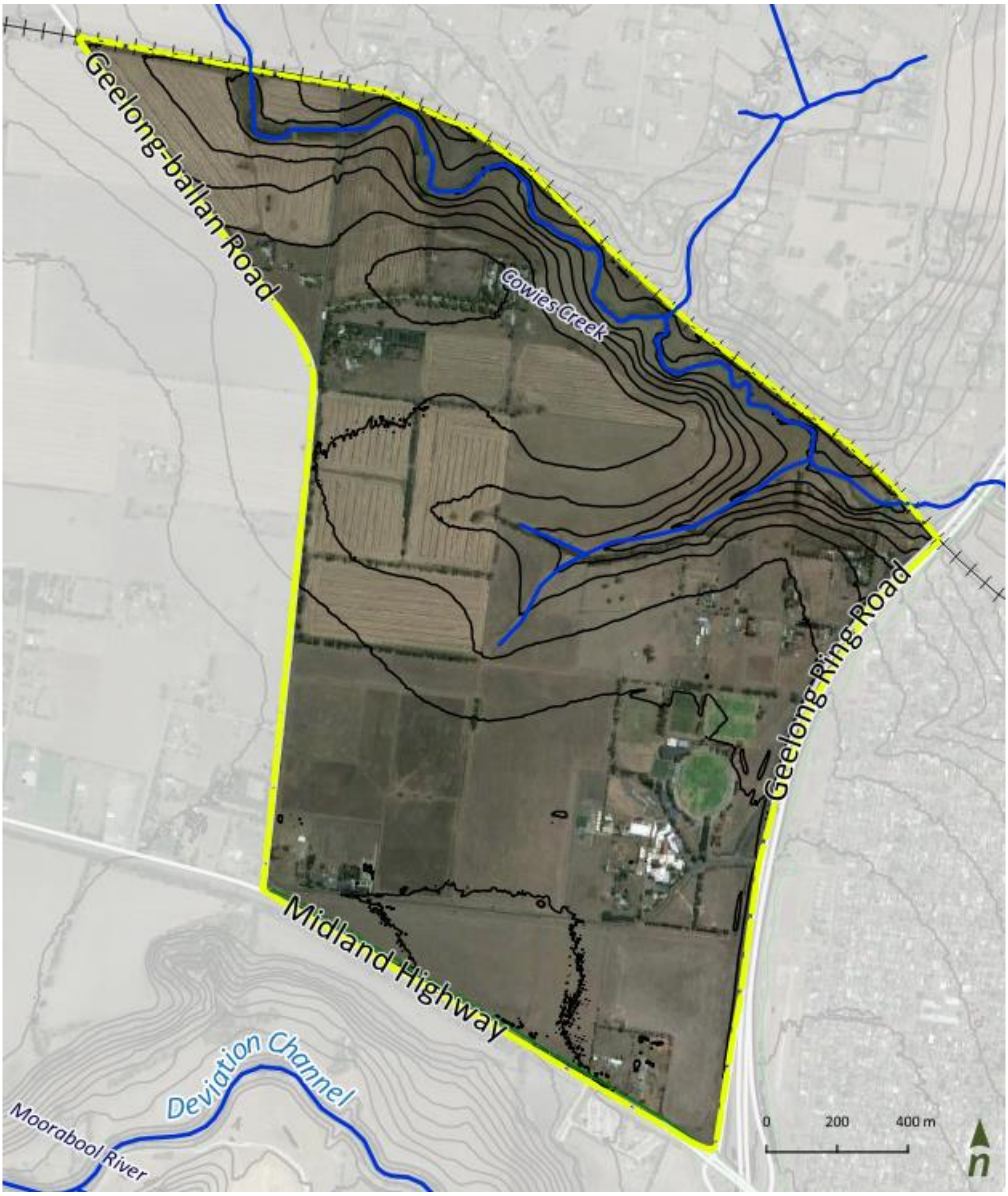


Figure 5. *Current land use*

2.3 Geology

The Creamery Road Precinct is within the Western Volcanic Plains, which is made of both volcanic plains from the Newer Volcanics Group, and marine sedimentary plains, mapped in Figure 6.

- The precinct is largely dominated by basalts from the Newer Volcanics Group
    - Quaternary (Miocene-Holocene) lava flows, 'older' Newer Volcanics formed between 1-2 million years ago.
    - The basalt profile typically comprises high plasticity clay over variably weathered basalt rock.
    - Basalt boulders/core stones/floaters often occur in the clay profile above the rock head.
- Along the creek lines and valleys the underlying Black Rock Sandstone (also known as Sandringham Sandstone) and Gellibrand Marl – marine sedimentary deposits from the Miocene.
- The downstream end of the creek has unconsolidated alluvial sediments with significant sand, silt and gravel.

There are no sites of geological and geomorphological significance within the study area.

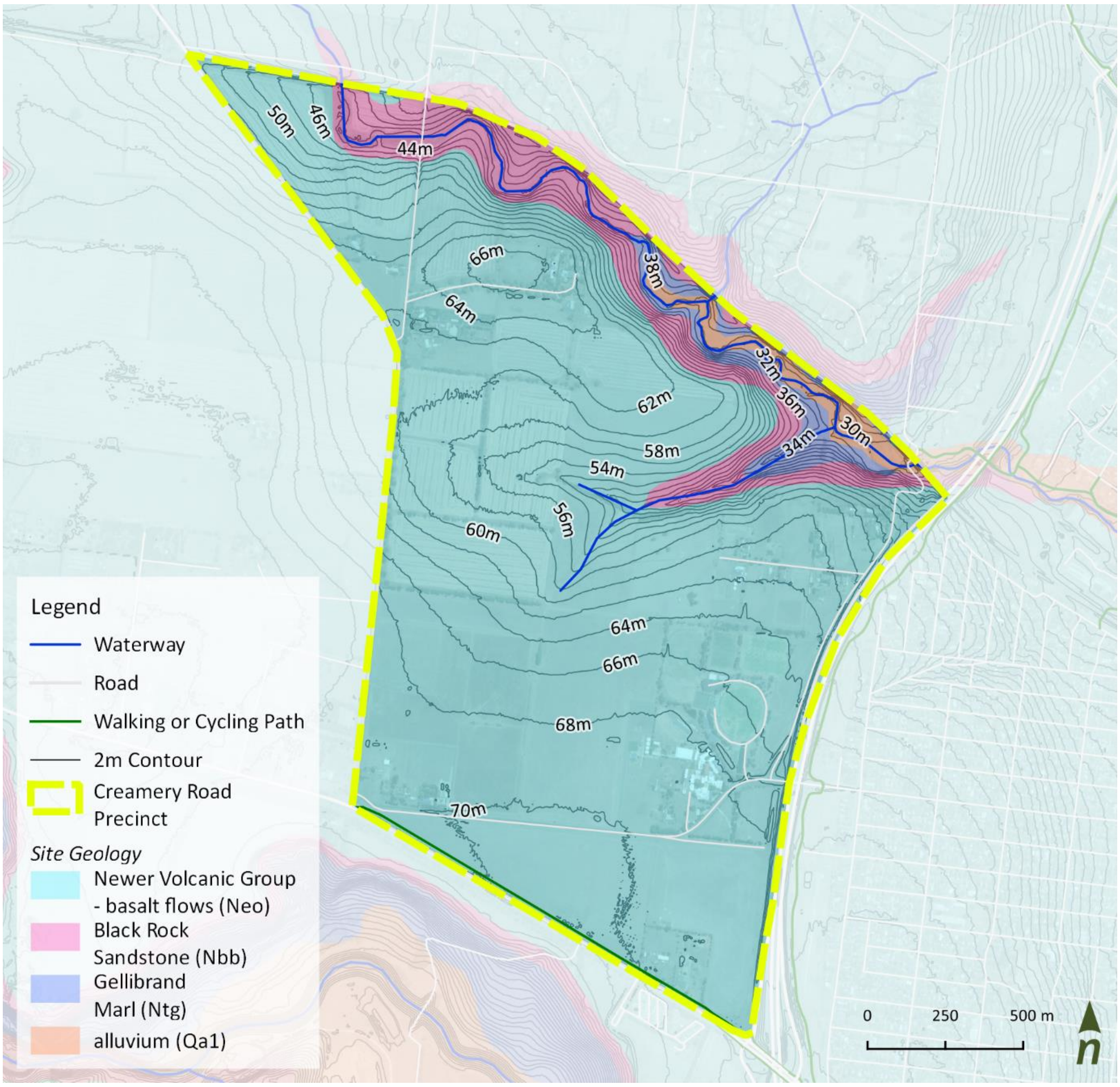


Figure 6. *Geology of the project study area (Source: DELWP/Vicmap, 2020)*

Report on Geotechnical, Hydrogeological and Preliminary Environmental Study (Douglas Partners, May 2017)
The report presents the results of a geotechnical, hydrogeological and preliminary environmental study undertaken for the Western Geelong Growth Area Project. Findings relevant to the Creamery Rd Precinct include:

- Boreholes 26, 27 and 28 (located within the Creamery Rd Precinct). The materials can be summarised as topsoil, silty clay and basaltic cobble.
- Groundwater was not encountered during the investigation.
- No significant soil contamination was detected.
- Fyansford Formation clay is exposed on the Moorabool River and Cowies Creek banks. This material has historically failed even at relatively shallow slope gradients (1V:3.3H).
- Whilst the basaltic clays are typically of low permeability, they are also typically dispersive. Therefore, the use of these as clay liners will need careful consideration and potentially further erosion protection will be required.

The geotechnical report indicates that there are potential slope stability issues within the areas (particularly around Cowies Creek and the tributary), and also for the potential for dispersive clays. Figure 7 shows the geology of the region, as well as the landslide susceptibility.

Technical Memorandum: Creamery Road PSP – Geotechnical Assessment (Draft) (GHD, August 2022)
GHD were engaged by the City of Greater Geelong to provide advice on geotechnical conditions in the Creamery Rd Precinct, and considerations in relation to landslide susceptibility. The assessment included a desktop review, site walkover, assessment of landslide hazards and susceptibility based on the review.

The assessment included a review of the Douglas Partners susceptibility mapping, with the aim of updating mapping and recommendations, where considered necessary. The GHD assessment generally agreed with the mapping by Douglas Partners.

The mapping categorised the landslide susceptibility into zoning, as shown in Table 1. The medium susceptibility zone includes slopes <5 °. The high susceptibility zone includes slopes >10°. Mapping of the landslide susceptibility is provided in Figure 8.

Table 1. Summary of susceptibility zones (GHD, 2022)

Table 3 Summary of susceptibility zones

Landslide susceptibility zone	Implications for development
Low susceptibility (Green)	There are no restrictions to development
Moderate susceptibility (Orange)	Any development within this zone should undertake a geotechnical assessment in accordance with AGS 2007 (Australian Geomechanics Guidelines for Landslide Risk Management). The assessment should determine whether risk is acceptable, tolerable or unacceptable. In the absence of existing risk evaluation criteria, AGS 2007 recommendations for risk criteria should be adopted.
High susceptibility (Red)	Avoid development in this zone. Any permanent structures would have exposure to landside hazards. Should development be required in this zone (should not include habitable development or structures occupied for extended periods) then a full geotechnical assessment which includes detailed subsurface investigation and risk evaluation for both individual risk and societal risk must be undertaken. The assessment should achieve Low to Very Low risk levels (deemed acceptable risk) to allow development

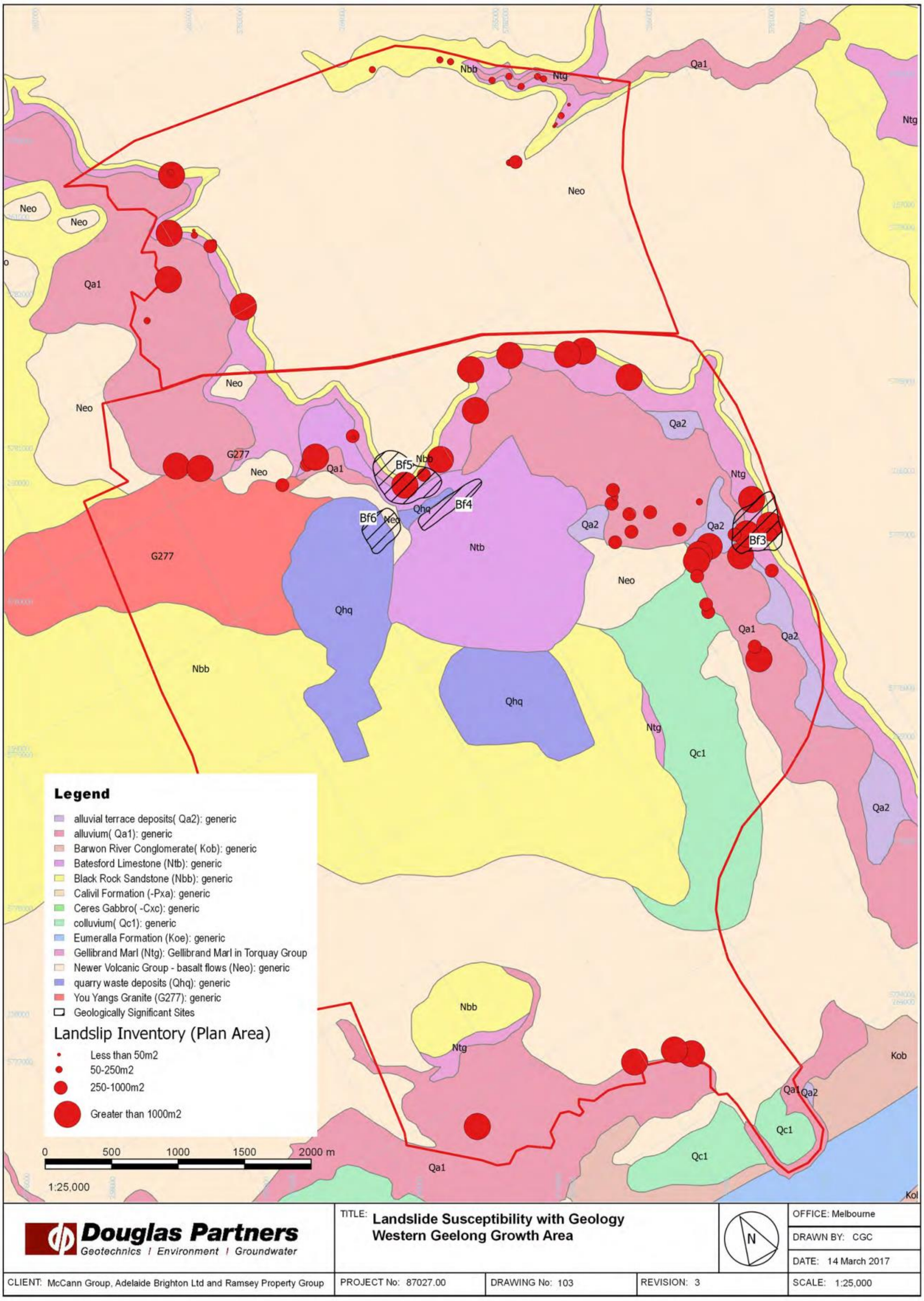


Figure 7. *Geology (Douglas Partners, 2017)*

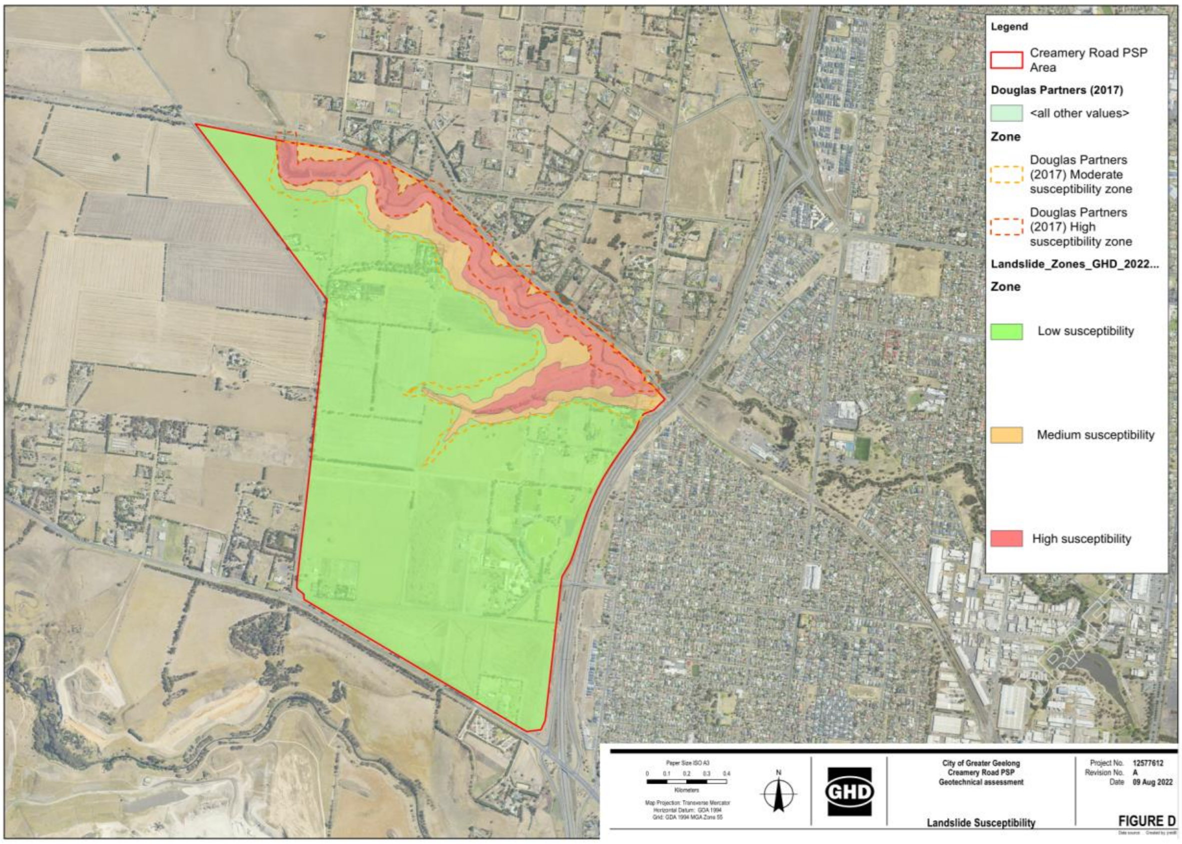


Figure 8. *Landslide susceptibility (GHD, 2022)*

Impact on DSS:

- Assets will avoid unstable slope areas and ensure slope stability is managed within assets.
- Design of assets should consider dispersive soils and erosion protection.
- Alluvium will site wetland/ retarding basins outside of the GHD medium landslide susceptibility zoning given the potential risk of failure.

2.4 Topography

The majority of the site is relatively flat, with a slope developing into the valley of Cowies Creek and its tributary. Figure 9 shows the slope and elevation change across the site with observed areas highlighted.

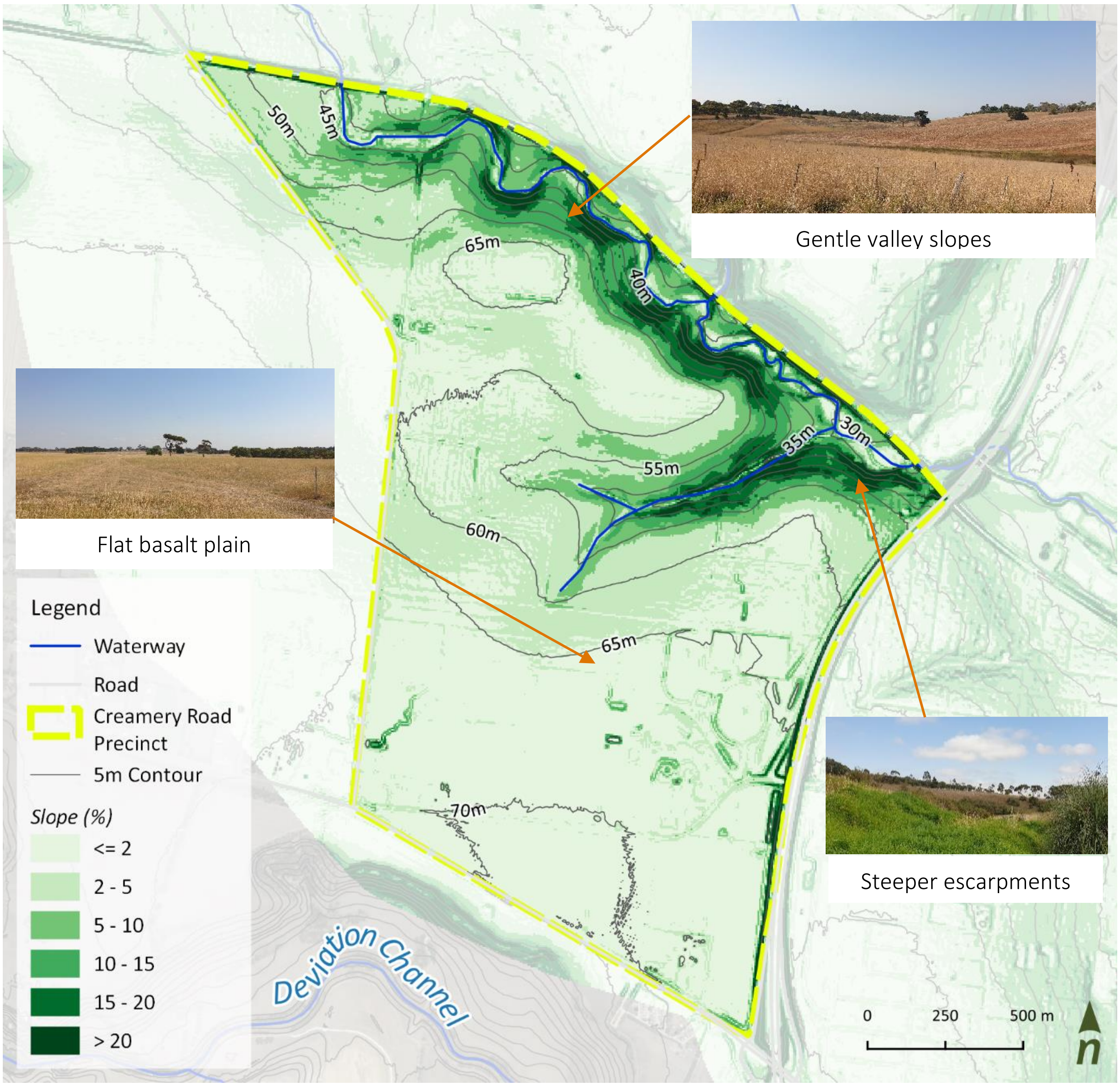


Figure 9. *Site topography and observations*

Impact on DSS:

- Stormwater management assets will avoid steep escarpment areas to reduce design complexity and earthworks.
- Stormwater management assets will be designed to manage stormwater outside of the stream valley to protect this waterway.

2.5 Soils

Soil types have been mapped from Vicmap (DELWP, 2020), in line with the Australian Soil Classification (Figure 10). Data indicates that the site is brown vertosols, with black vertosols on the waterway – the soils data set is at a low resolution and there may be some cross over with this area. No data is given for the urbanised region of Geelong, including an area in the northeast of the precinct –this presumably matches the vertosols.

Vertosols are clayey soils with "shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates". Cracks are at least 5mm wide and generally appear at the same time each year. Cracks were visible on the site visit in March (inset Figure 10). The broader catchment is dominated by vertosols (Figure 11).

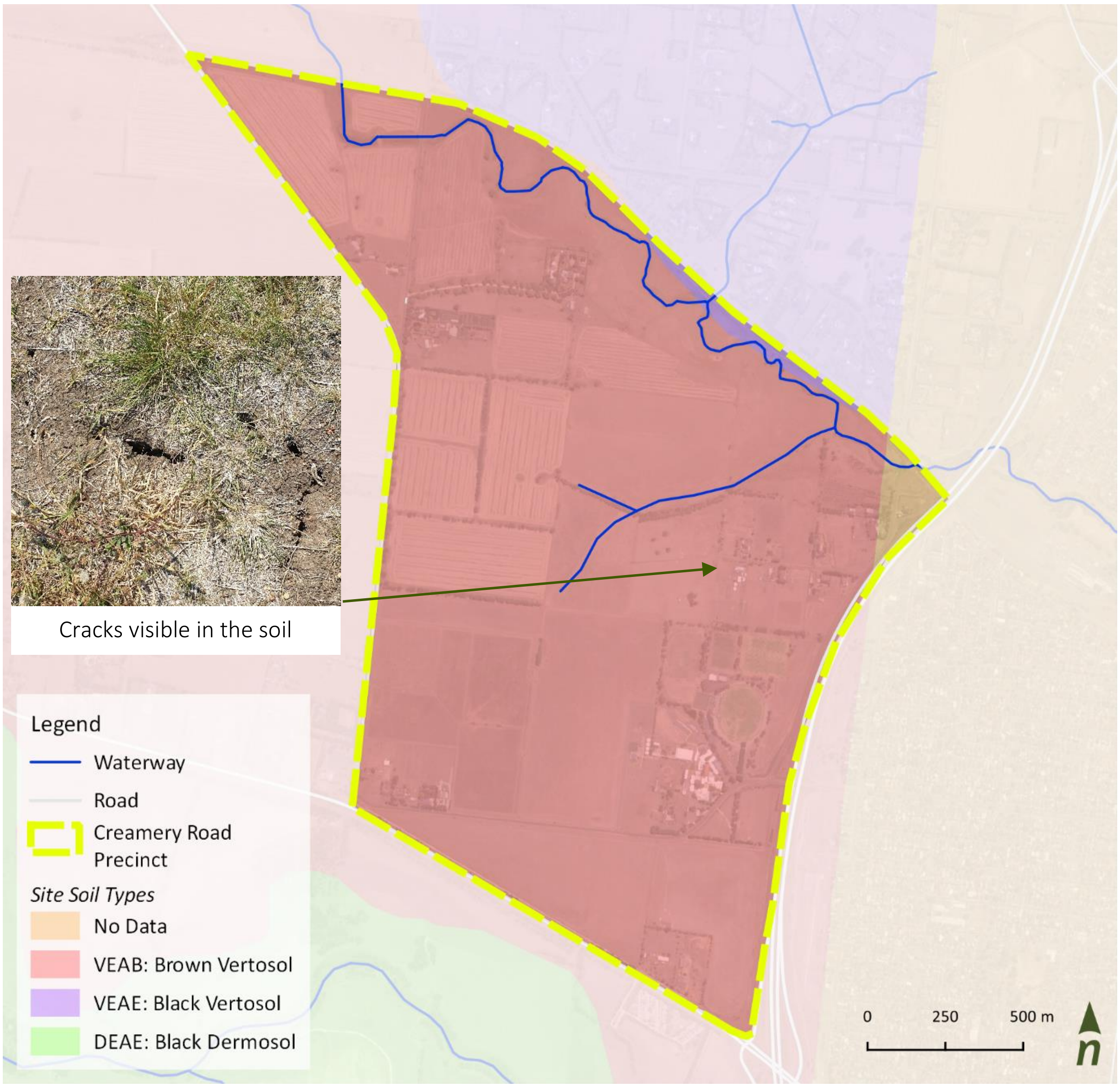


Figure 10. *Soils across the project study area (Source: DELWP/Vicmap)*

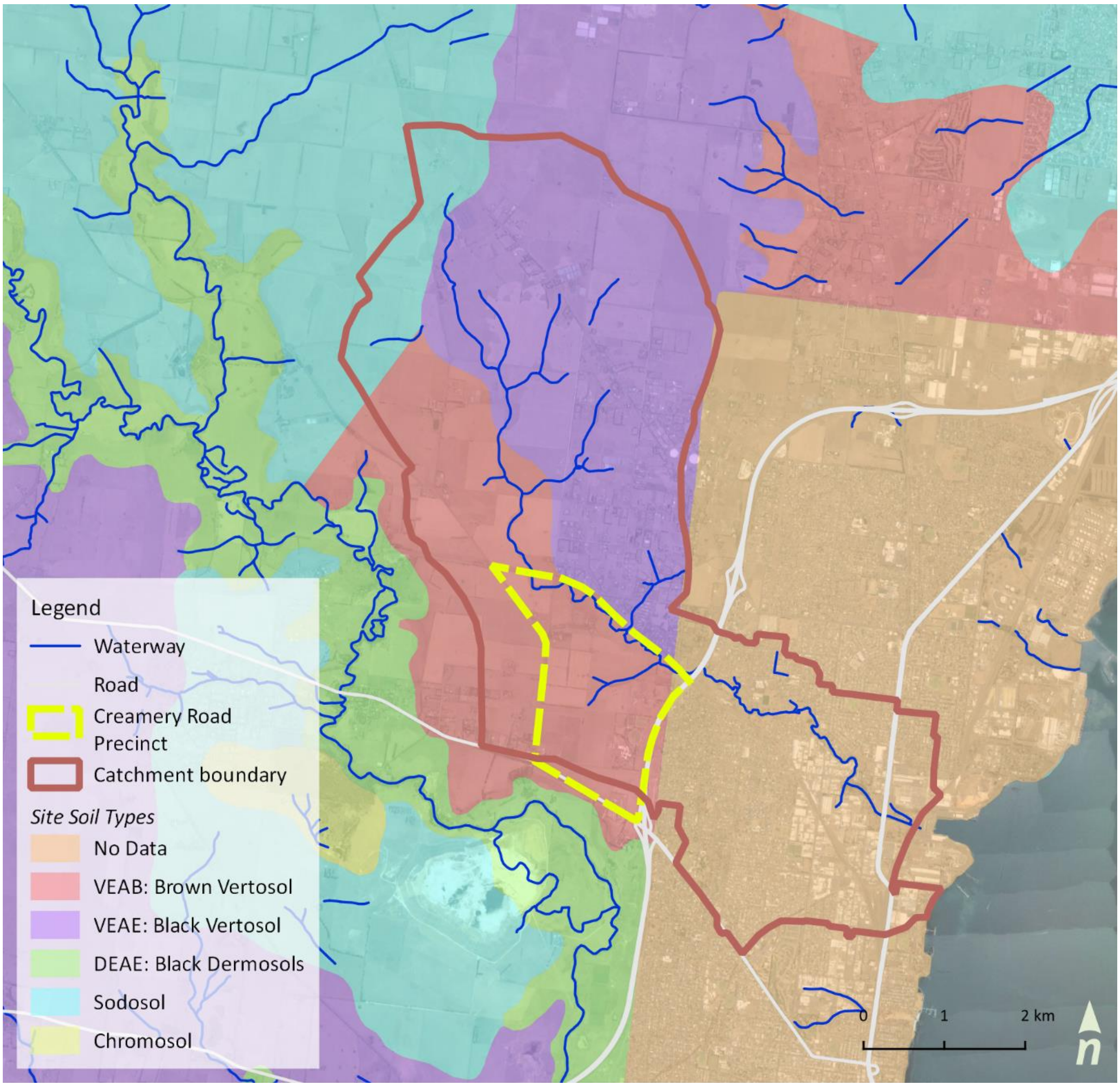


Figure 11. *The catchment is dominated by vertosols*

Impact on DSS:

- Stormwater management assets will avoid steep escarpment areas to reduce design complexity and earthworks.
- Further geotechnical assessment should determine whether site clays are appropriate to use within the wetlands and sediment basins as impermeable clay liners (cost benefits in reuse vs disposal and importation of new).

2.6 Contamination

Meinhardt Infrastructure & Environment (Meinhardt) were engaged by The City in late 2020 to complete a Land Capability Assessment for selected parcels within the Creamery Rd PSP. An addendum was undertaken in August 2021 as a result of the update to the Planning Practice Note for Potentially Contaminated Land.

The objective of the addendum was to provide guidance on the outcomes of the identification of potentially contaminated land within the precinct to understand the capability of residential, commercial and industrial land uses and inform strategic decisions.

The assessment (desktop and site inspections) identified the potential for contamination, as well as potential contamination sources and contaminants of concern. No sampling and analysis of soils, surface water or groundwater was undertaken.

Some of the identified potentially contaminating activities included the following:

- Cropping and agricultural activities (metals, herbicides, pesticides, nutrients)
- Importation of fill material for earthworks/ construction (heavy metals and other contaminants)
- Stockpiling of imported fill / excavated material (heavy metals and other contaminants)
- Burning or burial of wastes on rural properties (heavy metals and other contaminants)

To assess whether an environmental audit is necessary, a Potential for Contamination (PfC) assessment was undertaken (Figure 12). The ratings were based on the outcomes of the desktop assessment. No properties were identified as having a high PfC. One property was identified as having a medium PfC, and all others were identified as having a Low PfC.

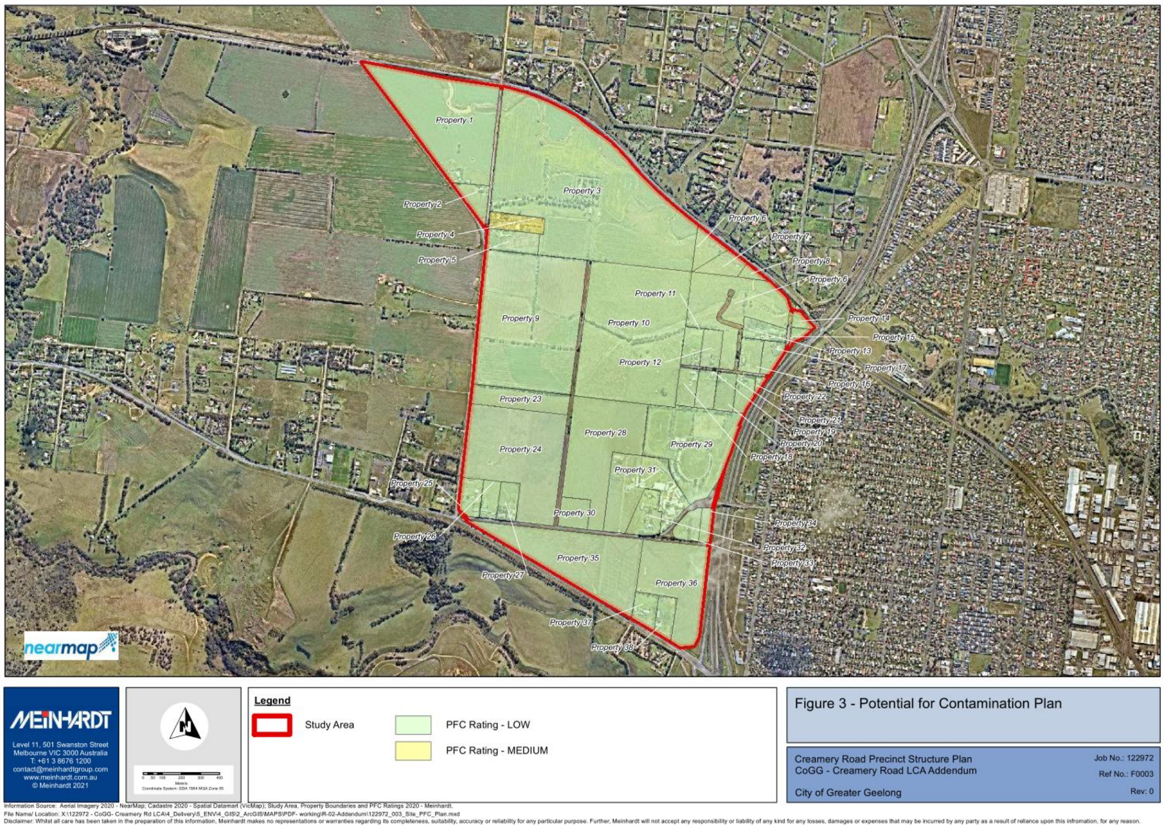


Figure 12. *Potential for Contamination assessment (Meinhardt, 2021)*

Impact on DSS:

- No stormwater management assets have been proposed within the medium contamination risk areas.

2.7 Catchment and waterway geomorphology

Geomorphological Management Units (GMU)

Geomorphological Management Units provide a classification of diverse information about the landscape, geology, stratigraphy (rock and soil layering) and geomorphometry (quantitative land surface analysis) of an area. As with the soil type and geology, the site is dominated by one GMU, with others at the edges and towards the creek. The units are shown in Figure 13 and listed below.

6.1.3 Volcanic Western Plains with poorly developed drainage

This GMU covers the majority of the precinct. It is characterised by plains with poorly developed drainage and a thin regolith (blanket of unconsolidated, loose, superficial deposits covering base rock) formed on the basaltic lava flows of the older Newer Volcanics. Natural drainage lines generally formed along the boundaries of lava flows. Discontinuous drainage lines can form ephemeral wetlands and swamps – this was not observed within the study area given the largely altered landscape.

6.2.4 Plains, rises and low hills of the Sedimentary Western Plains

In the precinct, this GMU occurs along the creek area and is characterised as sedimentary plains mainly comprising the marine pliocence sand deposits (i.e. Blackrock Sandstones – see Geology, section 2.3) and exposed underlying Gellibrand Marl. The unit appears as windows in the volcanic plains where lava flows did not cover the sedimentary deposits.

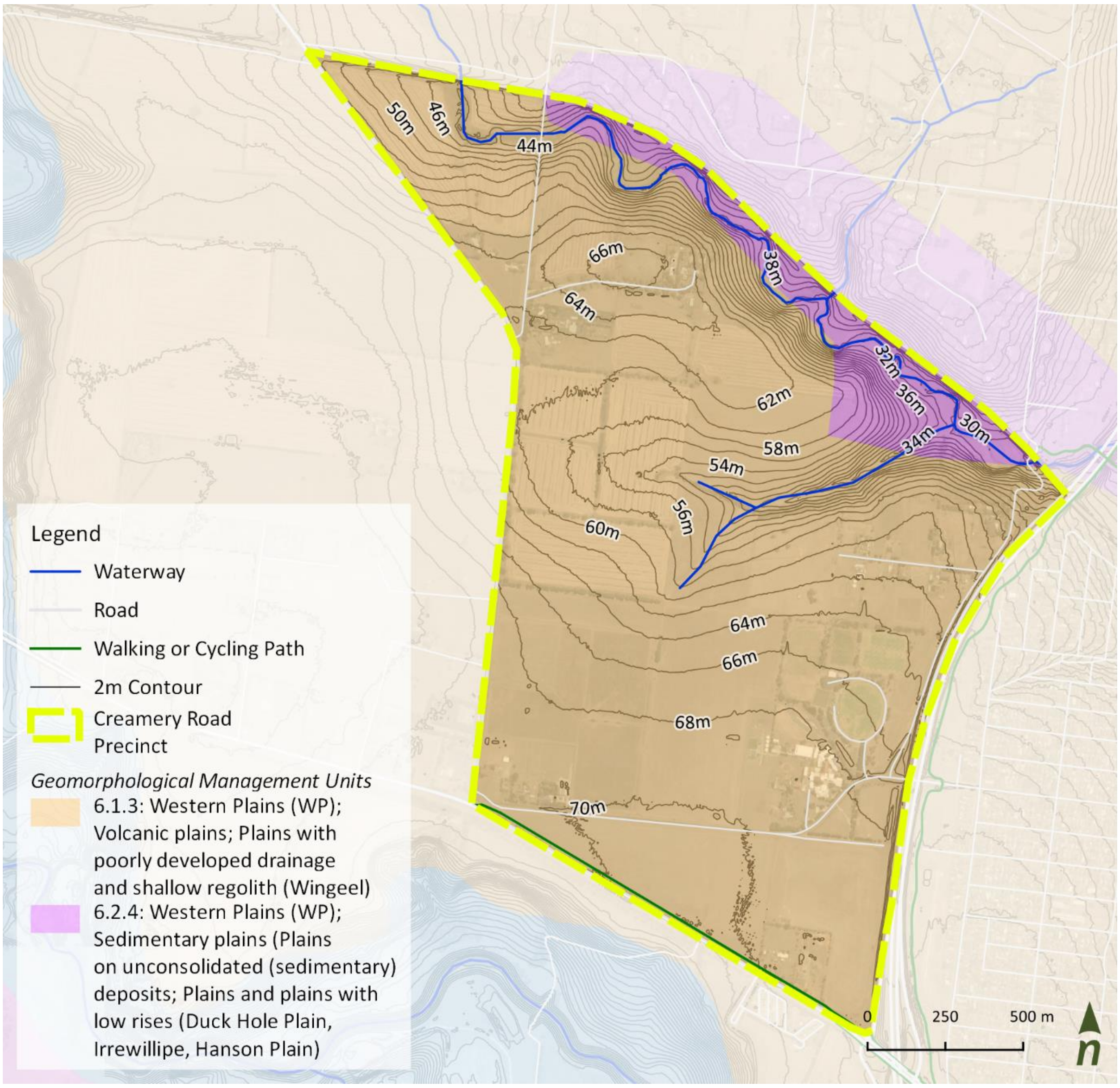


Figure 13. *Geomorphic management units across the project study area*

Waterways

A 2.5km reach of Cowies Creek flows through a valley on the northern section of the site. Cowies Creek flows from its headwaters, wetlands 3km north-east of the site, and drains into Corio Bay approximately 3.5km downstream in North Geelong. Downstream of the site the creek flows through an urbanised area. There is a second order stream which starts in the centre of the site and flows to Cowies Creek. Figure 14 shows the reach of Cowies Creek meandering through the precinct, looking upstream from the north-east corner of the site; the reach here is characterised by a confined valley with occasional floodplain pockets.

Figure 14. *Cowies Creek reach*

Impact on DSS:

- Stormwater assets will be designed to protect the receiving waterways (quantity and quality management).

2.8 Ecology

Ancestral

- The study area is located within the Victorian Volcanic Plains bioregion and based on DELWP's pre-1750 Ecological Vegetation Class (EVC) modelling, as EVC 132: Plains Grassland
- This is described as a treeless vegetation community mostly less than 1m tall dominated by largely graminoid and upright herb life forms. Occupies fertile basalt, heavier soils prone to seasonal cracking and waterlogging in areas receiving at least 500mm annual rainfall.

Existing

- Most of the vegetation throughout the study area is highly modified through previous and current agricultural practices, infrastructure, and development, there are some remnant vegetation areas indicated on mapping in Figure 15. Plains Grassland communities are considered endangered, and the area holds several species listed under the Victorian *Flora and Fauna Guarantee (FFG) Act 1988* and the national *Environment Protection and Biodiversity Conservation (EPBC) Act 1999.*

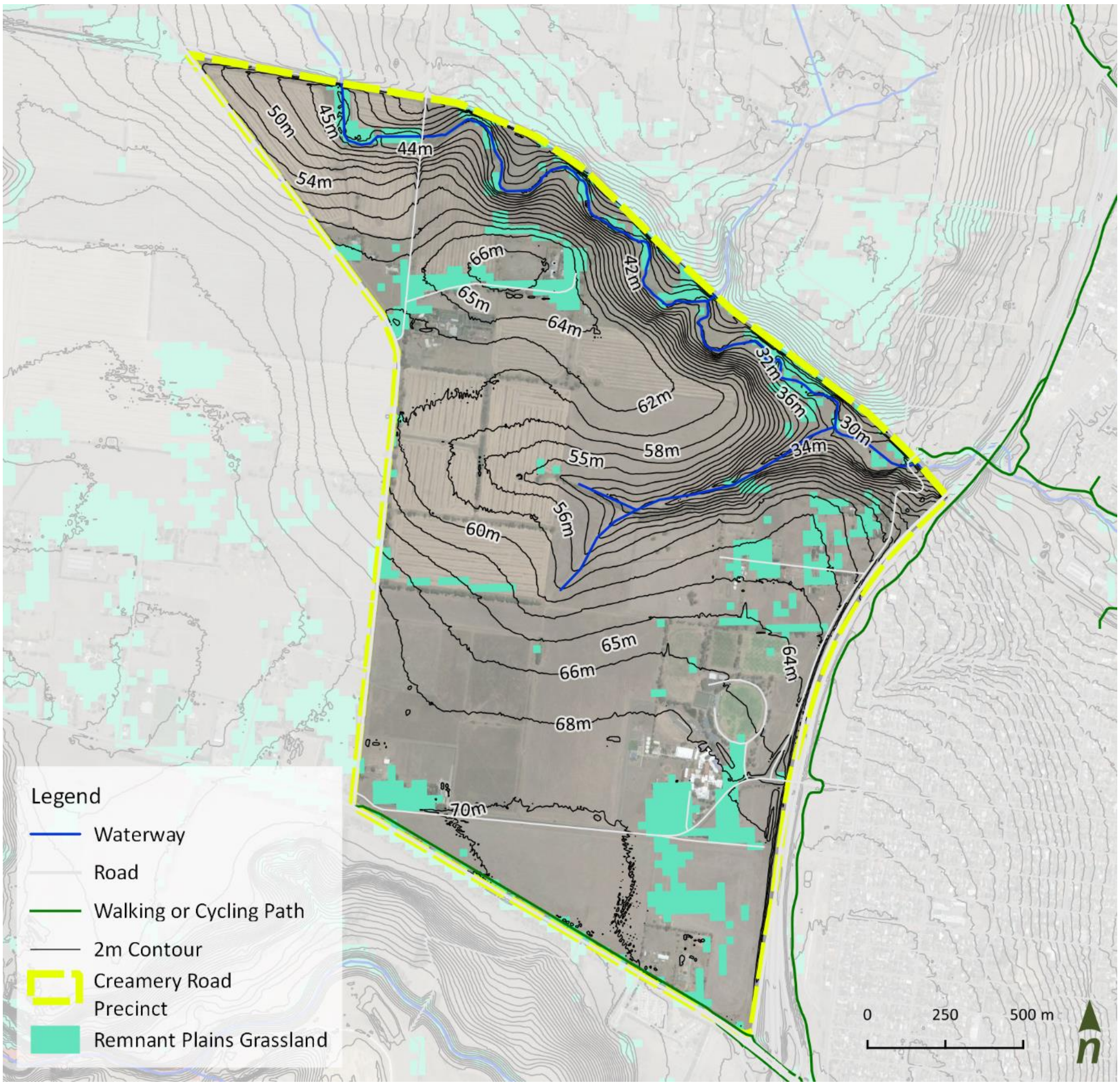


Figure 15. *2005 remnant EVC mapping of the study area (DELWP, 2020)*

Modelled EVCs provide some guidance about the landscape, however they need to be coupled with further interpretation to help guide ongoing planning and development decisions and actions for restoration and preservation in an urbanising catchment. Detailed investigations have been conducted by Ecology and Heritage Partners for the NWGGA and are summarised below.

Existing Ecological Conditions: Northern and Western Geelong Growth Areas (Draft) (Ecology & Heritage Partners, 2021)

Ecology and Heritage Partners were engaged by The City in 2021 to undertake a detailed ecological investigation for the Northern and Western Growth Areas to help inform further planning for the PSPs. The assessment focussed on identifying the location and extent of native vegetation, fauna habitat and species presence. A summary of findings and recommendations relevant to the Western Growth Area is provided below:

- The site is highly modified due to past and current agricultural and farming practices.
- Much of the indigenous vegetation and terrestrial fauna is confined to riparian corridors.
- The native vegetation is covered by three EVCs - Low Rainfall Plains Grassland, Creekline Grassy Woodland, Floodplain Riparian Woodland.

- No nationally significant flora was recorded in the study area.
- Along the Cowies Creek corridor is a confirmed habitat for Growling Grass Frog (GGF). "Given the confirmed presence of a viable population within the study area that is not isolated or fragmented from other habitats, it is considered that this population is an 'important population'."
- To mitigate against a potential impact to GGF and associated habitats, a buffer of 200 metres is recommended along each bank
- "Where possible, modification of stream banks should be located outside of areas supporting patches of native vegetation to avoid and minimise impacts to existing native vegetation."
- Feature waterways/landscaping and stormwater treatment infrastructure be designed as a series of smaller, connected systems (rather than one isolated basin) and designed to provide habitat for flora and fauna.
- Integrate WSUD techniques at appropriate scales (distributed systems) to manage urban runoff quality and provide linear habitat corridors and open space integration.

Alluvium notes that during the development of the functional designs, and through later iterations of the future land use, the GGF corridor reduced to 100m. The corridor is shown on the functional design drawings (Attachment F).

Maps showing the EVCs and recorded GGF are provided in Figure 16 to Figure 18, as well as a potential biolink network. The mapping shows the tributary of Cowies Creek as a potential habitat corridor.

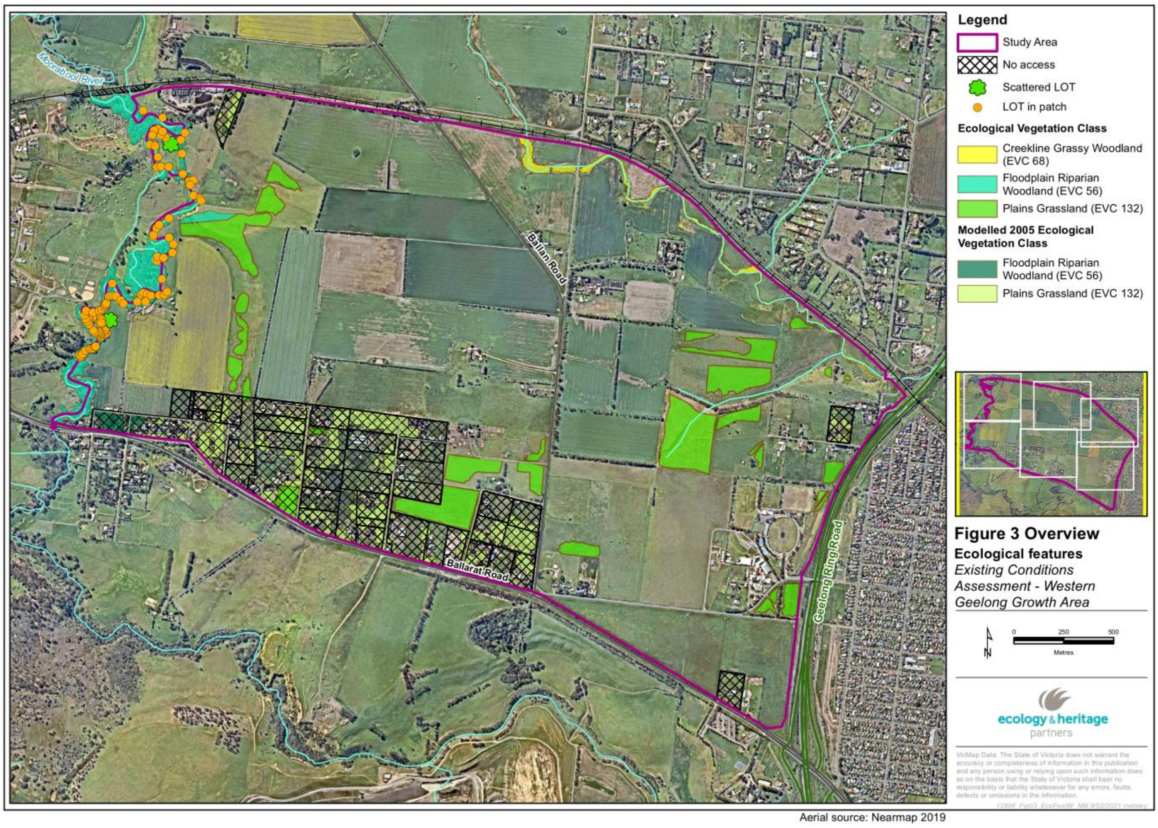


Figure 16. *Ecological features (Ecology & Heritage Partners, 2021)*

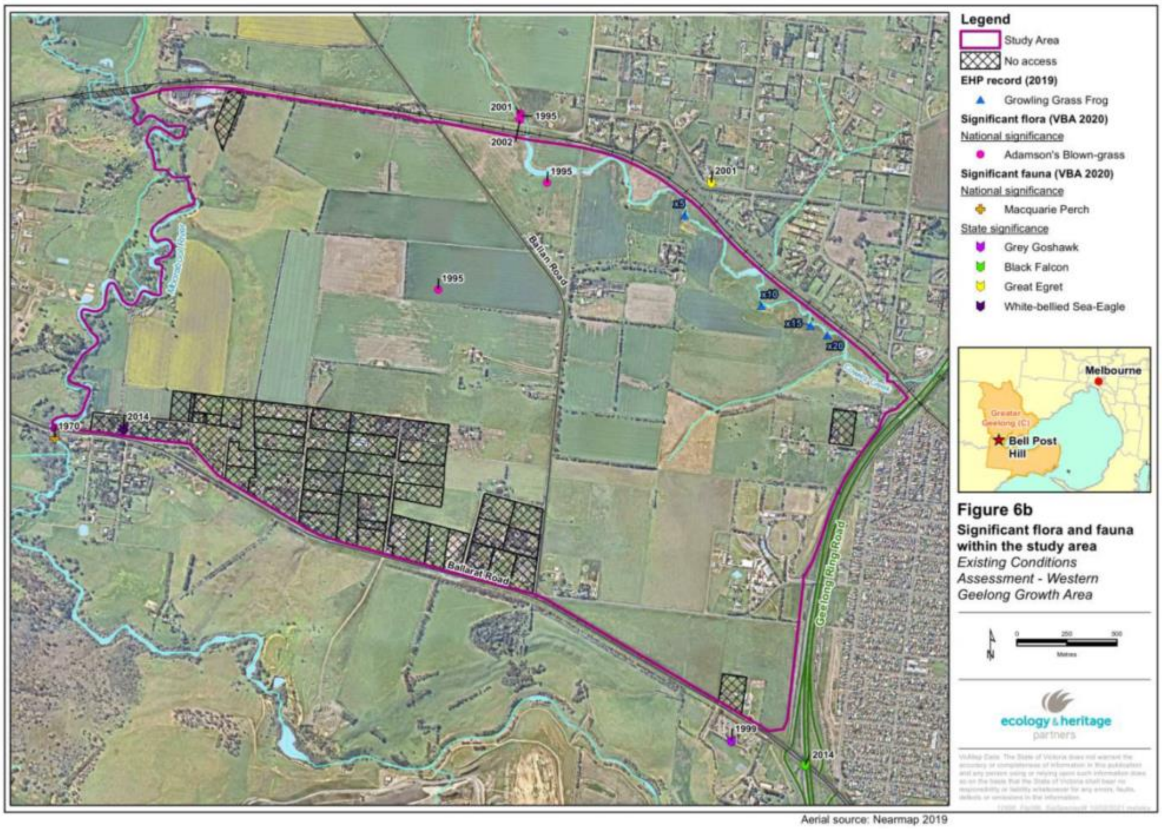


Figure 17. *Significant flora and fauna in the study area (Ecology & Heritage Partners, 2021)*

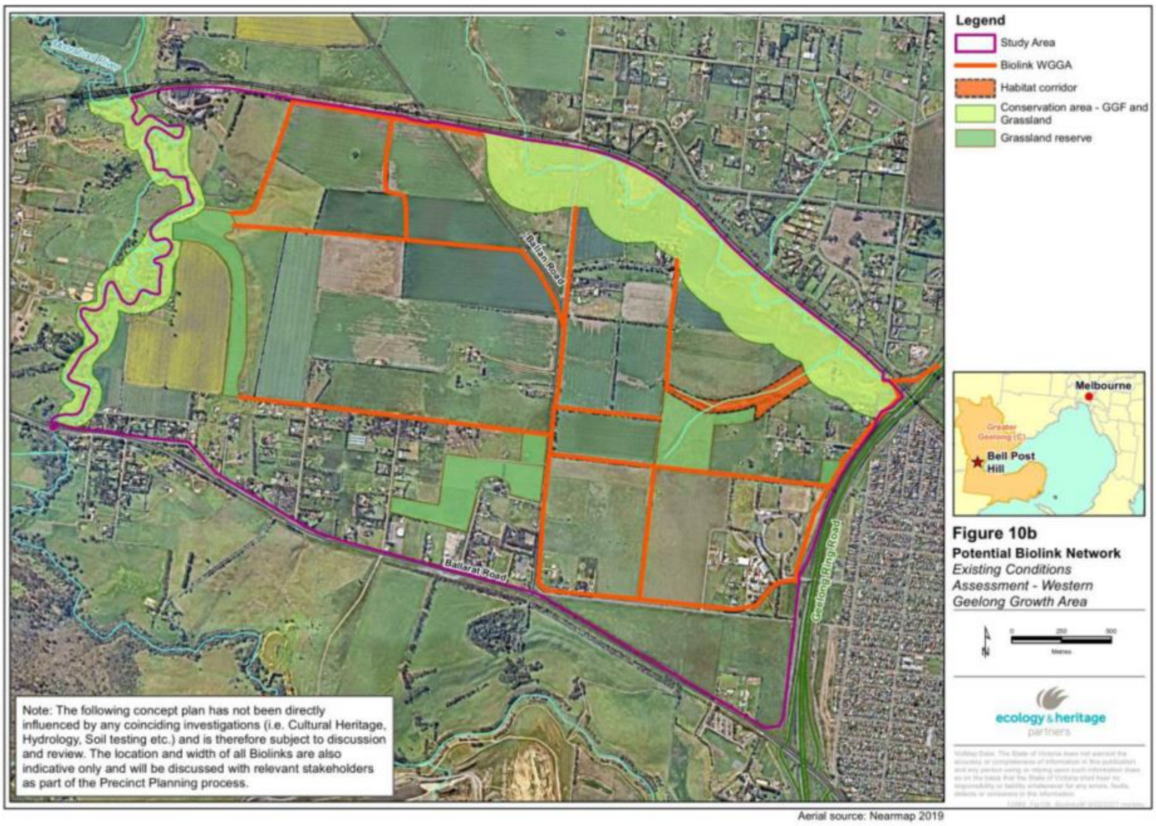


Figure 18. *GGF conservation area (Ecology & Heritage Partners, 2021)*

Alluvium notes that at the time of writing this report The City was developing a Biodiversity Conservation Strategy. An executive summary is currently available through the council website.

In consultation with The City during the development of the concept designs for the precinct, it was established that the native grasslands will be removed, and as such stormwater assets can be located in these sites.

Growling Grass Frog Corridor

Constructed wetlands can be located within GGF conservation zones, as per the GGF Habitat Design Standards, Melbourne Strategic Assessment (MSA) (DELWP, 2017). Figure 19 below demonstrates this.

Whilst the MSA does not explicitly cover Geelong, the same principles would apply for a species listed as threatened in the EPBC Act. The *Areas of Strategic Importance* will need to be identified for this area. As per the MSA's Growling Grass Frog Masterplan for Melbourne's Growth Corridors (DELWP, 2017) Areas of Strategic Importance mapping "*informs decisions about the location and design of infrastructure within Growling Grass Frog conservation Areas".*

The GGF Masterplan for Melbourne's Growth Corridors also states that "The Areas of Strategic Importance are the least suitable for infrastructure. Stormwater assets may be acceptable in some cases where it is shown that they will not have a negative impact on the construction of the Growling Grass Frog wetland in the Area of Strategic Importance. Functional design of stormwater management assets demonstrating integration with Growling Grass Frog objectives is usually required in these cases. Terrestrial habitat buffers around the core Areas of Strategic Importance and along waterways may be suitable locations for compatible infrastructure provided that sufficient terrestrial habitat remains in the vicinity of the adjacent Area of Strategic Importance and instream waterbodies."

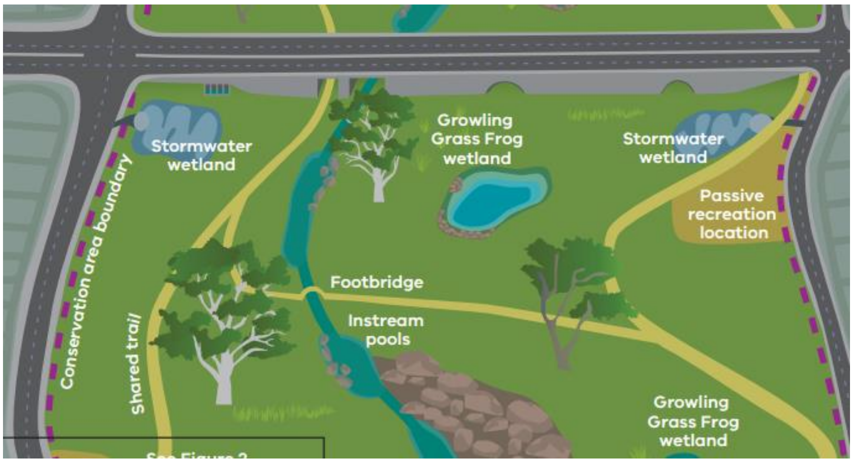


Figure 19. *Screenshot of conservation area overview (GGF Habitat Design Standards, DELWP, 2017).*

In the Flora and Fauna Technical Report: Western Geelong Growth Area (Ecology and Heritage Partners, 2017) states that: "Drainage infrastructure, such as wetlands, channels or detention basins, should be strategically located to integrate biodiversity features. An opportunity to achieve this outcome is the establishment of appropriately designed wetlands within the vicinity of Cowies Creek, which is known to support the nationally significant Growling Grass Frog."

As per Ecology & Heritage Partners' *Existing Ecological Conditions: Northern and Western Geelong Growth Areas* report (2021), a Growling Grass Frog Management Plan will need to be prepared and implemented prior to construction. This will need to detail how aquatic and terrestrial habitat along Cowies Creek will be protected.

Impact on DSS:

- Stormwater management assets will be located outside of grasslands conservation zone unless indicated by The City that these grasslands will be removed.
- Stormwater management assets proposed within the Growling Grass Frog corridor will be designed to protect GGF values and follow GGF habitat design guidelines.

2.9 Climate

Rainfall

Geelong is in a mild oceanic climate zone with warmer, drier summers and cooler, wet winters, with an annual rainfall of 520 mm (SILO gauge 87024, 1975-2020 average). Figure 20 shows the monthly average temperatures and rainfall across the year at Point Wilson (site 087166), and Figure 21 shows the total annual rainfall from 1975-2019.

On average most rainfall occurs through winter and spring while lower rainfall totals are generally recorded between December – March. Despite this, it is not uncommon for large rainfall events to occur over summer.

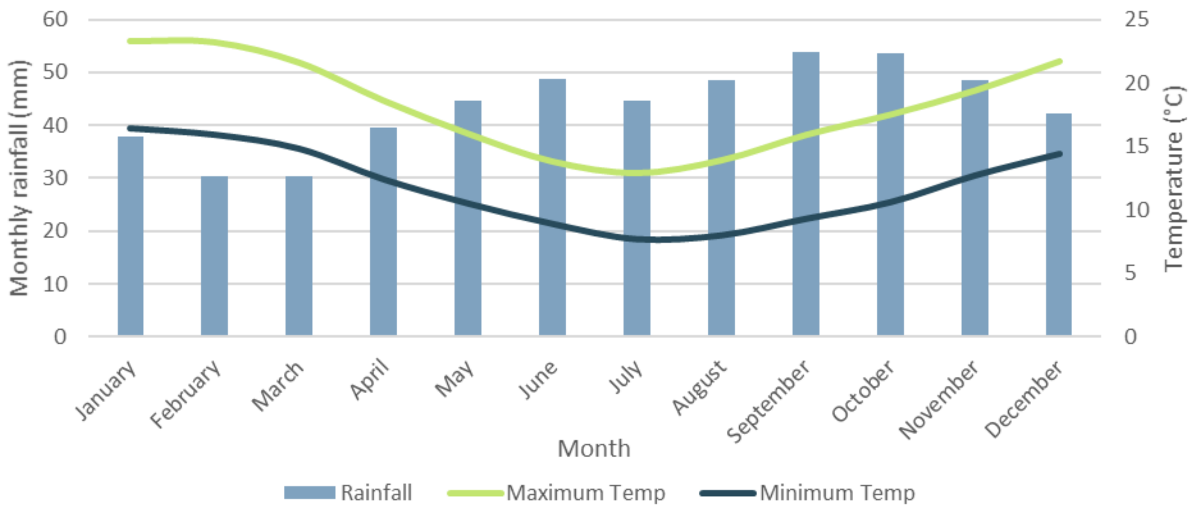


Figure 20. *Geelong's average monthly rainfall (mm), average maximum temperature (°C) and average minimum temperature (°C) based on climate data from 1975 to 2020 (SILO gauge 87024, BOM station 087166 – Pt Wilson).*

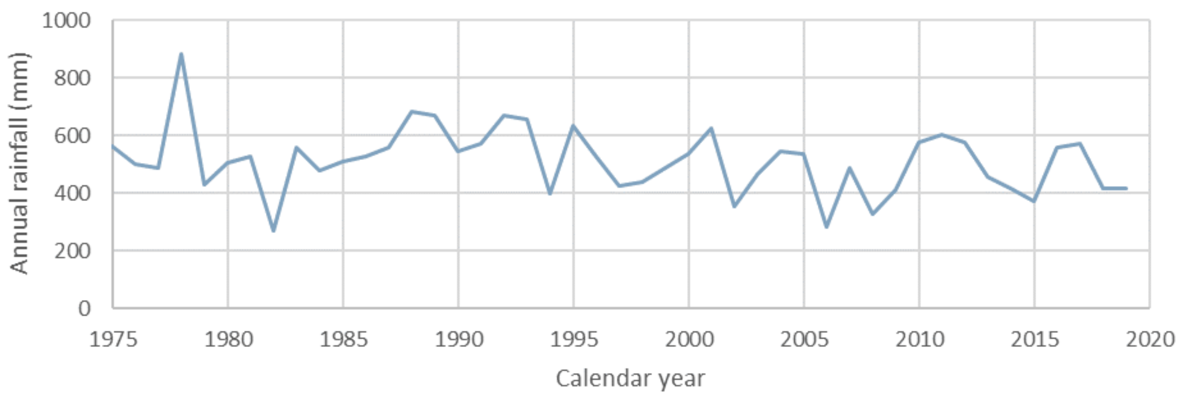


Figure 21. *Geelong's annual rainfall (mm) from 1975 to 2019 (SILO gauge 87024).*

Impact on DSS:

- Wetland assets will provide urban cooling / microclimate benefits
- The DSS will explore opportunities for stormwater harvesting for open space irrigation / cooling benefits.

2.10 Flooding

As part of the Cowies Creek Catchment Stormwater Management Strategy project, Water Modelling Solutions undertook flood modelling to establish the existing conditions for the entire Cowies Creek catchment. Figure 22 and Figure 23 show the 1% Annual Exceedance Probability (AEP) and 20% AEP flood extents within the precinct. For the 1% AEP, the flood extent can be shown to be contained within Cowies Creek and the tributary. This is unsurprising given the relatively steep topography of the valley. Localised flooding is also apparent in the overland flow path from Geelong-Ballan Road connecting with the tributary. Localised pooling is also present in the southern portion of the precinct, near Myers Reserve.

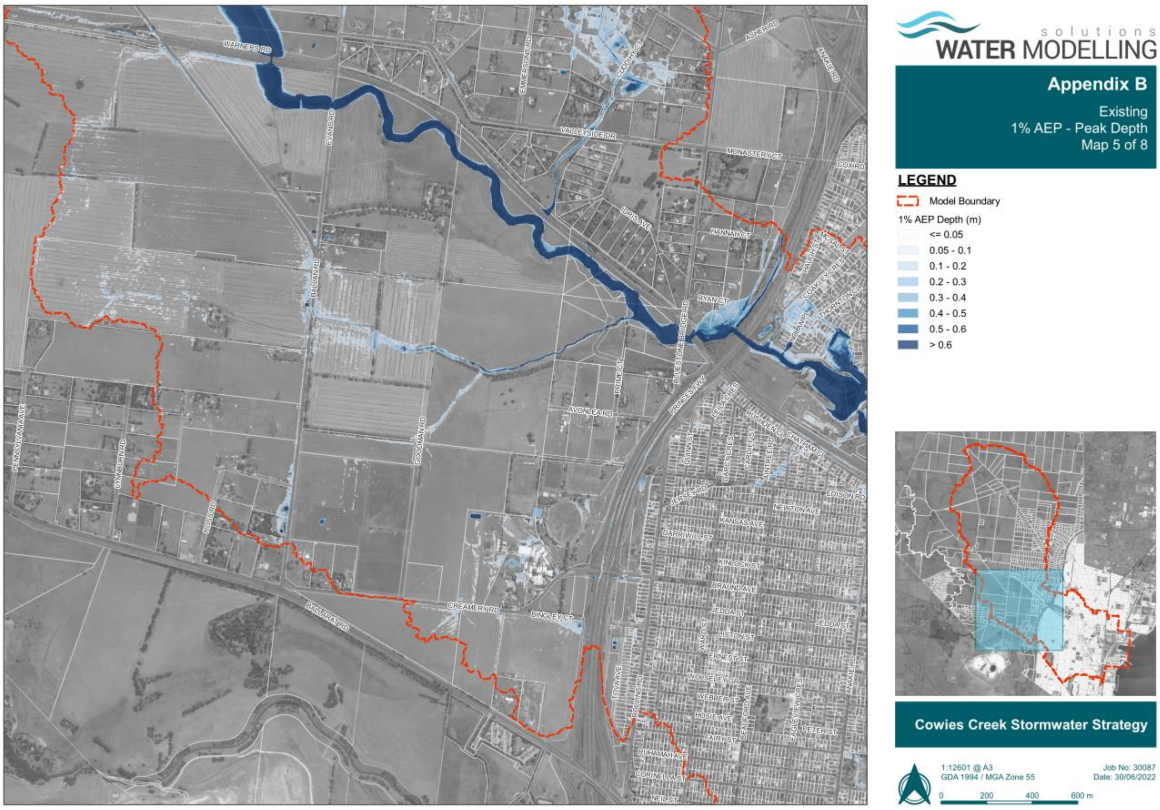


Figure 22. *Existing flood conditions - maximum depths, 1% AEP (1-in-100 year) flood (WMS, 2022)*

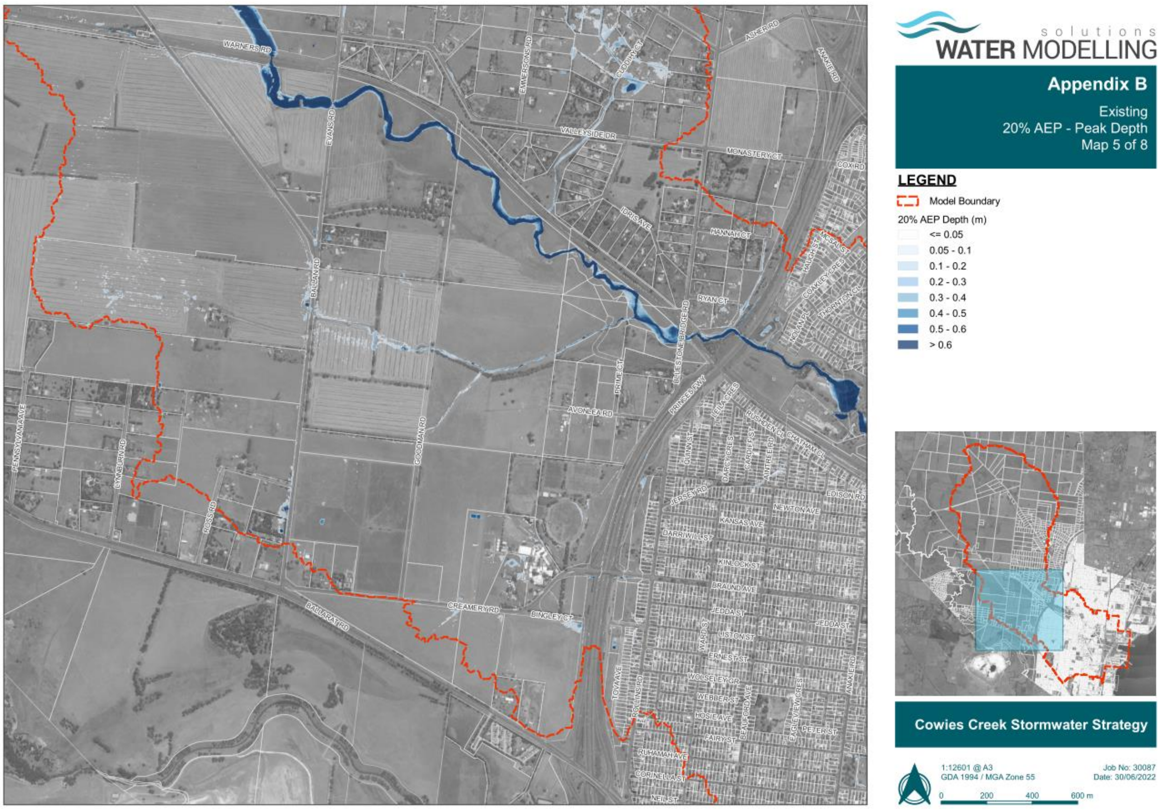


Figure 23. *Existing flood conditions - maximum depths, 20% AEP (1-in-5 year) flood (WMS, 2022)*

Impact on DSS:

- Stormwater management assets will be designed to ensure no adverse impact on existing flood conditions.
- Scheme design will need to consider major overland flow paths as per flood modelling outputs.
- As per Council direction, stormwater assets should be located outside of the 1% AEP flood extent.

2.11 Assets and services

A Dial-Before-You-Dig (DBYD) enquiry was made on 24 November 2021 to identify all assets within the subject site. The inquiry indicated that the site is largely unaffected by underground services. The results from the DBYD assessment are provided in Table 2.

Future design work should also consider any proposed alignments of future major services such as sewer, water, recycled water and gas pipelines.

Table 2. Summary of results from DBYD enquiry

Authority	Service	Comment from authority / Observation
Australian Rail & Track Corporation (ARTC)	Rail	Northern border of Creamery Road PSP is the rail reserve. Will not impact drainage assets.
Barwon Water	Water and Sewerage	Water assets servicing existing development and along the Midland Hwy, Evans Rd, and Bluestone Bridge Rd.
City of Greater Geelong	The City's stormwater pipes	Local stormwater infrastructure around existing developments. To be considered during detailed design, will have limited impact on this aspect of the investigation.
NBN Co VicTas	Telco Cables	Some assets on site in developed areas.
Nextgen (VIC)	Telco Cables	Underground cable along Evans Rd and Creamery Rd.
Powercor - Geelong	Electricity	Sections of underground low voltage cable along Geelong-Ballan Rd. Unlikely to impact DSS.

Impact on DSS:

- Stormwater management assets will avoid major infrastructure and services.
- Limited existing services found within the precinct.
- Consideration of proposed major infrastructure services including sewer and water supply networks, where available, will further impact the DSS.

3 Post development objectives and conditions

The following sets out the aim, objectives and approach of the assessment for the post-development conditions.

3.1 Stormwater drainage requirements

As per Clause 14.02 -1S-2S of the Victorian Planning Provisions (VPP) and the Greater Geelong Planning Scheme, the catchment planning and management and water quality objectives are to:

- to assist the protection and restoration of catchments, waterways, estuaries, bays, water bodies, groundwater, and the marine environment
- to protect water quality

As per Clause 53.18 of the Victorian Planning Provisions (VPP) and the Greater Geelong Planning Scheme, the purpose of stormwater management is:

- to ensure that stormwater in urban development, including retention and reuse, is managed to mitigate the impacts of stormwater on the environment, property and public safety, and to provide cooling, local habitat and amenity benefits

As per Clause 56.07-4 of the Victorian Planning Provisions (VPP) and the Greater Geelong Planning Scheme, the stormwater management objectives are to:

- minimise damage to properties and inconvenience to residents from stormwater
- ensure that streetscapes operate adequately during major storm events and provide for public safety
- minimise increases in stormwater runoff and protect environmental values and physical characteristics of receiving waters from stormwater impacts
- encourage stormwater management that maximises the retention and reuse of stormwater
- encourage stormwater management that contributes to cooling, local habitat improvements and provision of attractive and enjoyable spaces.

The following are the general stormwater drainage requirements that need to be followed in a stormwater assessment. These have been considered when identifying asset options.

Stormwater quantity management

In order to protect downstream environments from adverse impacts on flood conditions, typically, the fully developed 1% AEP stormwater runoff rates are to be retarded back to the equivalent 1% AEP pre-development peak flow rates, prior to discharging downstream. Alternatively, as per the Planning Scheme, the design of the local stormwater drainage network should “ensure stormwater is retarded to a standard required by the responsible drainage authority.”

This is typically achieved through the implementation of retention (or detention) systems within the catchment. Ultimately, a stormwater management strategy and design solution should demonstrate no impact on downstream environments, and that increases in stormwater discharges to receiving waters is minimised.

This is achieved through best practice approaches, integrating asset functionality for both quantity and quality management. This further allows consideration of broader community benefits through multi-outcome designs.

Stormwater conveyance

As per the Infrastructure Design Manual (IDM) and VPP clause 56.07-4, stormwater conveyance is typically designed to a major and minor flow regime where:

- Minor flows – that is, up to and including the 20% AEP storm event (approximately the 1 in 5-year ARI event) are conveyed via the sub-surface stormwater network (for residential areas)
- Major flows – that is, between the 20% AEP and 1% AEP event are typically conveyed on the surface via roadways, overland flow paths, open channels, and waterways.

As per the IDM, where minor flows are managed through underground piped networks, the opportunity to integrate surface-level stormwater assets for conveyance through water sensitive urban design options forms part of the approach to the Creamery Rd PSP concept layouts where vegetated (or grassed) swales, linear biofilters, infiltration basins etc have been considered.

These further support compliance with the new EPA stormwater guidance (see below) relating to flow reductions and landscape retention (infiltration) targets.

Stormwater quality treatment

Stormwater treatment concepts are required to meet the Urban Stormwater Best Practice Environmental Management (BPEM) Guidelines (CSIRO, 1999) pollution reduction targets as set out in the VPPs, before being discharged into stormwater networks and receiving waters. These targets are defined as:

- 70% removal of the Total Gross Pollutant load
- 80% removal of Total Suspended Solids (TSS)
- 45% removal of Total Nitrogen (TN)
- 45% removal of Total Phosphorus (TP).

EPAV stormwater guidance

Stormwater volume reduction requirements are driven by an ecological and physical form response. The EPAV have published an Urban Stormwater Management Guidance (2021) which identifies the need to manage stormwater volumes within landscapes.

Recent updates to EPA stormwater guidance sets out flow volume reductions for different areas, based on the annual rainfall. These reductions are designed to reduce the impact of increased impermeable surfaces (and decreased vegetation) on the receiving environment by setting out a percentage of impervious runoff to be:

- either infiltrated or filtered to replace the water that would have permeated to the water table to support waterway baseflows, and
- harvested or evapotranspired to make up for water that would have been used by vegetation or evaporated from soils.

For Geelong, with an annual rainfall of 525mm per year, the removal targets are based on the 500mm band.

	Harvest / Evapotranspiration	Infiltrate / Filter
Priority areas	77%	5%
Other areas	31%	4%

The EPA guidance states, a risk assessment is to be undertaken to determine if areas are high priority and should therefore consider the values at risk and the degree of impact, and to do what is “reasonably practicable” to meet the targets.

At a broader level the risks to waterway health upstream of the Geelong Ring Road could be considered as a *higher risk* than the risks to the waterway at the downstream extent within the existing urban areas. The section of Cowies Creek upstream of the ring road has had less historical impact and therefore carries a higher level of ecological value, hence the degree of change expected through future development is therefore greater by comparison.

This does not mean that the intrinsic waterway values through the urbanised reaches should be dismissed – these should still be maintained, protected and/or enhanced accordingly, wherever possible. This is consistent with the NWGGA IWM Plan (F3.2) which states: *major waterway corridors, including Cowies Creek, are to be stabilised, rehabilitated, enhanced, and naturalised to deliver flow retention and natural waterway values*.

Reduction of stormwater volumes has not been investigated in detail as part of this functional design development stage. However, stormwater harvesting opportunities, including access to treated stormwater from PSP wetlands present a way to contribute to volume reduction, along with reducing potable water consumption, and urban cooling should the water be used to irrigate nearby sports fields and open space. However, stormwater harvesting from these wetlands alone will not meet the above targets. A suite of harvesting opportunities would be required, as well as maximising demand (i.e. where farm irrigation opportunities may arise, or looking at stormwater for indirect potable supply).

Table 5 in section 5.1 details the total inflow into the wetlands as per the treatment modelling – 847.6ML/yr. This is a significant amount of water which could be harvested.

Multi-functionality for multi-benefits

IWM principles applied to stormwater drainage assessments and design solutions allows for a more optimised suite of outcomes to be gained, that in turn deliver broader community and landscape benefits and sustainable water infrastructure solutions (extending beyond intended asset function) for level of effort and investment made.

An assessment of IWM opportunities for the catchment extends design thinking from flood mitigation to water quality treatment and waterway protection, through to stormwater harvesting and reuse and retention within the landscape. In the opportunities identification process we have considered the following aspects and reflected on their response to the NWGGA IWM Plan (F3.2) requirements:

- Landscape and topographic features that lend themselves to asset types and locations (SW1)
- Scalable interventions (e.g. lot, street, precinct) that best suit site challenges and intrinsic values (SW1, SW3, SW5)
- Proximity of potential detention systems with active open space alignments for efficient stormwater harvesting and reuse that is fit for purpose (SW4, SW6)
- Sustainability of community assets – service standards, asset preservation, access, usage and enhancements
- Potable conservation through stormwater reuse - reducing runoff volumes and associated impacts to local waterways (SW1, SW2, SW3, SW4, SW6)
- Blue-green corridors and relationships to the urban form - how these improve human thermal comfort, community and landscape resilience, connectivity for existing and future communities (SW1, SW2, SW5)

- Infrastructure multi-functionality for protection of local values (environmental, social, cultural, economic)
- Creating desirable destinations and social connectedness, community health and wellbeing (SW1)
- Enhanced liveability outcomes locally and regionally.

3.2 Future land use

To determine the stormwater quality requirements of the precinct, the post-development conditions of the site are modelled. While it is understood that the layout and proposed land use concepts are subject to change over time (and that the stormwater assessment will inform the proposed layout), a preliminary layout is required for modelling assumptions.

The layout of the precinct, specifically the density of the proposed development and proportion of open space, will impact the volume of stormwater runoff and therefore the treatment and flood mitigation systems required.

The most recent update of the draft future urban structure has been included in Figure 24. The majority of the site is proposed as general residential, with higher density residential, commercial and community area along the Clever and Creative Corridor. This version (August 2022) has been adopted for all functional design modelling in terms of land use and fraction impervious assumptions.

Please note: Relatively different urban structures were initially provided and adopted for the concept modelling and concept designs, hence why there has been a significant shift in asset locations and sizes from concept to functional design. These have been attached in Appendix B. It is expected that many iterations of the urban structure will occur, but that the fraction impervious assumptions are unlikely to alter a great deal beyond this latest version (August 2022).

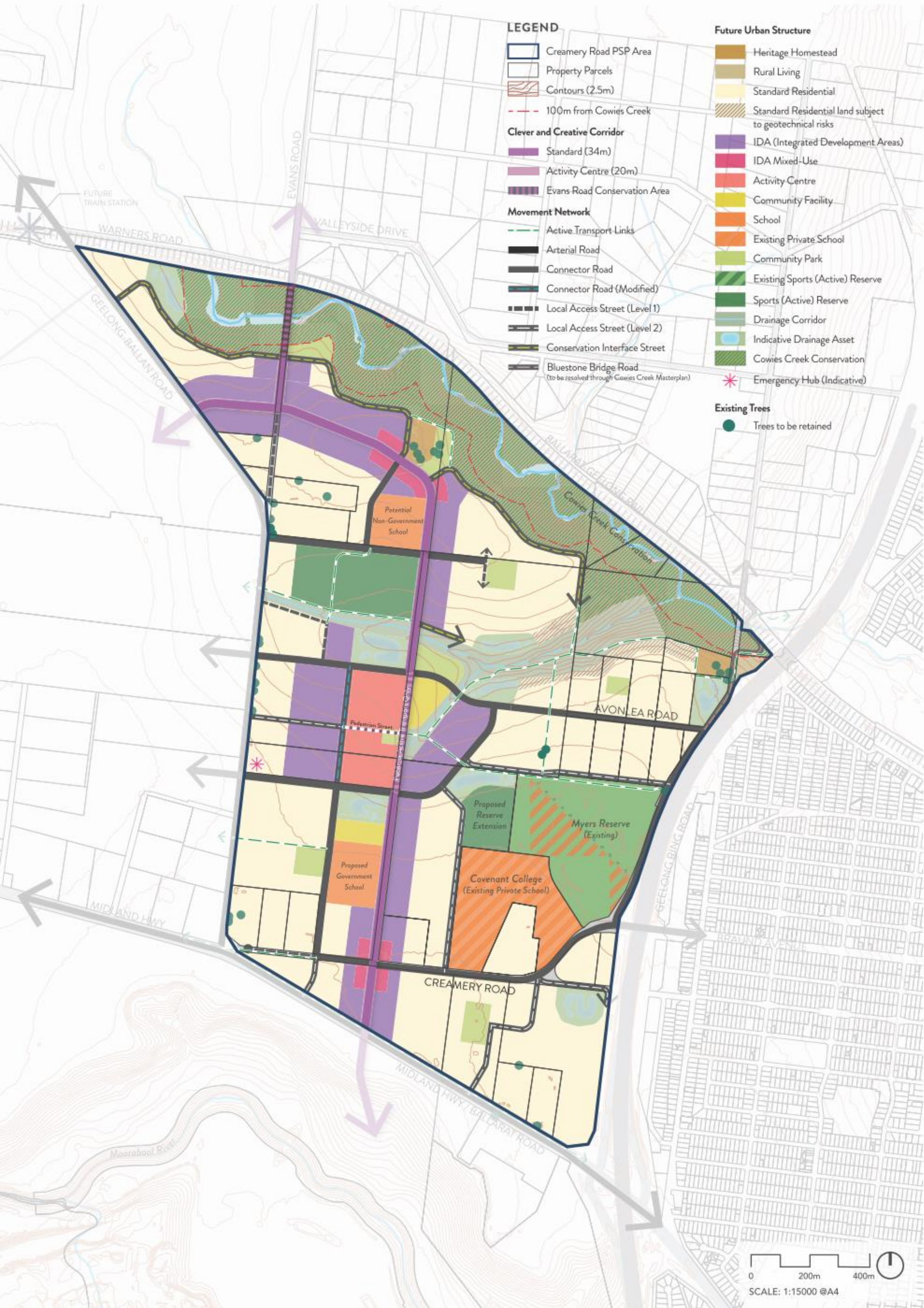


Figure 24. *Planned future land use in Creamery Road PSP (August 2022)*

4 Preferred drainage strategy for functional design

Three revisions of the concept design report were developed in responses to Council and stakeholder feedback. For full details of the concept design development, refer to Alluvium's Creamery Rd DSS Concept Design Report (May 2022).

The concept design development was an iterative process including:

- Treatment modelling
- Asset calculations
- Hydrologic modelling and storage sizing
- Consultation with The City on the flexibility of the current draft future urban structure (FUS), and various site constraints and values.

Consideration of asset multi-functionality and multi-benefit outcomes were considered and align with the NWGGA IWM Plan (2021) requirements for the PSP and region more broadly. IWM principles applied to stormwater drainage assessments and design solutions allows for a more optimised suite of outcomes to be gained, that in turn deliver broader community and landscape benefits and sustainable water infrastructure solutions (extending beyond intended asset function). The proposed concepts address the requirements and guidance as per Appendix F, SW1 to SW6 (NWGGA IWM Plan).

The concepts presented in this section were used as the basis to develop the designs into functional designs following final feedback from The City and key stakeholders. It should be reiterated that there were significant land use changes to the draft urban layout following the development of the concept design, and as such the functional designs of the assets are responsive to this latest layout. Catchment areas and overall effective fraction imperviousness have changed, and have therefore influenced required treatment and storage areas.

4.1 Concept overview

The concept designs for the options investigated are presented below. Each option includes:

- The macrophyte treatment area (NWL) as established in MUSIC
- The storage requirements as established in the hydrologic modelling
- A Normal Water Level (NWL) identified by looking at the topography of the site, as well as the inclusion of 0.35m EDD, the required 1% AEP flood depth and any freeboard requirements (minimum 300mm).
- An approximate overall footprint based on the selected NWL and battering up to existing surface at a 1-in-5 grade.
- Indicative inlet pipe, transfer pipe (sediment basin to wetland), and outlet pipe locations.

Other factors that influenced the configuration of the assets included:

- Subdivisional drainage requirements for the surrounding development (not typically a constraining factor given the topography)
- The ability to outfall
- The requirement to meet a length to width ratio of at least 4:1 [MZ4 in the Constructed Wetlands Manual], and the associated maximum width, and how this fits with the surrounding terrain
- Meeting velocity requirements

- Minimising excavation requirements (where possible)
- A desire to not have the assets in fill and instead in cut (i.e. no reduction in flood storage and no minimising triggering ANCOLD requirements).

An overview of the concept plan for the PSP is provided in Figure 25.

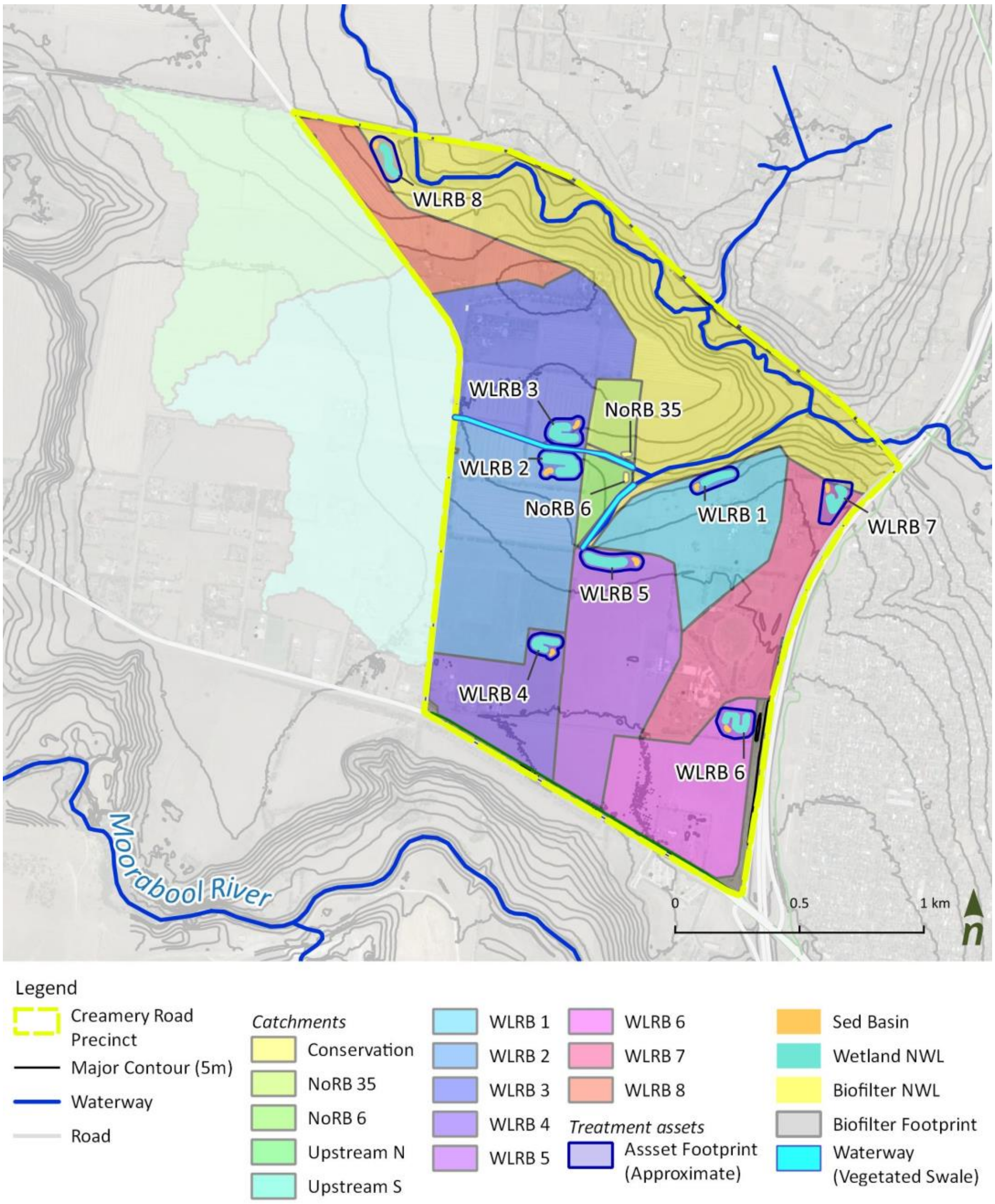


Figure 25. *Concept plan overview*

4.2 Clever and Creative Corridor – long term water strategy

The NWGGA IWM Plan (Appendix F) identifies *stormwater for indirect potable supply* as a long-term strategy for stormwater harvesting to be sourced directly from PSP treatment wetlands and conveyed (gravity or pumps) to the CCC where it is proposed a future stormwater distribution ring main will service the precinct (and broader areas potentially) with alternate water supplies through connector pipes in the development (SW6). It is intended that the CCC will in the future be connected to the Wurdi Boluc Reservoir via construction of a 30km length transfer main. Details on this main have not been finalised or provided at the time of the functional design.

While the above SW6 is considered an 'aspirational target' of the NWGGA IWM Plan, the opportunity to fulfil this target in the future has been accounted for in the designs. For instance, the proposed WLRB 2, 3a, 3b, 4 and 5 are located near the CCC and these wetland outflows (treated) could be gravity fed to the primary CCC distribution main proposed. However, WLRBs 1, 6, 7 and 8, and the proposed biofilter are located downstream of the CCC distribution main and will require pumping from the wetland outfall to the CCC distribution main. The details of these opportunities will need to be confirmed once more details on the main are known.

The WLRB outlet pit designs will need a wet well or sump to allow for future pumping of treated flows to the CCC distribution main. The alignment of pipes could likely fall within proposed stormwater easements for the PSP assets to reduce overall developable land take (subject to available space and appropriate pipe clearances etc).

Similarly, should the proposed recycled water / stormwater distribution ring main not progress, it does not limit the opportunity to access treated flows from respective PSP wetlands, where a proposed open space area has been nominated and/or exists in proximity of the wetland (i.e., potable substitution and open space irrigation as per SW4).

For instance, the proposed WLRB 5 and WLRB6 are located near Myers Reserve (existing parklands within the PSP boundary). An opportunity exists to direct these treated flows to a site storage for later irrigation use. Similarly, proposed WLRBs 2 and 3a could harness treated flows if pumped to a storage at the proposed active open space (current FUS) to the north-west of these assets. Treated flows from the proposed biofilter could be used to passively irrigate the proposed 'local open space' area to the east of these assets (north of the stormwater corridor).

4.3 Stakeholder consultation

The draft PSP and associated background studies were provided for agency consultation in July 2022. Key feedback that has been considered in the functional design development includes:

- Clarification on waterway corridors.
- Clarification on catchment delineation and rationale.
- The feasibility of the locations of assets 1 and 7 due to the steepness of the topography.
- Consideration of alternative location for asset 6 based on existing 1% AEP flood extent (water currently pooling behind Bingley Ct).
- The opportunity to utilise Myers Reserve for stormwater infrastructure.

Additional feedback from Council that has been incorporated into the functional design development includes:

- A requirement for 1 in 8 batters for the retarding basin batters.
- An openness to have WLRB8 located within the GGF corridor, but a requirement to keep the asset outside of the 1% AEP flood extent.
- The opportunity to integrate WLRB5 into the proposed Myers Masterplan.

Following the agency consultation, Alluvium held a number of meetings with Council to discuss the feedback, and to option up various asset arrangements given the changes in the urban layout since the development of the concept designs. The functional design asset locations are the result of an iterative design process, and extensive consultation with Council throughout the design development.

5 Catchment analysis

With an understanding of existing site conditions, existing flood issues, the proposed urban layout, and preferred stormwater infrastructure locations based on the concept design process and stakeholder feedback, the catchments of each asset were refined, along with associated land uses. The site's sub-catchments were defined through a combination of:

- Topography (LiDAR provided by Council)
- Major roads which may delineate between sub-catchments (e.g. the Clever Creative Corridor).

Major catchments can be broken into many sub-catchments, but ultimately it depends on what makes sense in terms of the potential future road layout, and ensuring the overall catchment for an asset is not too big or small (i.e. there is a balance required). Where possible, there is an objective to minimise the number of treatment assets to minimise land take, costs, and ongoing maintenance requirements; without compromising flexibility of development staging, if reliance were placed on a few, larger scale, end of line assets.

It important to map these catchments to better understand the pollutant loads generated from these areas in a post-development scenario. Where possible, the catchments are aligned with the flood modelling completed by WMS. However, for treatment modelling in a developed urban catchment, the road alignments will influence the drainage paths and ultimate catchments. Future road alignments, as per urban layout plans, have been applied in the modelling.

For the purposes of surface water modelling, each land use type assumes a fraction impervious. The fraction impervious is the proportion of land that is likely to be sealed or paved (impervious to water infiltration) following development. This impacts the volume of stormwater runoff that is generated in a specific rainfall event, for a specified land size. The impervious fractions for each planned land use type are included in Table 3 below. These numbers have been based on the MUSIC Guidelines (Melbourne Water, 2018).

Table 3. Adopted fraction impervious values for each proposed land use type

DSS proposed land use	Description	Comparable zone code	Fraction imperviousness
Road	Clever and Creative Corridor and other major roads	RDZ1	0.7
	Connector streets and key local roads	RDZ2	0.6
Conservation	Growling Grass Frog and Grasslands reserves. Minimal impervious surfaces		0.001
Parks and open space	Passive recreation areas	PPRZ	0.1
	Active open space - includes some impervious areas for carparks and facilities	PPRZ	0.2
Drainage	Drainage corridor		0.001
	Water treatment assets	UFZ	0.6
Neighbourhood activity centre	Local commercial and community areas	C1Z	0.9
Commercial	Commercial, retail.	C1Z	0.9
School	Primary and secondary schools	PU2Z	0.7
Community Facility	Health and community facilities	PU3Z	0.9
General Residential	Detached houses on lots <500 m^2	RGZ, GRZ, NRZ	0.75

5.1 Sub-catchments

Based on the existing topography and provided urban layout, the precinct was divided into sub-catchments (Figure 26). These catchments include small areas along the south of the precinct which would naturally drain towards the Moorabool River, however due to the road network and drainage infrastructure these areas will be contained within the precinct.

Sub-catchment delineation was informed by both the slope (natural fall) of the existing topography and the future urban layout (e.g. road alignment). Rationale for sub-catchment delineation is provided below.

- Sub-catchment 1: bound by Myers Reserve to the south, falls north towards the existing waterway.
- Sub-catchment 2: bound by CCC to east, falls north-east towards valley.
- Sub-catchment 3a: ridge line northern extent of catchment, bound by CCC to east, falls south towards valley.
- Sub-catchment 3b: ridge line northern extent of catchment, bound by CCC to west and road to north-east, falls south towards valley.
- Sub-catchment 4: bound by CCC to the east, falls north.
- Sub-catchment 5: ridge line south-east extent of catchment, bound by Creamery Road to south and CCC to west, falls north.
- Sub-catchment 6: bound by CCC and Creamery Road, falls to east.
- Sub-catchment 7: ridge line north-western extent of catchment, bound by Creamery Road to south, falls north-east towards Cowies Creek.
- Sub-catchment 8: ridge line southern extent of catchment, bound road to north-east, falls north-west.

This catchment information was used for the treatment modelling inputs to determine the likely target pollutant loading and the necessary treatment requirements to manage this for the precinct (section 7.2). The sub-catchment information was also used as inputs for the hydrologic modelling (section 6).

Figure 26 shows the catchment layout and flow directions. Table 4 shows the areas and future Fraction Impervious (FI) based on the land use planning for each sub-catchment. The total FI is based on the various land uses within the catchment. A more detailed table has been included in Appendix C. Table 5 shows the total loads for each catchment of the target pollutants.

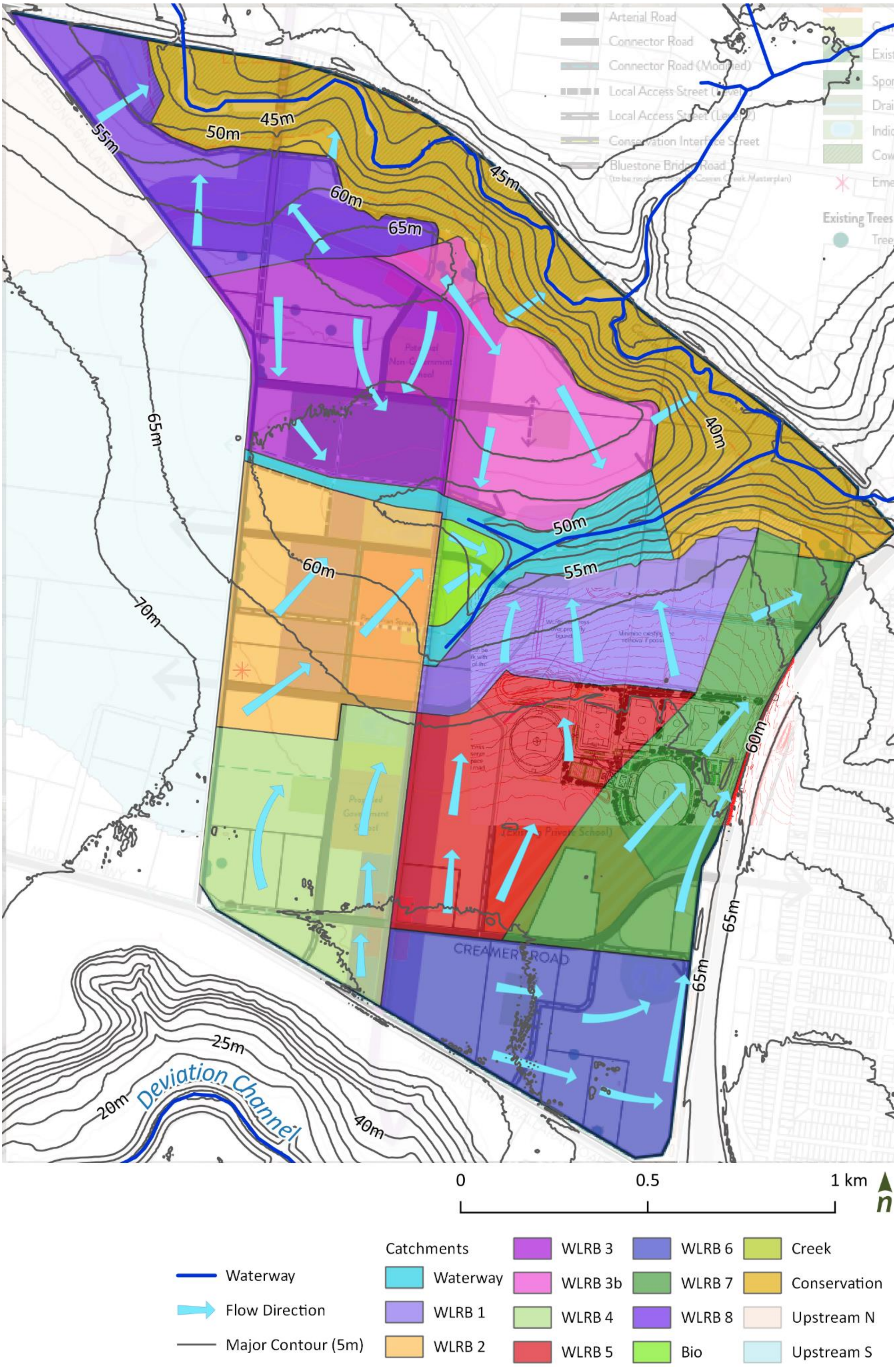


Figure 26. *Sub-catchment layout showing flow direction. The urban layout is shown as an underlay.*

Table 4. Developed conditions effective imperviousness area by sub-catchment

Sub-Catchment	Area (ha)	Fraction Impervious (FI)
WLRB 1	24.01	0.76
WLRB 2	33.50	0.79
WLRB 3a	31.83	0.59
WLRB3b	24.67	0.71
WLRB 4	32.16	0.72
WLRB 5	32.51	0.59
WLRB 6	31.51	0.72
WLRB 7	35.32	0.55
WLRB 8	26.47	0.75
Bioretention system	3.39	0.56
Total developed area*	347.25	

* No conservation and waterway corridors included.

Table 5. Developed mean annual flow and pollutant loads in each catchment

Subcatchment	Flow (ML/yr)	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
WLRB1	81.2	16300.0	33.3	232.0	3570.0
WLRB2	117	23500.0	47.4	335	5110.0
WLRB3a	87.0	17000.0	35.2	248.0	3970.0
WLLRB3b	78.8	16000.0	32.0	226.0	3500.0
WLRB4	104	20600.0	42.3	297.0	4610.0
WLRB5	88.9	17200.0	35.9	252.0	4050.0
WLRB6	102.0	20300.0	41.6	292.0	4520.0
WLRB7	91.2	17300.0	35.8	261.0	4180.0
WLRB8	88.6	17800.0	36.7	257.0	3900.0
Bioretention system	8.88	1710.0	3.5	25.1	407.0
Total	847.6	167,710.0	343.69	2425.1	37,817.0

6 Hydrologic analysis

In general terms, the approach to flood management is to equate post development and pre-development peak flow rates for the 1% AEP event such that the development is not having an adverse impact on downstream flooding. This is typically achieved through the addition of retention (or detention) storage within the relevant catchment. The hydrologic analysis is used to determine the storage capacities of proposed retarding basins required to retard the fully developed peak stormwater runoff rates back to pre-developed conditions.

The hydrologic modelling is also used to establish peak flows to size waterways at specific locations.

6.1 Hydrologic modelling

The hydrologic analysis was undertaken using RORB (v6.31), which is a runoff-routing software designed to simulate attenuation and time of concentrations to produce flood estimates at specified catchment locations.

A RORB model was created for the precinct to determine:

- Existing peak flows
- The impact of development on peak flows
- The reduction in peak flows that is possible using retarding basin storage.

The RORB models were built by delineating the major catchments into sub-areas based on topography and potential road alignments. This section details the peaks flows and storage requirements for each catchment. The same FI values were adopted for the stormwater treatment modelling (in MUSIC).

The hydrologic modelling was also used to estimate the peak flows for sizing the swales/waterways.

6.2 Input parameters

Using the Bureau of Meteorology's online IFD tool an intensity-frequency-duration assessment has been undertaken. The rainfall volume, less typical design losses, was input to the hydraulic model through distributed source points, located along the major flow paths as defined by the local topography.

Model inputs including temporal patterns and aerial reduction factors were obtained from the ARR2019 data hub and the Bureau of Meteorology's Intensity Frequency Duration (IFD) data. RORB models were built by delineating the area based on flow directions derived from LiDAR data and future preliminary development plans.

Across the catchment there are a total of eight locations where flood attenuation will be required before discharge into the local stream, or to Cowies Creek. An overview of the model setup including catchments and reaches is shown in Figure 27.

Key inputs into the RORB modelling include:

- The model used an initial loss/continuing loss model with an initial loss of 15mm and a continuing loss of 2mm/hr for existing conditions. These parameters in line with the catchment flood study undertaken by WMS (WMS, 2021).
- Kc was determined using the *Pearse et. al* regional kc equation, in line with the catchment flood study.
- Intensity Frequency Duration (IFD) data was sourced from the Bureau of Meteorology's (BoM) website, nearest grid cell 38.0.875(S), 144.3125(E).

- Temporal patterns were sourced from the AR&R data hub, Southern Slopes.
- Catchment areas were as per those established in the catchment analysis.
- FI values were based on existing conditions and updated to proposed land uses (summarised for each catchment in Figure 26 and Table 4, with details for each subarea in Appendix C).
- Natural reaches were used in the current condition catchment.
- Reaches were updated to 'unlined channel or drain', in the developed scenario to represent overland flow in the 1%AEP, except for the waterway which remained natural (for developed conditions model). Modelling of more frequent events which would be confined to the stormwater pipes should use 'lined channel or pipe' type reaches.
- Ensemble simulations were used to determine the critical flows at each flood retention location and determine the appropriate flood storage.
- There were some small areas where an RB has not been proposed. Ensemble simulations were also used to determine the change in flows (and impact of modelled flood retention) downstream of these areas.

Table 6. Adopted RORB parameters.

Parameter	Existing conditions	Developed conditions
Rainfall Intensity Frequency Duration (IFD)	Obtained from Bureau of Meteorology's IFD tool	Obtained from Bureau of Meteorology's IFD tool
Temporal Pattern details	ARR2019 data hub	ARR2019 data hub
Areal Reduction Factor d	ARR2019 data hub	ARR2019 data hub
kc		2.71
m	0.80	0.80
Initial loss (IL) (mm)	11	11 (Upstream sub-catchments)
		7.7 (Creamery Rd DSS: 70% of the value obtained from ARR data hub)
Continuing loss (CL) (mm/hr)	2	2 (ARR data hub)

The model extends beyond the precinct to include upstream areas (Upstream N and Upstream S), as well as precinct areas which will not be developed (e.g. GGF conservation areas). Flows from the upstream areas will be managed outside the precinct, however they will need to be conveyed through or around the precinct. For catchment Upstream N, it is assumed treated and retarded flows will be piped adjacent to the rail reserve, and outfall into Cowies Creek (as per Water Technology's stormwater strategy, May 2019). Asset 8 will be located in a way that allows for the upstream outfall pipe. There may be an opportunity to have these outfalls at the same location, therefore minimising the disturbance on the creek. For catchment Upstream S, flows will need to be conveyed through the DSS area. This will be via a vegetated swale. This is discussed further in sections 6.5 and section 9 of the report.

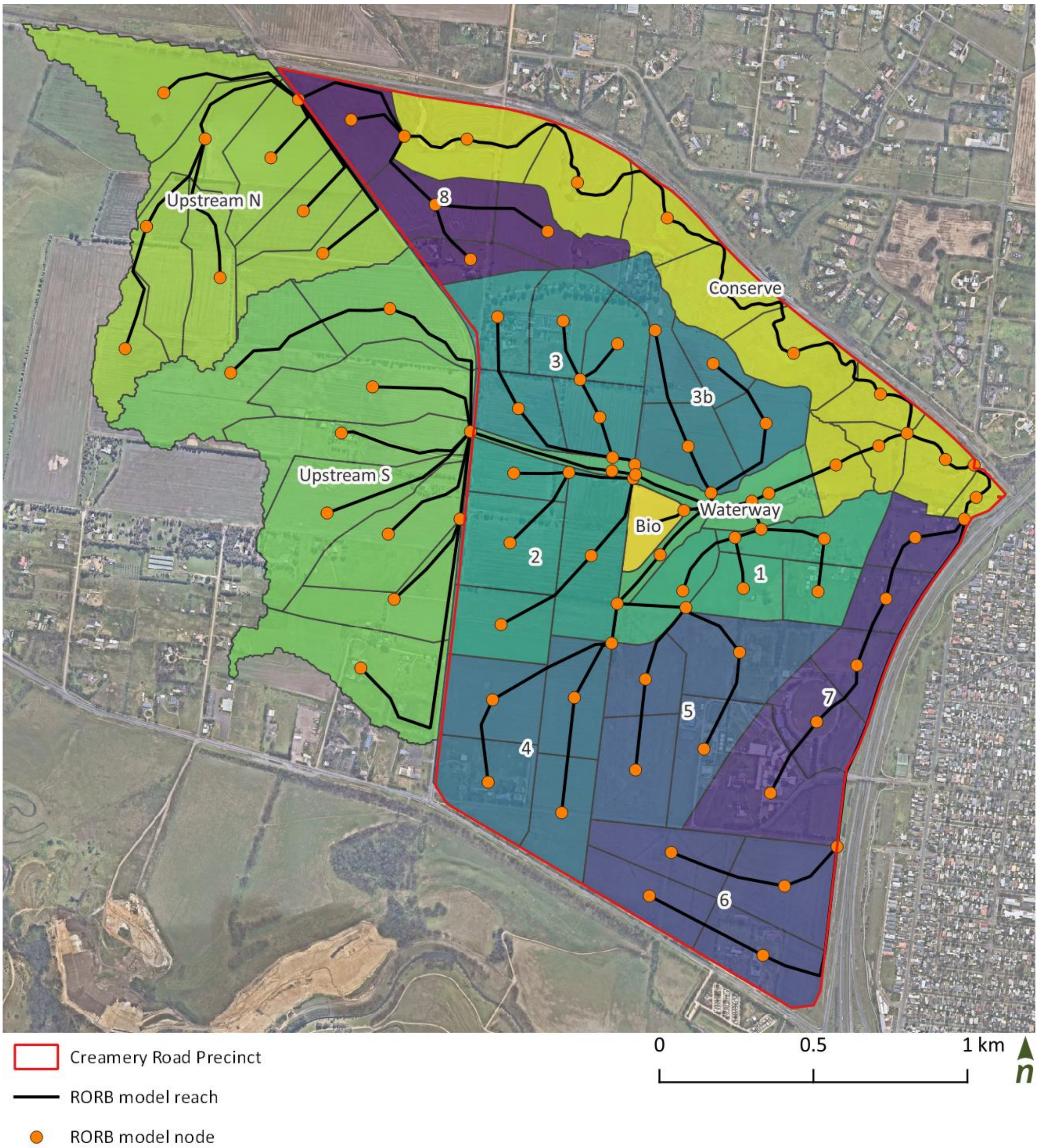


Figure 27. *Delineated subcatchments for hydrologic modelling – RORB layout*

6.3 Results

The RORB model was computed for the pre and post developed conditions under the 1% AEP flood event with results as shown below. The peak flows are at the locations of the future assets.

Table 7. 1% AEP RORB modelling results

Asset	Catchment area	Current conditions		Developed conditions	
	Ha	Peak flow m^3/s	Storm duration	Peak flow m^3/s	Storm duration
WLRB 1	24.01	2.00	45 min	4.81	20 min
WLRB 2	33.50	2.08	1.5 hr	6.44	20 min
WLRB 3a	31.83	1.99	1.5 hr	5.54	20 min
WLRB 3b	24.67	1.69	45 min	4.68	20 min
WLRB 4	32.16	1.86	1.5 hr	5.14	20 min
WLRB 5	32.51	2.14	1 hr	5.92	20 min
WLRB 6	31.51	1.67	1.5 hr	3.43	20 min
WLRB 7	35.32	1.61	2 hr	4.67	30 min
WLRB 8	26.47	1.90	45 min	5.20	20 min
Bioretention system	3.39	0.39	45 min	0.84	20 min

6.4 Retarding basin design

Following the establishment of existing (pre) and post-development peak flows without mitigation, the retarding basins have then been modelled and sized to control the 1% AEP peak flow.

Wetlands will be located in the base of the RBs. Melbourne Water has published compliance criteria for the design and construction and establishment of constructed wetlands (Melbourne Water, 2020), which has been referred to during design development. The required wetland footprint was established by treatment modelling (detailed in Section 7). The retarding basin sizing was undertaken iteratively with the treatment modelling to ensure the wetland can fit within the RB, and that the required storage was provided in order to meet the discharge criteria.

- RB actual *stage storage relationships* were developed using storage volumes obtained from the 3D earthworks modelling and updating these relationships in the hydrologic modelling. The wetland volume has not been included in the storage calculations (i.e. storage above NWL is what is needed to retard flows). This was an iterative process, identifying potential wetland NWLs, RB base levels, RB extents, and testing this with various outfall arrangements in RORB in order to achieve the allowable peak discharge. The stage storage relationships for each RB are provided in Appendix C.
- The total required area for each asset has been designed in the earthworks model assuming a 1(V):8(H) batter from the internal access track (500mm above wetland TED) to the peak flood level, and an allowance of a minimum of 300mm of freeboard on top of the peak 1% AEP flood depth to the existing surface. The systems are designed so they are cut and not in fill (i.e. no loss of any flood storage and no ANCOLD requirements).
- Storage outlet sizes were adjusted until the peak 1% AEP outflows from the RB were equal or less than the current peaks. This was done through altering outlet properties in the hydrologic model (i.e. outlet pipe sizing or weir sizing) until the peak flows were less than or close to the existing peak flows. The outlet pipe/weir arrangements are sized for peak RB outflows.

- Peak storage volumes and flood heights within the basins were extracted from representative hydrographs runs.

Table 8 shows the required capacities of the retarding basin based on the RORB modelling conducted. Note: all retarding basins (RB) are integrated assets with a proposed wetland treatment floor (as per WL) to increase functionality, minimise land take and provide a functionally aesthetic asset for the landscape and community.

Table 8. Retarding basin requirements

Asset	Existing Peak flow (from Table 7) (m^3/s)	Peak RB outflow (1% AEP) (m^3/s)	Peak RB storage (m^3)	Peak RB flood depth (m)	Freeboard above peak flood depth (mm)	Outlet structure (Spillway# width, m)
WLRB1	2	1.95	5460	0.90	min 300	2.8
WLRB2	2.08	2.02	8830	1.03	min 300	2.1
WLRB3a	1.99	1.9	7260	1.10	min 300	1.7
WLRB3b	1.69	1.58	5940	1.02	min 300	1.7
WLRB4	1.86	1.75	7970	1.07	min 300	1.7
WLRB5	2.14	2.11	7070	1.08	min 300	2
WLRB6	1.67	1.66	6920	0.95	min 300	2.1
WLRB7	1.61	1.53	8710	1.23	min 300	1.1
WLRB8	1.9	1.79	6600	0.98	min 300	2.1

 # Outlets were modelled as weirs set at the TED

A plan overview of the RB locations and footprints are provided in Figure 28. This map also shows the integrated wetlands within the RBs that are required to meet State pollutant reduction targets (discussed in Section 7.2 of this report). The map indicates the overland flow paths along proposed roads. It can be seen that there is a small portion of the catchment below WLRB7 which will not fall into the RB due to the topography. Due to topographic and heritage constraints, the asset was not able to be massaged into the north-east corner of the catchment. It has been instead arranged along the contours, which also helps minimise overall battering requirements and land take. Despite this small section of the catchment falling away from the asset, WLRB7 has been designed for treatment and retardation of the entire catchment. Therefore, no additional treatment should be required for this land.

Asset designs are provided in the Functional Design Drawings (Appendix F).

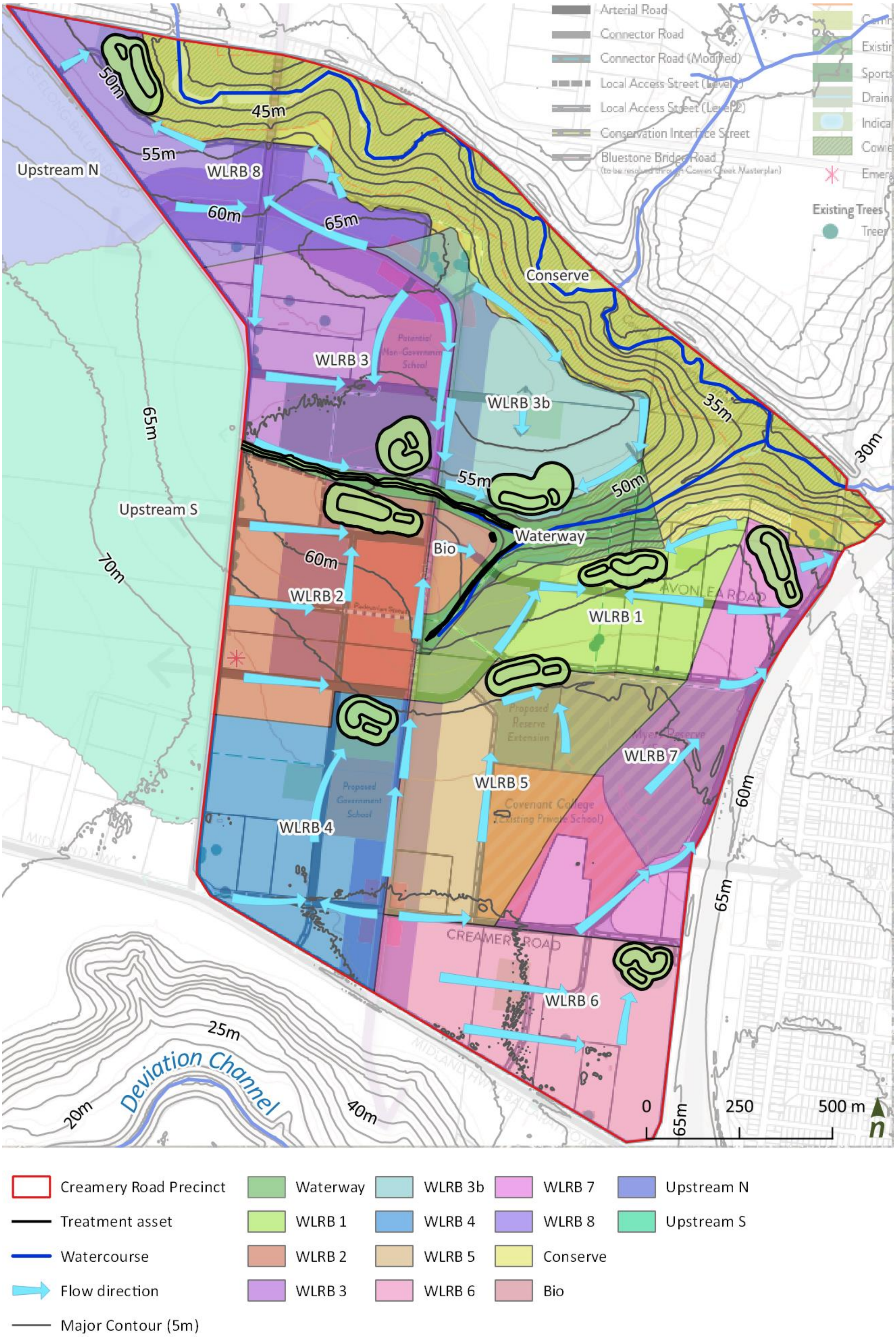


Figure 28. *Integrated Retarding Basin & Treatment Wetland (WLRB) plan overview*

ANCOLD and spillway design

Melbourne Waters *Retarding Basin Design and Assessment Guidelines (2017)* indicates that a dam, defined as where the embankment is 500mm in height or more above the downstream natural surface level, will require failure impact assessment under the ANCOLD guidelines. See extract below:

> *A dam, for the purposes of this document, is defined as anything in which by means of excavation or other works, a bank or barrier is created where water is collected, stored or concentrated. This includes water supply dams, retarding basins, levees and wastewater lagoons with a maximum height of 0.5 metres or more above the downstream natural surface level.*

WLRB2: Within the Creamery DSS an embankment is required on the downstream side of WLRB2. WLRB2 requires an embankment approximately 72 m in length with a maximum height of 490 mm including 300 mm freeboard to the adjacent waterway corridor.

Based on the above and in line with the current *Retarding Basin Design and Assessment Guidelines* (Melbourne Water, 2017) the embankment is less than 500 mm in height to the downstream natural surface level. Therefore, under these guidelines they are not classified as a dam and not subject to application of the ANCOLD assessment.

WLRB1, WLRB3a, WLRB3b, WLRB7, and WLRB8: Whilst there is no embankment for these retarding basins there is some risk due the adjacent valley, therefore an overflow spillway has been designed.

To ensure a conservative approach is undertaken during the functional design, the overflow spillways have been designed as per the ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams (2000), for a "Low" consequence category, which is 1 in 1000 AEP.

As part of the detailed design development a review of the ANCOLD assessment is required to be undertaken in line with any proposed changes to the retarding basin/embankment design, its height and risk failure analysis.

WLRB4, WLRB5, and WLRB6

There are no embankments for these assets. Due to the relatively flat adjacent topography and due to the assets being surrounded by development, an overflow spillway has not been incorporated into the design of these retarding basins. Instead, an auxiliary/emergency flow path has been identified.

The key design parameters for each retarding basin, including design levels, are provided in the tables below.

Climate change sensitivity check

Climate change scenarios have been adopted within the hydrologic models built. The purpose of adopting climate change scenarios is not to design assets to these increased peaks, but to perform a sensitivity check on how increased peak flows will move through the systems designed. For example, how an increased peak 1% AEP will sit within the provided freeboard in a proposed retarding basin.

The approach adopted for establishing climate change scenario has been:

- the use of Bureau of Meteorology (BoM) IFD curves derived for the site.
- that the IFD curves are adjusted to reflect increased intensity arising from climate change.
- ARR 2019 recommends the adoption of a 5% increase in rainfall intensity per degree of global warming (Book 1, Chapter 6) for events up to the 1% AEP.
- RCP 8.5 were adopted for climate change. The catchment is located within the Southern Slopes cluster, which estimates the temperature increase in the RCP 8.5 scenario of 3.6 degrees in the year 2090.
- This approach results in a 19% in rainfall intensity for 1% AEP event for the RCP 8.5 scenario

- The increase in rainfall intensity is not applied to events greater than the 1% AEP.

The results indicate that the 1% AEP climate change scenario results in a reduction in freeboard above the peak flood depth compared to the 1% AEP developed scenario. In the 1% AEP climate change scenario the freeboard ranges from 180 to 280 mm (compared to the minimum 300 mm freeboard provided in the 1% AEP developed scenario). The results indicate no overtopping of the retarding basins.

More detailed modelling is required to understand the increase in the storage requirement that could cater for climate change scenario, should Council require this. The results from modelling are provided in Table 9.

Table 9. Retarding basin analysis (climate change scenario)

	1% AEP developed scenario				Climate change scenario			
	1% AEP	1% AEP	1% AEP	1% AEP	1% AEP	1% AEP	1% AEP	1% AEP
Asset	Peak RB outflow (m^3/s)	Peak RB storage (m^3)	Peak RB flood depth (m)	Freeboard above peak flood depth (mm)	Peak RB outflow (m^3/s)	Peak RB storage (m^3)	Peak RB flood depth (m)	Freeboard above peak flood depth (mm)
WLRB1	1.95	5460	0.90	min 300	2.38	6110	0.98	220
WLRB2	2.02	8830	1.03	min 300	2.46	9990	1.13	200
WLRB3a	1.9	7260	1.10	min 300	2.34	8340	1.22	180
WLRB3b	1.58	5940	1.02	min 300	1.93	6760	1.11	240
WLRB4	1.75	7970	1.07	min 300	2.15	9090	1.17	280
WLRB5	2.11	7070	1.08	min 300	2.58	8090	1.18	220
WLRB6	1.66	6920	0.95	min 300	2.01	7790	1.03	220
WLRB7	1.53	8710	1.23	min 300	1.89	10100	1.36	190
WLRB8	1.79	6600	0.98	min 300	2.17	7460	1.07	230

Table 10. Retarding basin 1 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.79 ha
Normal water level (wetland)	56.20 m AHD
Top of Extended Detention (TED) (wetland)	56.55 m AHD
Peak 1% AEP RB inflow	2 m^3/s | 45 min event
Peak 1% AEP RB outflow	1.95 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	57.1 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	57.4 m AHD
Peak storage (1% AEP)	5460 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	2.8m weir (outlet pit, min.), crest TED
	750mm dia. pipe, drops pits
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3 m
Spillway width (set at 1% AEP peak flood elevation)	27 m (Peak 0.1% AEP flow 7.42 m^3/s)

Table 11. Retarding basin 2 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	2.42 ha
Normal water level (wetland)	53.20 m AHD
Top of Extended Detention (TED)	53.55 m AHD
Peak 1% AEP RB inflow	2.08 m^3/s | 1.5 hr event
Peak 1%AEP RB outflow	2.02 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	54.23 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	54.53 m AHD
Peak storage (1% AEP)	8830 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	2.1 m (outlet pit, min.), crest TED
	2 x 750mm dia. pipes
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m
Spillway width (set at 1% AEP peak flood elevation)	36 m (Peak 0.1% AEP flow 9.98 m^3/s)

Table 12. Retarding basin 3a key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.86 ha
Normal water level (wetland)	53.70 m AHD
Top of Extended Detention (TED)	54.05 m AHD
Peak 1% AEP RB inflow	1.99 m^3/s | 1. 5 hr event
Peak 1%AEP RB outflow	1.9 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	54.8 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	55.1 m AHD
Peak storage (1% AEP)	7260 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	1.7 m (outlet pit, min.), crest TED
	825mm dia. pipe
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m
Spillway width (set at 1% AEP peak flood elevation)	32 m (Peak 0.1% AEP flow 8.92 m^3/s)

Table 13. Retarding basin 3b key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	2.37 ha
Normal water level (wetland)	50.05 m AHD
Top of Extended Detention (TED)	50.40 m AHD
Peak 1% AEP RB inflow	1.69 m^3/s | 45 min event
Peak 1%AEP RB outflow	1.58 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	51.07 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	51.4 m AHD
Peak storage (1% AEP)	5940 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	1.7 m (outlet pit, min.), crest TED
	900mm dia. pipe
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m
Spillway width (set at 1% AEP peak flood elevation)	26 m (Peak 0.1% AEP flow 7.26 m^3/s)

Table 14. Retarding basin 4 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.65 ha
Normal water level (wetland)	63.50 m AHD
Top of Extended Detention (TED)	63.85 m AHD
Peak 1% AEP RB inflow	1.86 m^3/s | 1.5 hr event
Peak 1%AEP RB outflow	1.75 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	64.57 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	64.95 m AHD
Peak storage (1% AEP)	7970 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	1.7 m (outlet pit, min.), crest TED
	750mm dia. pipe
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m

Table 15. Retarding basin 5 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.73 ha
Normal water level (wetland)	61.45 m AHD
Top of Extended Detention (TED)	61.80 m AHD
Peak 1% AEP RB inflow	2.14 m^3/s | 1 hr event
Peak 1%AEP RB outflow	2.11 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	62.53 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	62.85 m AHD
Peak storage (1% AEP)	7070 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	2 m (outlet pit, min.), crest TED
	900mm dia. pipe
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m

Table 16. Retarding basin 6 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.45 ha
Normal water level (wetland)	67.30 m AHD
Top of Extended Detention (TED)	67.65 m AHD
Peak 1% AEP RB inflow	1.67 m^3/s | 1.5 hr event
Peak 1%AEP RB outflow	1.66 m^3/s | 1.5 hr event
Peak RB flood elevation (1% AEP)	68.25 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	68.55 m AHD
Peak storage (1% AEP)	6920 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	2.1 m (outlet pit, min.), crest TED
	750mm dia. pipe
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m

Table 17. Retarding basin 7 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	1.87 ha
Normal water level (wetland)	55.30 m AHD
Top of Extended Detention (TED)	55.65 m AHD
Peak 1% AEP RB inflow	1.61 m^3/s | 2 hr event
Peak 1%AEP RB outflow	1.53 m^3/s | 1.5 hr event
Peak RB flood elevation (1% AEP)	56.53 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	56.85 m AHD
Peak storage (1% AEP)	8710 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	1.1 m (outlet pit, min.), crest TED
	600mm dia. pipe, drop pits
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m
Spillway width (set at 1% AEP peak flood elevation)	28 m (Peak 0.1% AEP flow 7.63 m^3/s)

Table 18. Retarding basin 8 key parameter summary.

Parameter	Value
Total footprint area (incl. perimeter track)	2.15 ha
Normal water level (wetland)	44.45 m AHD
Top of Extended Detention (TED)	44.80 m AHD
Peak 1% AEP RB inflow	1.9 m^3/s | 45 min event
Peak 1%AEP RB outflow	1.79 m^3/s | 1 hr event
Peak RB flood elevation (1% AEP)	45.43 m AHD
Freeboard above peak flood depth	min 300 mm
Top of bank (lowest point)	45.75 m AHD
Peak storage (1% AEP)	6600 m^3
Typical bank battering slope (above TED)	1 in 8
Outlet configuration	2.1 m (outlet pit, min.), crest TED
	2 x 825mm dia. pipes
RB perimeter maintenance track minimum width allowance	4 m
RB internal access track minimum width allowance	3m
Spillway width (set at 1% AEP peak flood elevation)	29 m (Peak 0.1% AEP flow 8.02 m^3/s)

6.5 Other peak flow rates

Additional flow rates as established in the developed conditions RORB model are provided in Table 19 and Table 20. Flow locations are shown in Figure 29. These have been used to inform the waterway design.

- Point A - Flows from catchment Upstream S will be conveyed through a waterway (vegetated swale). When development occurs upstream, flows will be required to be retarded back to the current condition. Existing conditions peak flows at this location were used as inputs to the start of the waterway. The waterway was sized for the combined external flows, plus the outflows from WLRB2 and WLRB3a.

- Point B – Flows from WLRB4 and WLRB5 will be conveyed from this point through a waterway (vegetated swale). Flow results at model point B were used to size the waterway through this area.

- Point C – there is one sub-catchments where an RB has not been proposed due to the small nature of the catchment. Model point C is downstream of these sites and results will be used to ensure the overall peaks flows at this point do not exceed existing conditions, and therefore pose a risk to downstream environments.

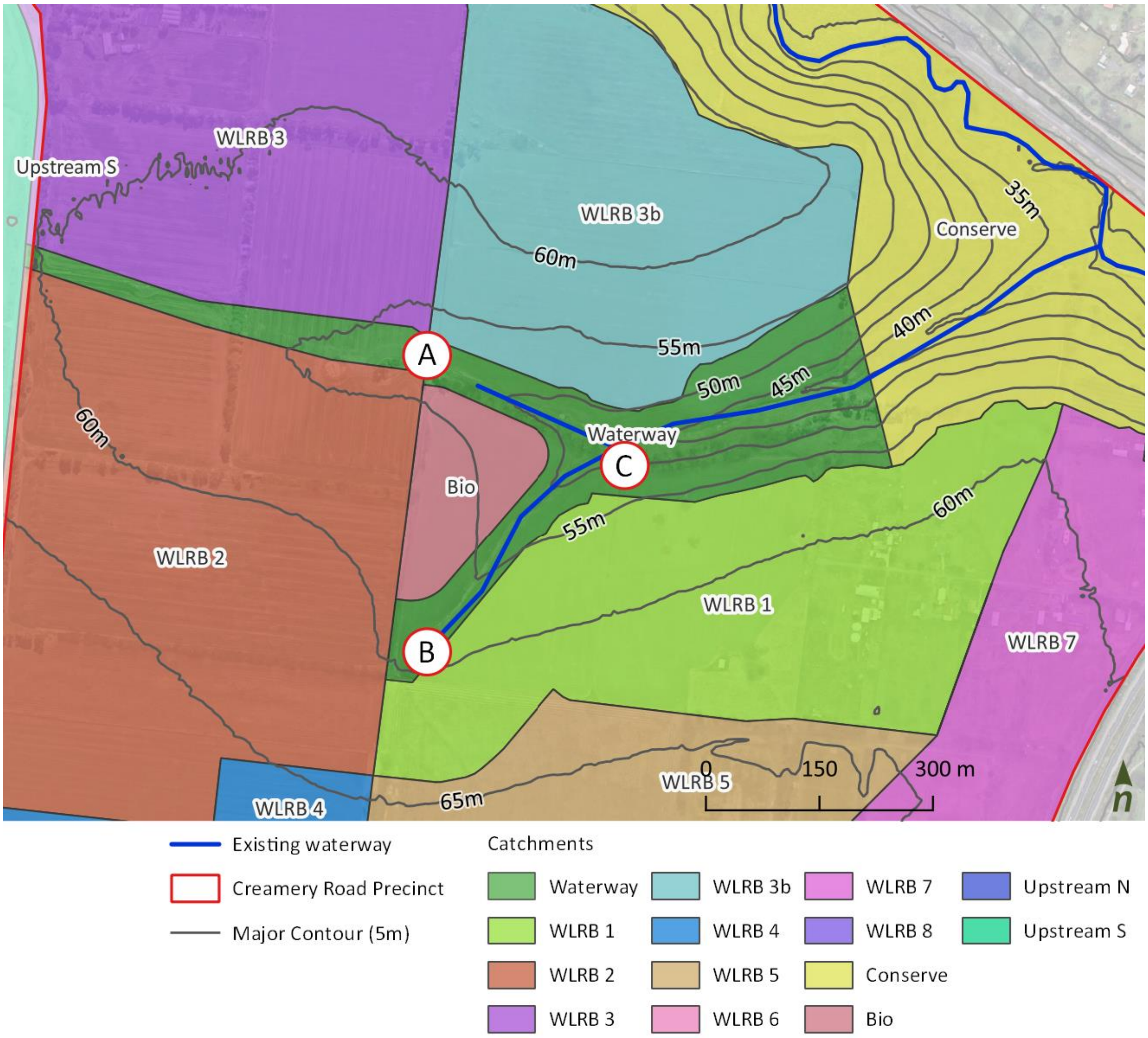


Figure 29. *Constructed waterway flow locations*

Table 19. Calculated flow rates for waterway design.

Storm event	Flow rate (m^3/s) – Waterway 1	Flow rate (m^3/s) – Waterway 2
1% AEP	4.89m^3/s (flow from external catchment S, at start of waterway. 7.15m^3/s, flows downstream of WLRB2 and WLRB3a (Point A).	3.83 m^3/s, combined flows from WLRB4 and WLRB5. (Point B)

Table 20. Other calculated flow rates

	Existing conditions flows	Developed conditions flows (including RBs)
Point C	10.54m^3/s	11.21 m^3/s

The results show that at Point C, the peak flows are marginally more than existing conditions. Having no retarding basins on the small catchments next to the tributary will likely have a negligible impact on flooding. To be confirmed through WMS's developed conditions flood modelling.

7 Wetland and sediment basin design

This section details the analysis, modelling, and results for the treatment assets.

7.1 Design arrangement overview

Eight wetlands were developed and are discussed in this section. This includes:

- Wetland 1: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to the tributary of Cowies Creek. The wetland is located within an RB (RB1). Key design considerations included the steep topography and the medium susceptibility landslide risk in this area. The steep topography results in much larger batter extents on the upstream (southern) side.
- Wetland 2: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to a new constructed vegetated swale, which also receives flows from upstream catchment N (external to the PSP), and outfalls from WLRB3a. The wetland is located within an RB (RB2). Key considerations included ensuring an allowance for the waterway corridor for the new swale.
- Wetland 3a: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to a new constructed vegetated swale. The wetland is located within an RB (RB3a).
- Wetland 3b: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to Waterway 1 near the confluence with Waterway 2. The wetland is located within an RB (RB3b). Key design considerations included the steep topography and the medium susceptibility landslide risk in this area. The steep topography results in much larger batter extents on the upstream (northern) side.
- Wetland 4: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to a new constructed vegetated swale, which also receives outflows from WLRB5. The wetland is located within an RB (RB4). The topography is relatively flat for this asset.
- Wetland 5: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to a new constructed vegetated swale, which also receives outflows from WLRB4. The wetland is located within an RB (RB5). The asset has been designed to be integrated into Myers Reserve, in line with the Myers Reserve Masterplan.
- Wetland 6: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling into vegetated swale alongside Princes Fwy, and eventually into Cowies Creek. The wetland is located within an RB (RB6). The topography is very flat within this catchment. Key considerations for this asset included ensuring free-draining subdivisional outfall into the RB, and design of the outfall given the long distance to the creek. The outfall is proposed to be into the adjacent existing swale along the Geelong Ring Rd.
- Wetland 7: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to Cowies Creek. The wetland is located within an RB (RB7). The topography is relatively steep in this area, which heavily influences battering extents. Other considerations include the medium susceptibility landslide risk in this area, adjacent GGF corridor, and heritage homestead.
- Wetland 8: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin which connects to the wetland, before outfalling to Cowies Creek. The wetland is located within an RB (RB8). The asset is located within the GGF corridor, and as such the wetland will need to ensure GGF wetland design guidelines are followed in the detailed design stage.

An allowance for rockwork for rock piles has been included in the costing. The asset has also been located outside of the 1% AEP flood extent as provided by WMS.

The design arrangement of the sediment basins and wetlands has been based off the following design principles:

- The assets are to be fed by the minor drainage network (20% AEP) from the contributing catchments.
- The sediment basins have been designed to capture 95% of coarse particles ≥ 125µm diameter entering the system.
- The wetlands have been sized based on achieving best practice treatment targets.
- Design should allow for maintenance requirements.
- Designs should aim to avoid fill where possible.

A design arrangement for the assets was completed based on the design principles and arranged to fit within the existing topography and site constraints. The Functional Design drawings are provided in Appendix F.

The sediment basin and wetland arrangements (refer to design drawings) have been designed to optimise treatment, and meet Melbourne Water's Constructed Wetland Design Manual deemed to comply criteria as best possible.

A GGF Management Plan will need to be prepared and implemented prior to construction of wetlands and waterways.

It should be noted that whilst distributed blue-green infrastructure throughout the precinct such as passively irrigated street trees or roadside treatment swales may reduce the required treatment footprints of the end-of pipe wetlands, they will not influence the flow retardation and storage requirements of the RBs, and as such will not reduce required asset footprints.

7.2 Stormwater treatment modelling

A key principle for the strategy is that all stormwater is to be treated to BPEM (Best Practice Environmental Management) Guidelines before being discharged from the study area. As such, the development site will require numerous treatment techniques in order to achieve the targeted reduction in pollutant load concentrations. The following BPEM targets have been adopted:

- 70% removal of the Total Gross Pollutant load
- 80% removal of Total Suspended Solids (TSS)
- 45% removal of Total Nitrogen (TN)
- 45% removal of Total Phosphorus (TP).

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was developed to estimate the pollutant loads generated from the developed conditions scenario. This allowed us to understand the target pollutant load reduction, and therefore test the sizing and treatment capacity of various opportunities required to meet the pollutant reduction targets. The concept design MUSIC model was updated as part of the functional design stage, with updated catchments and land uses.

Modelling inputs

The key modelling inputs for the MUSIC model are rainfall and evapotranspiration. Generally, for MUSIC a 10-year rainfall period is selected for a site which is a good representation of the average rainfall. The period adopted should consider a completeness of record, and representation of wet and dry periods.

The City has developed a 6-min infilled rainfall and evaporation template for Geelong North (station # 087133 from 1971-1980 for use in MUSIC modelling which has been adopted for this modelling. This template has an annual average rainfall of 533mm, and evaporation rate of 1108 mm/year.

Wetlands were selected as the preferred water quality assets due to their amenity, ease of maintenance, and ability to deliver a multi-functional asset when co-located within retarding basins (RBs). However, due to the steep topography around the central tributary, wetland assets would be difficult to construct and would require a prohibitive amount of battering, earthworks, and consequently an inefficient footprint. Therefore, in certain areas a bioretention system has been proposed to meet the treatment requirements for a small catchment which could not be treated in wetlands.

When modelling wetlands in MUSIC, an Extended Detention Depth (EDD) of 0.35m is typically adopted and a detention time of 72 hours is aimed for. This allows sufficient contact time with the vegetation, and therefore treatment of the stormwater. Bioretention systems were designed with an EDD of 0.2. Additional bioretention details are provided in Section 8.

The sediment basin areas for each wetland were sized using the Fair and Geyer equation, where sediment basins are required to meet a minimum 95% sediment capture efficiency of coarse particles ≥ 125 µm diameter for the peak 4EY (4 Exceedances per Year) event. The sediment basins were assumed to have an average depth of 0.8m, and the volume was used in the MUSIC modelling. The details of the sediment basin sizing calculations are provided in Section 7.3.

The catchment nodes used in the model have been calculated based on the areas, land use and associated FI values listed in Table 4. The MUSIC model layout is shown in Figure 30.

The treatment assets (wetlands, sediment basins and bioretention system) have been sized to treat the loads being generated from the future developable area to BPEM standards for each catchment. There is no treatment of external catchments.

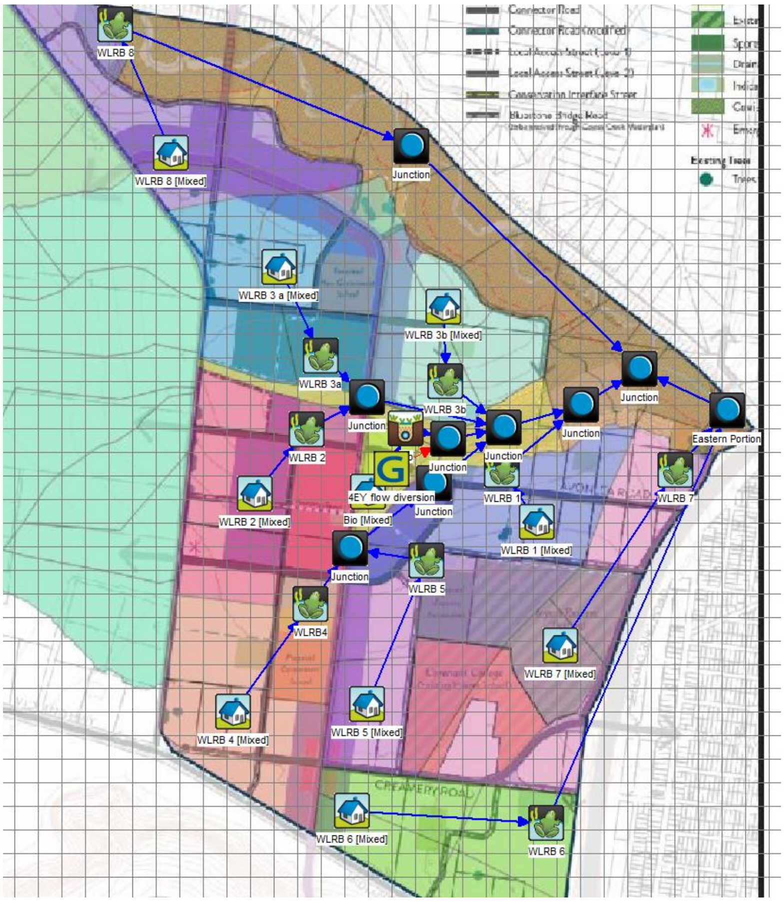


Figure 30. *MUSIC model layout*

All wetlands were modelled with custom stage storage discharge relationships. The stage storage was extracted from the earthworks model. The wetland sizing was done in conjunction with velocity checks and sediment capture efficiency calculations. For full details on wetland dimensions see section 7.5.

High flow bypasses in the treatment nodes were set at 100 as per Melbourne Water MUSIC Guidelines.

Asset Performance

The MUSIC modelling determined the sizing required for the wetland assets located at each of the catchment low points. The wetlands have been designed to inform the retarding basin stage-storage relationship presented in the hydrologic modelling section of this report. The details of the treatment systems are shown in Table 21.

Table 21. Treatment asset parameters for stormwater treatment assets

	Catchment area	Normal Water Level (NWL) area (m^2)	Inlet pond volume (m^3)	Average depth wetland (m)	Extended detention (m)	Extended detention time (hr)*
WLRB1	24.01	4000	800	0.4m	0.35	72hrs
WLRB2	33.50	6000	800	0.4m	0.35	48hrs
WLRB3a	31.83	4300	640	0.4m	0.35	72hrs
WLRB3b	24.67	3800	600	0.4m	0.35	72hrs
WLRB4	32.16	5000	720	0.4m	0.35	48hrs
WLRB5	32.51	4200	720	0.4m	0.35	72hrs
WLRB6	31.51	5000	800	0.4m	0.35	72hrs
WLRB7	35.32	4400	600	0.4m	0.35	48hrs

	Catchment area	Normal Water Level (NWL) area (m^2)	Inlet pond volume (m^3)	Average depth wetland (m)	Extended detention (m)	Extended detention time (hr)*
WLRB8	26.47	4700	600	0.4m	0.35	72hrs
Bio	3.39	100			0.2	

*Refer to inundation frequency analysis for more detail

The results of the MUSIC modelling analysis demonstrate that BPEM Guidelines / State pollutant reduction targets are met with the performance of those assets, as shown in Table 22.

The MUSIC model results for each individual wetland and the bioretention system are provided in subsequent tables. It should be noted that the limiting pollutant was Total Suspended Solids (TSS). Therefore, the targets for Total Phosphorus and Total Nitrogen were exceeded in most cases. Furthermore, for several assets the TSS targets were slightly exceeded. This was particularly the case for WL4 and WL7, which exceeded 81%. These two assets have 2-day detention times only. Having more flow-through systems increases treatment results in MUSIC, even though the wetlands are not achieving the recommended 3-day residence time and sufficient contact time with vegetation. Therefore, it is reasonable that the targets are slightly exceeded. During detailed design the arrangement and treatment modelling can be further refined.

Table 22. Overall MUSIC modelling results

	Source load	Residual load	% Reduction	kg/yr removed
Flow (ML/year)	193	181	6.4	
Total Suspended Solids (kg/yr)	37900.0	7220.0	80.9	30680.0
Total Phosphorus (kg/yr)	77.0	23.8	69.1	53.2
Total Nitrogen (kg/yr)	548.0	290.0	47.1	258.0
Gross Pollutants (kg/yr)	8700.0	0.0	100	8700.0

Table 23. Wetland 1 treatment results

	Source load	**Residual load**	**% Reduction**	**kg/yr removed**
Total Suspended Solids (kg/yr)	16300.0	3180.0	80.5	13120.0
Total Phosphorus (kg/yr)	33.3	10.3	68.9	23.0
Total Nitrogen (kg/yr)	232.0	121.0	48	111.0
Gross Pollutants (kg/yr)	3570.0	0.0	100	3570.0

Table 24. Wetland 2 treatment results

	Source load	**Residual load**	**% Reduction**	**kg/yr removed**
Total Suspended Solids (kg/yr)	23700.0	4600.0	80.6	19100.0
Total Phosphorus (kg/yr)	48.0	14.6	69.7	33.4
Total Nitrogen (kg/yr)	336.0	175.0	47.9	161.0
Gross Pollutants (kg/yr)	5110.0	0.0	100	5110.0

Table 25. Wetland 3a treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	16900.0	3400.0	79.9	13500.0
Total Phosphorus (kg/yr)	35.1	10.8	69.2	24.3
Total Nitrogen (kg/yr)	246.0	129.0	47.4	117.0
Gross Pollutants (kg/yr)	3970.0	0.0	100	3970.0

Table 26. Wetland 3b treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	15600.0	3140.0	80	12460.0
Total Phosphorus (kg/yr)	31.7	10.0	68.3	21.7
Total Nitrogen (kg/yr)	224.0	119.0	47	105.0
Gross Pollutants (kg/yr)	3500.0	0.0	100	3500.0

Table 27. Wetland 4 treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	20500.0	3900.0	81	16600.0
Total Phosphorus (kg/yr)	42.3	13.1	69	29.2
Total Nitrogen (kg/yr)	297.0	157.0	47	140.0
Gross Pollutants (kg/yr)	4610.0	0.0	100	4610.0

Table 28. Wetland 5 treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	17300.0	3430.0	80.1	13870.0
Total Phosphorus (kg/yr)	35.5	11.2	68.5	24.3
Total Nitrogen (kg/yr)	253.0	133.0	47.4	120.0
Gross Pollutants (kg/yr)	4050.0	0.0	100	4050.0

Table 29. Wetland 6 treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	20300.0	3950.0	80.6	16350.0
Total Phosphorus (kg/yr)	41.7	12.8	69.3	28.9
Total Nitrogen (kg/yr)	294.0	156.0	47.1	138.0
Gross Pollutants (kg/yr)	4520.0	0.0	100	4520.0

Table 30. Wetland 7 treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	17600.0	3310.0	81.3	14290.0
Total Phosphorus (kg/yr)	36.4	11.1	69.7	25.3
Total Nitrogen (kg/yr)	259.0	136.0	47.5	123.0
Gross Pollutants (kg/yr)	4180.0	0.0	100	4180.0

Table 31. Wetland 8 treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	17900.0	3530.0	80.4	14370.0
Total Phosphorus (kg/yr)	36.3	11.2	69.1	25.1
Total Nitrogen (kg/yr)	256.0	132.0	48.4	124.0
Gross Pollutants (kg/yr)	3900.0	0.0	100	3900.0

Table 32. Bioretention treatment results

	Source load	Residual load	% Reduction	kg/yr removed
Total Suspended Solids (kg/yr)	1710.0	337.0	80.3	1373.0
Total Phosphorus (kg/yr)	3.5	1.5	55.9	2.0
Total Nitrogen (kg/yr)	25.1	13.6	45.8	11.5
Gross Pollutants (kg/yr)	407.0	0.0	100	407.0

Inundation frequency analysis

One of Melbourne Water's 'deemed to comply' design criteria is for the water level in the wetland not to exceed half the average mature plant height for more than 20% of the time. This condition exists to achieve optimum plant health and function and can inform plant species selection in the shallow zone and deep marsh zones. The wetland guidelines also specify a residence time of three days (72 hours).

The "wetland analysis tool" in the MUSIC auditor tool enables flux files from MUSIC to be used to assess if a wetland meets the residence requirements. MUSIC auditor was used to check the desired 3 day detention time, and conduct an inundation frequency analysis to ensure plants will not be drowned out in the wetland.

Decreasing the size of the weir (sidewinder penstock) opening (the wetland outlet) limits the flow out of the wetland, and therefore increases residence time as well as increases the effective NWL. Opening the weir up creates a more flow-through system, and decreases the detention time and effective NWL. However, creating a flow-through system can also artificially create better treatment results. Changing the weir opening, and checking the MUSIC auditor results was conducted iteratively to strike a balance between the desired residence time, effective NWL, and inundation frequency. Essentially, we do not want water sitting above the EDD for longs periods of time.

Example results for the inundation frequency analysis for the WL1 can be seen in Figure 31 below, and the required weir openings and associated residence time for each wetland is provided in Table 33. All inundation results are provided in Appendix D.

The results show that a 3-day detention time was not possible for each wetland. For WL2, WL4 and WL7, a minimum of 2 days was aimed for. Closing the side-winder further caused the effective NWL to increase so it was a balance of achieving this minimum of 2 days, and minimising the effective NWL.

High effective NWLs can be managed through careful selection of plant species, and the consideration of shallowing out the wetland bathymetry in the detailed design stage should a 3-day detention time be achieved, but with an effective NWL over 0.05m exceed for 50% of the time.

Table 33. Wetland outlet properties and residence time results

	WL1	WL2	WL3a	WL3b	WL4	WL5	WL6	WL7	WL8
Weir opening (side-winder penstock) (m)	0.082	0.105	0.085	0.081	0.095	0.085	0.093	0.088	0.09
Residence time	3 days	2 days	3 days	3 days	2 days	3 days	3 days	2 days	3 days
Water level exceeded for 50% of the time (m)	0.0478	0.0487	0.0493	0.0467	0.0489	0.0495	0.0499	0.0486	0.0465

Choose file WL1.csv
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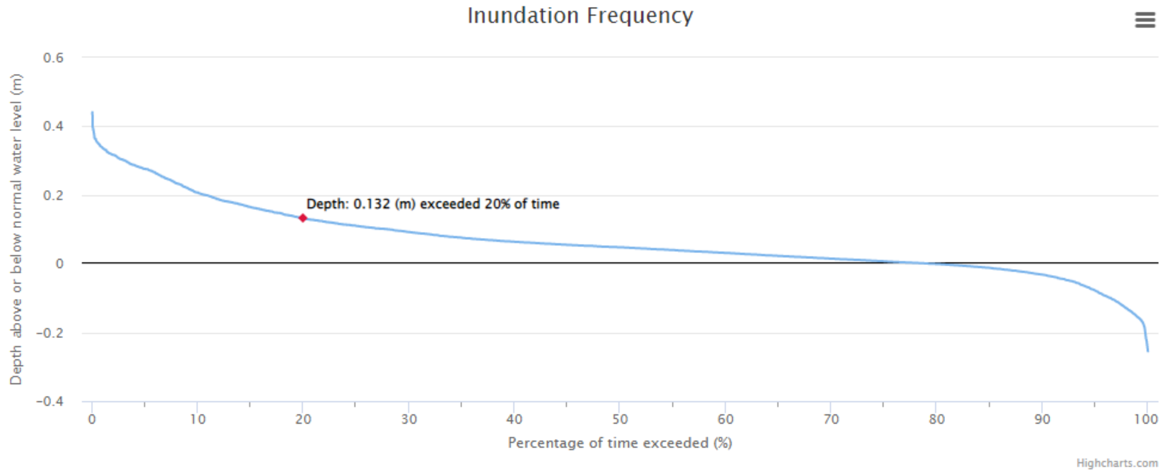

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL1.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.132 m

Water level exceeded for 50% of time: 0.0478 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 31. *Wetland 1 inundation frequency results*

7.3 Sediment Basin sizing

The wetlands were designed with sediment basins which first receive the minor drainage flows, to allow coarse sediments to drop out before entering the macrophyte zone.

The sediment basins in the treatment modelling have been sized using the Fair and Geyer equation, where sediment basins are required to meet the following criteria - capture 95% of coarse particles ≥ 125 µm diameter for the peak three-month ARI event. The procedure outlined in *WSUD Engineering Procedures* (2005) has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment. The sediment basins have been modelled with a pool depth of 1.5 m and a standard cleanout frequency of 5 years. The sediment basin sizing was used for the inlet pond in the wetland nodes (assuming an average depth of 0.8m).

The sediment basin arrangements have also been informed by the need to meet velocity requirements. That is, that the velocity within the basin needs to be <0.5m/s for the 20% AEP flows.

The velocity calculations (Table 35) and sediment capture efficiency calculations (Table 36) were performed iteratively to ensure all criteria was met and the sediment basins were sized appropriately. The flows used in these calculations have been extracted from the RORB model.

The batter requirements, including a 1 in 8 safety bench, are specified Table 34 below. Where a batter of a minimum of 1 in 3 above open water cannot be met, a fence or barrier should be adopted for safety reasons. This requirement has been met so fences will not be required.

Table 34. Sediment basin batters

Description	Slope	Distance
NWL to -350 mm (Safety bench)	1 in 8	2.8 m
-350mm to -1500mm (Pool base)	1 in 3	3.45 m
NWL to TED (350mm)	1 in 6	2.1 m

Table 35. Velocity calculations

	Parameter	WLRB 1	WLRB 2	WLRB 3a	WLRB3b	WLRB 4	WLRB 5	WLRB 6	WLRB 7	WLRB 8
Flow conditions	4EY flow (m^3/s)	0.53	0.76	0.70	0.55	0.67	0.71	0.41	0.61	0.62
	20% AEP flow (m^3/s)	2.64	3.78	3.51	2.77	3.34	3.53	2.05	3.04	3.09
	Flow depth (m)-between NWL and TED	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Sediment pond	Basin area (m^2)	1000	1000	800	750	900	900	1000	750	750
	Width at NWL (m)	17	20	19	18	20	19	20	18	18
	Width at EDD (m)	21.2	24.2	23.2	22.2	24.2	23.2	24.2	22.2	22.2
	Average width (m)	19.1	22.1	21.1	20.1	22.1	21.1	22.1	20.1	20.1
	Flow Area (m^2)	6.7	7.7	7.4	7.0	7.7	7.4	7.7	7.0	7.0
	Flow Velocity (m/s) (20% AEP)	0.39	0.49	0.48	0.39	0.43	0.48	0.27	0.43	0.44
	Check	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK
	Length to width ratio*	3.46	2.5	2.22	2.31	2.25	2.49	2.50	2.31	2.31

*The reduced length to width ratios are reflected in the hydraulic efficiency of the sediment basins

Table 36. Sediment basin sizing

	Parameter	WLRB 1	WLRB 2	WLRB 3a	WLRB3b	WLRB 4	WLRB 5	WLRB 6	WLRB 7	WLRB 8
Conditions	Contributing Catchment (ha)	24.01	33.5	31.83	24.67	32.16	32.51	31.51	35.32	26.47
	Area of Basin (m^2)	1000	1000	800	750	900	900	1000	750	750
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11	11	11	11	11	11	11	11	11
	Hydraulic Efficiency (λ)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	Permanent Pool Depth, dp (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Extended detention depth, de	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
	Number of CTSR's, n	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	1	1	1	1	1	1	1	1	1
	Design Discharge (m^3/s) [4EY]	0.53	0.76	0.70	0.55	0.67	0.71	0.41	0.61	0.62
	Capture Efficiency	98%	98%	97%	98%	98%	97%	99%	97%	97%
	Check (>95%)	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Desired clean-out frequency, Fr	5	5	5	5	5	5	5	5	5
	Storage volume required, St	189	262	247	193	251	254	249	275	206
	Available sediment storage volume	500	500	400	375	450	450	500	375	375
	Check (Available storage > required storage)	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Sediment dewatering	Depth for dewatering area (m)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Area required for dewatering (m^2)	378	523	495	385	502	507	499	550	412

7.4 Wetlands

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system complies with appropriate guidelines. The sediment basin and macrophyte zone were sized in 12d using LiDAR data to create a surface level Triangulate Irregular Network (TIN). This then allowed for iterative sizing by changing the layout, location, and Normal Water Level (NWL) height in order to integrate into the existing landscape and minimise cut into the site, and avoid requiring fill where possible. The sizing was conducted in conjunction with MUSIC modelling in order to optimise pollutant removal, and the hydrologic modelling to ensure detention requirements were met.

Other factors that influenced the configuration of the asset included:

- The requirement to meet a length to width ratio of at least 4:1[MZ4 in the constructed wetlands manual], and therefore the associated maximum width, and how this fit in with the surrounding terrain.
- Meeting velocity requirements
- Minimising excavation requirements where possible.

Batter slopes

The batter requirements, including a 1 in 8 safety bench, are specified in Table 37 below. Where a batter of a minimum of 1 in 3 above open water cannot be met, a fence or barrier should be adopted for safety reasons. This requirement has been met so fences will not be required.

Table 37. Wetland batters

Description	Slope	Distance
NWL to -350 mm (safety bench)	1 in 8	2.8 m
-350mm – 1500mm (pool base)	1 in 3	3.45 m
NWL to TED (350mm)	1 in 6	2.1 m

Velocities

The velocities through the wetlands were also checked. A flow depth of 0.35 m, which is the extended detention depth, has been assumed for all flows, which is a conservative approach (as a calculated smaller flow area will result in higher calculated velocities).

A manual calculation has been used to check the flow velocities through the assets. This calculates the flow area from the flow depth (between the extended detention depth and normal water level) and the average width in that area. The average width is determined from the narrowest part of the macrophyte zone or sediment basin. Velocities within the macrophyte zone should be under 0.05m/s. Peak flows were extracted from RORB.

The maximum width of the wetland was determined using the length to width ratio of at least 4:1[MZ4]. The calculations for the velocities through the wetlands, as well as the length to width ratios are shown in Table 38.

Some assets have relatively large incoming flows, which has resulted in the need for wide wetlands. In some cases this has results in reduced length: width ratios.

Table 38. Velocity calculations

	Parameter	WL1	WL2	WL3a	WL3b	WL4	WL5	WL6	WL7	WL8
Flow conditions	4EY (3 month flow) (m^3/s)	0.53	0.76	0.70	0.55	0.67	0.71	0.41	0.61	0.62
	Flow depth (m)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Wetland	Width at NWL (m)	31	42	37	30	35	35	35	33	34
	Width at EDD (m)	35.2	46.2	41.2	34.2	39.2	39.2	39.2	37.2	38.2
	Average width (m)	33	44	39	32	37	37	37	35	36
	Flow Area (m^2)	12	15	14	11	13	13	13	12	13
	Flow Velocity (m/s)	0.046	0.049	0.05	0.049	0.05	0.05	0.03	0.05	0.05
	Check	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK	< 0.05 OK
	Length: width ratios	4.16	3.40	3.14	4.22	4.08	3.43	4.08	4.04	4.07

7.5 Dimensions and quantities

The below tables detail the key asset parameters.

Table 39. Wetland dimensions and parameters (WL1, WL2, WL3a, WL3b, WL4)

Parameter	WLRB1	WLRB2	WLRB3a	WLRB3b	WLRB4
Sediment basin					
NWL	56.3 m AHD	53.3 m AHD	53.8 m AHD	50.15 m AHD	63.6 m AHD
NWL area	1000m^2	1000 m^2	800 m^2	750 m^2	900m^2
NWL width (average)	17 m	20 m	19 m	18 m	20 m
EDD	0.35m	0.35m	0.35m	0.35m	0.35m
TED	56.65 m AHD	53.65 m AHD	54.15 m AHD	50.5 m AHD	63.95 m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m	1.5m
Batters (NWL to TED)	1:6	1:6	1:6	1:6	1:6
Transfer pit crest (NWL)	56.3 m AHD	53.3 m AHD	53.8 m AHD	50.15 m AHD	63.6 m AHD
Transfer pipe diameter (4EY flows)	825mm	1050mm	1050 mm	900 mm	900mm
High flow transfer weir width (20% AEP – 4EY flows)	6m	9m	8m	6.5m	8m
Wetland	WL1	WL2	WL3a	WL3b	WL4
NWL	56.2 m AHD	53.2 m AHD	53.7 m AHD	50.05 m AHD	63.5 m AHD
NWL area	4000 m^2	6000 m^2	4300 m^2	3800 m^2	5000 m^2
NWL width (average)	31 m	42 m	37 m	30 m	35 m
EDD	0.35m	0.35m	0.35m	0.35m	0.35m
TED	56.55 m AHD	53.55 m AHD	54.05 m AHD	50.4 m AHD	63.85m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m	1.5m
Batters (NWL to TED)	1:6	1:6	1:6	1:6	1:6

Table 40. Wetland dimensions and parameters (WL5, WL6, WL7. WL8)

Parameter	WLRB5	WLRB6	WLRB7	WLRB8
Sediment basin				
NWL	61.55 m AHD	67.4 m AHD	55.4 m AHD	44.55 m AHD
NWL area	900 m^2	1000m^2	750 m^2	750 m^2
NWL width (average)	19 m	20 m	18 m	18 m
EDD	0.35m	0.35m	0.35m	0.35m
TED	61.9 m AHD	67.75 m AHD	55.75 m AHD	44.9 m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m
Batters (NWL to TED)	1:6	1:6	1:6	1:6
Transfer pit crest (NWL)	61.55 m AHD	67.4 m AHD	55.4 m AHD	44.55 m AHD
Transfer pipe diameter (4EY flows)	1050mm	750mm	900mm	900mm
High flow transfer weir width (20% AEP – 4EY flows)	8m	5m	7m	7.5m
Wetland	WL5	WL6	WL7	WL8
NWL	61.45 m AHD	67.3 m AHD	55.3 m AHD	44.45 m AHD
NWL area	4200 m^2	5000 m^2	4400 m^2	4700 m^2
NWL width (average)	35 m	35 m	33 m	34 m
EDD	0.35m	0.35m	0.35m	0.35m
TED	61.8 m AHD	67.65 m AHD	55.65 m AHD	44.8 m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m
Batters (NWL to TED)	1:6	1:6	1:6	1:6

7.6 Connections

Inflow into sediment basins

The inflow to the sediment basins will be via the minor drainage network. The stormwater main for the catchment will outfall into the sediment basins. Typically, this will be via a rocked endwall.

Sediment basin to wetland transfer

There will be piped connections between the sediment basins and the macrophyte zone to pass the 4EY AEP (3 month ARI) peak flow. The connections will be an outlet pit, with the top of the pit at the sediment basin NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The pipes have been sized to pass the 4EY peak flow as established in RORB. The invert of the pipe on the wetland side should be set 300mm above the base of the pool so to avoid being blocked by accumulated sediment. There are Melbourne Water standard drawings for these connection details (i.e. 7251/12/008 and 7251/12/001).

Balance pipes

300mm diameter balance pipes connected to submerged offtake pits will be located in the base of the wetland pools, connecting them up. This is important to be able to drain the system for maintenance purposes. This is as per Melbourne Water standard drawings 7251/12/015 and 7251/12/035.

Wetland outfall

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level, and flows in the macrophyte zone, to achieve the design detention time for treatment performance.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to a twin chamber outfall pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure for maintenance. These pits have been located next to the internal path.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The control pit has an outlet pipe which will connect with the RB outlet pit.

There is a Melbourne Water standard drawing for this wetland pit detail (i.e. 7251/12/006).

7.7 Maintenance

Access

An access track has been located around the treatment systems within the RB, ensuring access to the sediment basin and macrophyte area for maintenance purposes. These have been provided at a level of 500mm above the wetland TED. This to ensure the path does not regularly inundate. Access paths should be at least 3m wide and with a cross fall no steeper than 1:20m, graded towards the wetland.

A 4m wide concrete path is also provided around the RB perimeter. This can also serve as a recreational loop around the asset.

A maintenance ramp will be provided to the sediment basins. The ramp should extend from the base of the sediment basin to the RB top of batter. It will be 4m wide and no steeper than 1:6. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR (see Melbourne Water standard drawing 7251/12/013). The base of the sediment basins should be concrete or rocked (7251/12/012). Access to the sediment dewatering area has also been provided.

Sediment dewatering area

Sediment dewatering areas will be required to allow for accumulated sediment taken from the sediment basin to be dewatered before it is transported off the site. This is proposed to occur laterally of the asset, as shown in the design drawings. Access to the sediment basin is via a ramp to the base of the basin.

7.8 Wetland design checklist

The list below provides the design compliance criteria from the Melbourne Water *Wetland Design Manual: Design, Construction and Establishment of Wetlands (2020).* For criteria related to modelling and key design requirements calculated by Alluvium, the relevant section of this report is referenced.

Table 41. Compliance criteria

Category	Design condition	Brief description	Design phase	Met	Notes
General	GN1	Modelling in MUSIC	Concept Functional Detailed	✓	Performed
	GN2	MUSIC meteorological data	Concept Functional Detailed	✓	Geelong North (station # 087133) from 1971-1980
	GN3	MUSIC consistent with plans	Concept Functional Detailed	✓	Provided
	GN4	Peak design flows in accordance with AR&R	Concept Functional Detailed	✓	Peak flows are calculated using RORB and adopting ARR2019.
Maintenance provisions	MN1	Sediment pond drained with macrophyte zone at NWL	Functional Detailed	✓	SB NWL sitting 100mm above the wetland NWL
	MN2	Sediment pond accessibility	Functional Detailed	✓	An access track around the sediment basin has been included as well as an access ramp
	MN3	Sediment pond base	Detailed	✓	Concrete base provided
	MN4	Hardstand area for edge cleaned sediment basins	Detailed	✓	
	MN5	Maintenance access ramps for sediment ponds that cannot be edge cleaned.	Functional Detailed	✓	Provided
	MN6	Maintenance access tracks to sediment pond access ramp	Concept Functional Detailed	✓	Provided
	MN7	Turning circle	Detailed Functional	✓	Provided track with ability to turn

	MN8	Clearly marked intersections with pedestrian paths	Detailed	✓	
	MN9	Sediment dewatering areas	Concept Functional Detailed	✓	Sediment dewatering areas will need to be located outside of the RB.
	MN10	Maintenance vehicle access for macrophyte zone	Concept Functional Detailed	✓	4m maintenance access provided around the perimeter of the RB. Access also provided around the wetland for at least 50% of wetland perimeter.
Sediment Pond	SP1	Located offline to waterway, online to pipe	Concept Functional Detailed	✓	All SBs located within RBs.
	SP2	Located at each stormwater entrance point	Concept Functional Detailed	✓	SBs located where stormwater enters the wetland systems. No SB where the incoming stormwater is <5% of the total wetland catchment.
	SP3	Sediment pond size	Functional Detailed	✓	Designed to meet the requirements of capture efficiency and velocity thresholds, as well as adequate sediment storage.
	SP4	EDD <= 350 mm	Concept Functional Detailed	✓	EDD of 350mm
Macrophyte zone	MZ1	80% area must be less than 350 mm deep	Functional Detailed	✓	Approximately 80% of the wetland is less than 350 mm deep.
	MZ2	EDD <= 350 mm	Concept Functional Detailed	✓	EDD of 350mm has been adopted in all wetlands
	MZ3	Macrophyte zone located offline	Concept Functional Detailed	✓	Macrophyte zones located offline to waterways.
	MZ4	Length > = four times average width	Concept Functional Detailed	x	Length to width ratio is above 4:1 for most wetlands. Some less than 4:1 (minimum 3:1) due to managing velocities (i.e. requiring wider wetlands)
	MZ5	Outlet located at opposite end to inlet	Concept Functional Detailed	✓	Provided.
	MZ6	Submerged, shallow and deep marsh zones in a banded manner.	Functional Detailed	✓	Provided
	MZ7	Inlet and outlet pool depth <=1.5m	Functional Detailed	✓	Inlet and outlet pool depth is 1.5m
	MZ8	Intermediate Pools depth <=1.2m	Functional Detailed	✓	Intermediate pools are 1.2m deep.

	MZ9	Flow velocities limits	Functional Detailed	✓	4EY flow velocities are below the 0.05m/s thresholds.
	MZ10	Residence time 90th percentile of 3 days or 72 hours	Functional Detailed	x	Residence time is 2+ days for all wetlands. For some wetlands 3 days could not be achieved without resulting in high effective NWLs.
	MZ11	Minimum longitudinal grade	Functional Detailed	✓	Provided. Ranges from 1 in 150 to 1 in 400
	MZ12	Water level marker	Detailed	✓	Provided
	MZ13	No islands within wetland	Concept Functional Detailed	✓	No islands
Bypass	BY1	Sediment basin bypass/overflow sizing	Concept Functional Detailed	x	No bypasses provided.
Inlets and outlets	IO1	Pits, grilles and structures	Detailed	✓	Provided as per Melbourne Water standard drawings
	IO2	Outlet structures – easily identifiable and maintainable	Detailed	✓	Provided. Wetland outlet located out of wetland.
	IO3	Controlled outlet	Detailed	✓	Twin chamber outfall pit with side-winder penstock provided
	IO4	Sediment pond to wetland connection	Functional Detailed	✓	Pipe connection between SBs and macrophyte zones sized to take the peak 4EY flows.
	IO5	Controlled outlet submerged	Detailed	✓	Provided
	IO6	Control macrophyte zone water level	Functional Detailed	✓	Provided by sidewinder penstock in EDD control pit.
	IO7	Maintenance drawdown pipes	Functional Detailed	✓	Provided.
Vegetation	VG1	80% emergent macrophytes	Functional Detailed	✓	Provided.
	VG2	Open water < 20%	Concept Functional Detailed	✓	Share of open water from the macrophyte zone is less than 20%.
	VG3	Densely planted ephemeral batters	Functional Detailed	✓	Provided; 4 plants/m^2
	VG4	Ephemeral batters planting cells	Detailed	✓	200cm^3 tray cells recommended in planting schedule
	VG5	Densely planted shallow marsh	Functional Detailed	✓	Provided; 2 plants/m^2
	VG6	Densely planted deep marsh	Functional Detailed	✓	Provided; 2 plants/m^2
	VG7	Densely planted submerged marsh	Functional Detailed	✓	Provided; 1 plant/m^2
	VG8	Seedlings	Detailed	✓	600cm^3 tray cells to be used as per planting schedule

	VG9	Seedlings	Detailed	✓	600cm³ tray cells to be used as per planting schedule
	VG10	Effective water depth	Functional Detailed	✓	See inundation frequency analysis (see Appendix D)
	VG11	Stormwater harvesting	Concept Functional Detailed	✓	Ability to harvest off the wetland control pits in downstream chamber.
	VG12	Wetland outfall	Functional Detailed	✓	Outfall sized so plants do not drown out.
	VG13	Grassed areas	Functional Detailed	✓	1 in 8 RB slopes.
	VG14	Mulch and jute mat	Functional Detailed	✓	No mulch to be used below 1% AEP or frequently inundated areas. Jute mat between NWL and TEDD.
Liner and topsoil	LN1	Exfiltration rate	Concept Functional Detailed	✓	Clay liners in sediment basins, wetlands.
	LN2	Impermeable liners	Detailed	✓	Groundwater table below excavation.
	LN3	Topsoil depth	Functional Detailed	✓	200mm topsoil provided
	LN4	Topsoil type	Detailed	✓	*Detailed design must ensure topsoil complies with AS 4419 Soils for landscaping and gardening use*
Landscape design structures	LDS1	Landscape design structures in accordance with MW guidelines requirements	Detailed	✓	Shared paths located outside of 1 in 10 year flood extent difficult to achieve as in RB. Drown-outs required.
	LDS2	Boardwalks or viewing platforms not permitted over sediment ponds, pipes and pits, weirs, rock chutes	Concept Functional Detailed	✓	No boardwalks or viewing platforms.
	LDS3	Vehicle exclusion bollards	Concept Functional Detailed	✓	Provided
Edge treatment	ET1	Deep open water edge not obscured	Functional Detailed	✓	Provided. Safety bench provided in sediment basins and wetlands. Pit structures locked.
	ET2	Batters	Functional Detailed	✓	Edges no steeper than 1:6 (NWL to TED), and safety bench at 1:8 provided. 1 in 8 RB batters.
	ET3	Minimum offset of 15 m wetland NWL to any allotment	Detailed	✓	Minimum offset of 15 m provided

7.9 Stormwater harvesting and use

The proposed wetlands for the Creamery Road PSP present a good opportunity to harvest treated PSP flows for fit-for-purpose reuse (e.g., site irrigation) at the local scale and potentially, to contribute to a proposed alternate water supply distribution network. As discussed in section 4.2, Barwon Water have proposed a future stormwater distribution ring main along the CCC. The intention is for the distribution main to service broader areas of the catchment and the Creamery Road precinct, with alternate water supplies through a series of pipe connections. It is intended that the CCC will in future be connected to the Wurdi Boluc Reservoir via construction of a 30km length transfer main. Details on this distribution main / pipe network are yet to be finalised by Barwon Water and were not available at the time of the PSP functional designs.

However, the proposed Creamery Road PSP wetlands have been designed with this future alternate supply network in mind. Without further details on the proposed network, the opportunity to integrate the PSP stormwater assets, functionally, with the distribution main could only be considered at a high-level.

In the context of IWM, it is recommended that wherever possible, the PSP wetland assets be integrated with (connected to) the future alternate supply network for stormwater harvesting (SWH). This would also allow the PSP to respond favourably to the requirements of the new Environment Protection Act 2017, General Environmental Duty (GED), and EPA Guidance (2021), where a reduction in runoff volumes is part of current best practice targets. The opportunity to capture PSP flows and transfer these to the CCC distribution main for broader use, is strongly recommended.

Integrated stormwater harvesting should be adopted for PSP stormwater assets as this would provide a direct reduction in runoff volumes to Cowies Creek. Further, SWH provides for a reduction in potable water consumption through provision of a reliable source of irrigation water, further enhancing areas of open space, ensuring asset preservation through times of dry, and encourages urban greening and cooling outcomes.

The following assets provide opportunity to be gravity fed to the distribution main as they fall upstream of the CCC – WLRB2, WLRB3a, WLRB3b, WLRB4 and WLRB5. This will, of course, depend on the distribution main levels. For the wetlands that fall downstream of the CCC – that is, WLRB1, WLRB6, WLRB7, and WLRB8, these treated flows would require pumping services to the CCC. This option has been indicated in the functional design drawings and should be confirmed and refined further at the detailed design stage and/or when details of the proposed distribution main are confirmed by Barwon Water.

As indicated in the respective functional design drawings, treated flows could be harvested from the downstream chamber of the wetland outlet pit. These pit chambers will have a sump, enabling a pump to site, and operate, within the chamber. For wetland assets requiring a pump service/setup, a nominal allowance for a 3mx3m footprint for a future pump shed has been allowed for, outside the RB extents.

In the interests of maximising harvest potential, and allowing direct extraction from wetland outlet pools, the option of using the treatment wetlands as SWH storages with an extended detention depth (EDD) of 500mm was also considered. However, this option is not recommended as it would require constant pumping to the distribution network, resulting in higher energy / operating costs, to ensure wetland treatment vegetation is not at risk of failure due to prolonged inundation. A loss of treatment vegetation would render the treatment wetland to under-perform and not meet State pollutant reduction targets. It may also result in higher intervention costs by council to reinstate losses and replace pumping systems more frequently due to high usage. Therefore, the industry best practice standard of 350mm EDD is recommended.

Alternately, consideration should also be given to those wetland assets located in close proximity to an existing area of open space or proposed. For instance, WLRB5 is located next to Myers Reserve. Ideally, treated flows from WLRB5 should be used to irrigate vegetation communities and landscapes within Myers Reserve. While

WLRB3a is located close to proposed active open space reserves and will require a regular supply of water to maintain oval quality and use (e.g., approx. 3 irrigation cycles per week, at approx. 150ML per cycle, per oval).

It is highly recommended that where an area of green or public open space is existing or proposed for the PSP, that treated wetland flows be directed to these adjacent locations. Consideration should be given to the water-energy nexus, where the end use is best served (sustainably) close to the supply source, and not necessarily all pumped to the proposed CCC distribution main.

8 Bioretention system design

A bioretention system was adopted for the small catchment located between the two tributaries, servicing community facilities and open space. A wetland/retarding basin is not appropriate in this location given the relatively small catchment size (3.39ha). The bioretention system will be able to be integrated into the proposed park land use. Alternatively, the treatment could be distributed and incorporated into future building and road design. For the purposes of this functional design, an end-of-line bioretention system has been adopted.

A typical cross section of a bioretention system is provided in Figure 32.

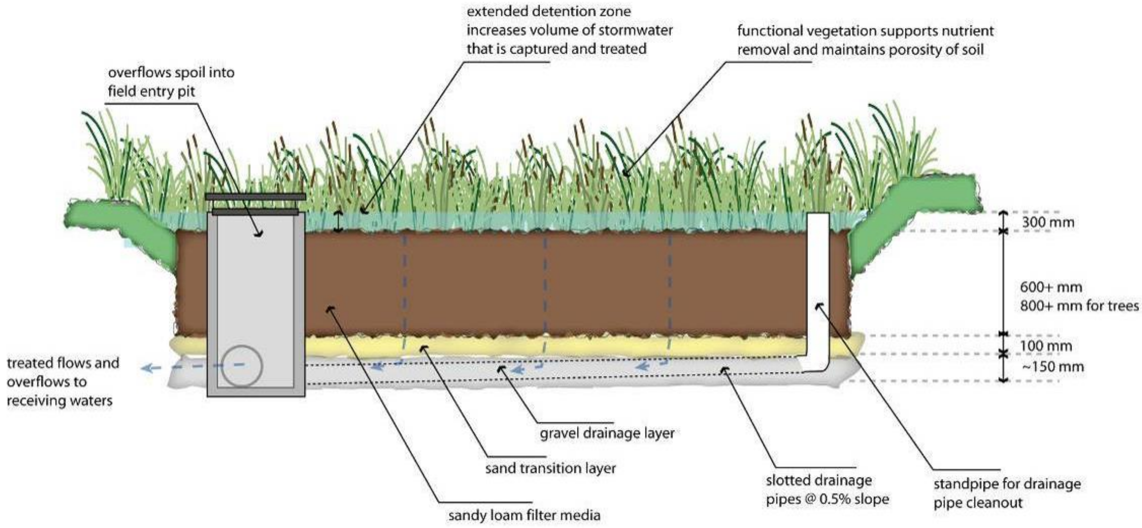

Figure 32. *Typical raingarden cross section*

Typical operational characteristics of a bioretention asset are summarised below:

- Redirect of stormwater to the bioretention asset (typically 4 Exceedances per Year flow)
- Stormwater drains through the bioretention filter media before reaching the drainage network via a sub-surface drain
- Vegetation planted within bioretention system slows flow of water, enhances stormwater treatment and adds to visual amenity.

8.1 Asset sizing

MUSIC has been used to size the bioretention asset. MUSIC modelling assumptions and outputs are outlined in Table 42. Bioretention design should adhere to Council's Design note 3 – Bioretention.

Table 42. MUSIC modelling design assumptions

Parameters	Value
Filter media area	100 m^2
Extended Detention	0.2 m
Lined / unlined	The bioretention system is lined with an impermeable liner to create a saturated zone which assists in stormwater treatment and provide an additional source of

	water for the biofilter plants to access. The liner also ensures groundwater does not interfere with drainage of the bioretention system.
Saturated Hydraulic Conductivity	100 mm/hr
Filter Depth	500mm
TN Content	800 mg/kg
Orthophosphate content	55 mg/kg
Exfiltration rate	0 mm/hr given inclusion of liner
Underdrain present	Yes
Submerged zone	Yes
Rainfall data	6-minute time-step, 'Geelong North (station # 087133 from 1971-1980)
Design flow	0.078m^3/s (4EY of contributing catchment)

8.2 Dimensions and quantities

A summary of the asset levels and dimensions is provided in Table 43.

Table 43. Bioretention system design summary

Item	Brief description	Notes/value
General information	Catchment area	3.39 ha
	Fraction Imperviousness	0.56
Design inflow	Design flow rate (4EY)	0.078 m^3/s
Treatment effectiveness	TSS reduction	80.3 %
	TP reduction	55.9 %
	TN reduction	45.8 %
	Gross pollutant reduction	100 %
	Water quality treatment meets best practice	Achieved
Bioretention profile	Sediment pre-treatment provided to protect filter media	Grouted rock scour protection. Catchment <10ha, no sediment basin required.
	Filter media hydraulic conductivity (100-300 mm/hr)	100 mm/hr
	Filter media depth (≥ 400mm)	500 mm
	Transition layer depth (≥ 100mm)	300 mm
	Drainage layer depth (≥ 50mm drainage material above underdrainage slotted pipe)	200 mm
	Extended detention depth (EDD)/ ponding depth (≤ 500mm)	200 mm EDD

	Freeboard to top of batter	200 mm minimum
	Total depth below top of filter media	1000 mm
	Liner (around base and sides of bioretention system)	Impermeable liner is proposed
Design levels	Diversion/inlet pipe – upstream invert level	TBC once subdivisional drainage design undertaken
	Diversion/inlet pipe – downstream invert level	52 m AHD
	Filter media surface level	52 m AHD
	Overflow pit invert level	52.2 m AHD
Layout	Filter area	100 m^2
	Batter slope	1 (V) : 4 (H)
	Total footprint	248m^2
Inlet and diversion design	Diversion type	Weir structure in proposed new pit to divert water to bioretention system
	Inlet type	Pipe
	Diversion pipe	300 mm Reinforced Concrete (RC) Class 2
Outlet and connection design	Overflow structure type	Overflow pit
	Overflow pit dimension (internal)	600 (W) by 600 (H) by 1200mm (H)
	Overflow weir length	N/A
	Outlet type	Pipe
Maintenance and erosion protection	Provision of maintenance vehicle access	Vehicle access through local roads (TBC). 4m wide access path from closest road in FUS allowed for.
	Scour protection provided at inflow location	Grouted rock scour protection
	Trees and shrubs to be included	No
	Planting density (number of plants/m^2)	6-8 plants/m^2
	Mulch type and depth	No mulch on filter media

8.3 Operation and maintenance requirements

Maintenance requirements are divided here into routine, irregular (or corrective) and long-term maintenance. Each depends upon site specific factors and required levels of service.

This summary includes typical maintenance task requirement and their frequency.

Routine maintenance

Routine maintenance should address the following:

- Removal of accumulated sediment, litter and debris from the sumps/weirs of the diversion structure, pipes, sediment forebay, filter surface, or overflow structures;
- Maintenance of the vegetation in the bioretention system, and surrounds, including:

- Removal of weeds from the system. Manual removal is preferred, to prevent herbicide contamination.
- Removal, as required and appropriate, of dead or diseased vegetation material to stimulate growth.

Most routine maintenance tasks are recommended on a 3-6 month basis. Details of the various frequencies and time requirements in relation to maintenance tasks during the establishment period are shown in Table 44. The 1-2 hour effort is estimated for a typical small bioretention system.

Table 44. Summary of establishment period maintenance components for a typical bioretention system

Task/requirement	Frequency	Quantity
Weeding	Monthly (for a minimum period of 12 months)	2 hr
Watering of plants	Weekly (for a minimum period of 12 months	1 hr

Irregular and corrective maintenance

Irregular and corrective maintenance activities may need to be undertaken as required over the long-term operation of the stormwater treatment system. The need for these activities should be identified via ongoing inspection. Irregular and corrective maintenance activities may include:

- Repairs to structural elements such as the retaining wall, inlet pits, overflow pits, and drainage pipes
- Flushing the diversion system to remove blockages or accumulated sediment
- Repairing any areas of scour or erosion, and addressing the source of the problem
- Re-planting vegetation which has died, and watering in new vegetation during its establishment as required
- Tilling the surface of the bioretention system to overcome any areas of clogging
- Flushing the slotted pipes at the base of the bioretention system, to remove blockages or accumulated sediment, using a high-pressure hose or an electric eel as required; and
- Take a core sample of the filter media to monitor and determine when the soil filter media needs to be replaced (see following description for more detail).

For filter media core sampling, it is recommended to:

- Take a core sample of the whole soil filter media;
- Test the core sample for nutrient and pollutant penetration at 100mm intervals along the depth of the core sample (and compare to the initial nutrient and pollutant concentration of the filter media);
- Conduct in–situ hydraulic conductivity tests of the soil in 3 to 4 separate and spatially distributed locations in the filter media surface;
- If the in-situ hydraulic conductivity shows consistently low hydraulic conductivity rates across the surface (<50mm/hr) undertake a PSD distribution analysis of the soil media at 100 mm depth intervals as per above and compare it to the initial PSD distribution of the soil.

If the pollutants penetrate the entire depth of the soil column or the in-situ hydraulic conductivity of the soil is below 50 mm/hr and the PSD has significantly altered from the original specification then consideration should be given to replacing the upper layer of the soil filter media (leaving all of the underdrainage system in place).

Long term maintenance

Long term maintenance requirements are typically those that occur on a frequency greater than ten years. There are several elements of stormwater treatment systems that will require long term maintenance.

The structural elements of the system, including inlet pits, scour pads, and overflow pits and pipes should have a lifespan of at least 50 years. If during inspection any of these elements are found to be damaged beyond repair they would need to be replaced with like for like replacements.

Plastic (PVC) pipes should have a minimum lifetime of approximately 20 to 30 years. PVC pipes are more prone to damage due to accidents or vandalism and have a relatively low strength compared to cast iron or concrete pipes. However, PVC pipes are used predominantly in non-trafficable areas or locations where they cannot be damaged.

The major element of the bioretention system that will require renewal and adaptation in the long-term is the soil filter media. Changes in the soil media are expected to occur over time, including:

- Build-up of sediment and pollutants, with a corresponding long-term decrease in hydraulic conductivity; (note that vegetation root action is intended to reduce clogging and prevent reduction of hydraulic conductivity)
- Exhaustion of soil cation sites which absorb pollutants including phosphorous and heavy metals.

It is expected that this replacement frequency will be more than 20 to 25 years based on laboratory column tests which simulate long term rainfall patterns. Monitoring and testing of the filter media can be undertaken per steps listed in previously. The recommended process for renewal of the bioretention system would be as follows:

- Removal of all vegetation from the bioretention system
- Removal of any mulch and top 200mm of the filter layer (a greater depth of filter media may be required to be removed depending on the results of the lab analysis)
- Replacement of the soil profile to the original design levels with media
- Replacement of the vegetation with appropriate vegetation from the plant species list, with appropriate establishment.

9 Waterway design

9.1 Constructed waterways

A constructed waterway (Waterway 1) is proposed from the outlet of the upstream WLRB outside of the PSP down to the valley (Figure 34). Although the peak 1% AEP flows from the combination of retarded outflows from the upstream wetland, plus the retarded outflows from WLRB2 and WLRB3a are still relatively small, a constructed waterway is recommended because this is a natural depression and therefore an existing major overland flow path. The existing conditions flood modelling demonstrates this (Figure 22). Blue-green infrastructure also provides amenity, biodiversity and urban cooling outcomes.

At this site a vegetated swale was selected over a more complex channel arrangement. A compound (low flow channel within a high flow channel) waterway arrangement for this waterway would result in a relatively small hydraulic width of less than 15m. Given the small hydraulic width, a simpler vegetated swale was recommended over a compound waterway arrangement (see Figure 33 for example images and schematic). This encourages the adoption of blue-green infrastructure over a possible pipe and road arrangement.

Figure 33. *Schematic of a potential small hydraulic width waterway typology – a vegetated swale and example images*

A constructed waterway was previously recommended in the Water Technology and Cardno stormwater strategies from SB4 (Figure 2 and Figure 3), flowing in a north-easterly direction, to the valley. A constructed waterway (Waterway 2) is still recommended downstream of the WLRB5 outfall. The peak 1% AEP flows downstream of WLRB5, combined with the outfall from WLRB4, are small, so again a simpler vegetated swale arrangement has been recommended.

9.2 Design objectives

The design objectives for waterway design are as follows:

- Safely convey large flood events within the waterway corridor and reduce or maintain current flood extents as modelled in base case (existing) conditions.
- Integrate drainage outfalls/stormwater connections in a way that enhances the waterway corridor and does not negatively affect the stability, ecology or amenity value of the waterway.
- Provide an appropriate level of erosion protection to public and private assets using native vegetation as the primary channel boundary material, in preference over rock or other hard engineered materials, subject to the design criteria being achievable.
- Have a naturalistic and variable form with an abundant and diverse native vegetation where possible.
- Create a stable and sustainable waterway asset.
- Be a safe environment for the community to interact with and provide an appropriate level of direct and indirect access to the waterway.
- Provide for the establishment of abundant and diverse native vegetation species within the waterway and provide suitable non-vegetative physical habitat.
- Ensure sufficient access and space for all required maintenance activities that is safe for Council officers and contractors to access and maintain.

9.3 Design constraints

The key design constraint for both waterways is the existing steep grades. Therefore, rock chutes and rock bases are required to help manage shear stresses and to ensure stable waterways. This is discussed further below.

9.4 Waterway design

Melbourne Water's Constructed Waterway Design Manual was used as a waterway design guide for the waterways, noting that they are not a typical constructed waterway design, and instead a simpler vegetated swale design. However, many of the design criteria are still relevant to ensure a stable, diverse and naturalistic system.

Design flows

As presented previously, the following peak flow rates were used to inform the waterway design, as established in the developed conditions RORB model.

Table 45. Calculated flow rates for waterway design (from RORB)

Storm event	Flow rate (m^3/s) – Waterway 1	Flow rate (m^3/s) – Waterway 2
1% AEP	4.89m^3/s (flow from external catchment S, at start of waterway. 7.15m^3/s, flows downstream of WLRB2 and WLRB3a (Point A).	3.83 m^3/s, combined flows from WLRB4 and WLRB5. (Point B)

Longitudinal slope

One of the key criteria for waterway design is to ensure that shear stress values are within an acceptable range. This is to ensure that the waterway is stable and to minimise the erosion potential. The shear stress threshold value is generally considered to be 80 N/m^2. Longitudinal grade is one of a few key drivers of shear stresses within a waterway. It is therefore critical to provide a stable, flat longitudinal grade to help manage shear stresses.

The longitudinal slope is dictated by invert controls at the downstream and upstream extents of the constructed waterways, combined with the overall length of the system. Meandering the low flow channel can help lengthen the waterway length, and flatten the grade.

The longitudinal grades were established through iteratively altering the waterway alignments, tie-in locations, and providing grade control structures where necessary. Another key consideration was RB outflows and how these would connect with the waterways.

Table 46 provides the approximate existing longitudinal slope along the proposed waterway alignments, showing the steep nature of the topography.

Table 46. Existing longitudinal slope

Reach	Upstream elevation (m AHD)	Downstream elevation (m AHD)	Channel length (low flow channel) (m)	Average slope low flow (1 in x)
WW1	60.05	46.5	796	58.7
WW2	59.1	46.5	384	30.5

Waterway 1 was design with a series of flat sections of 1 in 200 grade, with grade control structures in between to help manage the grade drop. A total of seven rock chutes were required to achieve this. In line with the Constructed Waterway Design Manual, rock chutes of 1 in 12 grade were adopted given the existing natural steep grade. The height of these chutes are a maximum of 1.2m. The change in waterway grade will provide a diversity of hydraulic conditions, and habitat opportunities.

In line with the Constructed Waterway Design Manual, given the natural grade of Waterway 2 is <1 in 35, a rock-lined waterway is required.

Longitudinal profiles of the waterways are provided in the functional design drawings (Appendix F).

Cross-section geometry

The cross-sectional geometry should be designed to accommodate the 1% AEP flows in the channel. These flows are determined using RORB modelling as discussed in the hydrologic modelling section. The proposed channel cross section of each waterway is provided in Table 47.

All waterways have been designed with a minimum of 300mm freeboard above the 1% AEP peak flow levels.

Table 47. Waterway cross-section geometry and design parameters.

Waterway	Parameter	Low flow channel
WW1	Base width (m)	2.5
	Minimum hydraulic depth (m)	1m (noting overall depth will vary with surrounding topography)
	Side slope	1 in 4
	Top width (m)	Minimum 13m (inc. freeboard)
	Manning's n (assumed)	0.05 (vegetated)
WW2	Base width (m)	2.5
	Minimum hydraulic depth (m)	0.5 (noting overall depth will vary with surrounding topography)

Side slope	1 in 4
Top width (m)	9m (inc. freeboard)
Manning's n (assumed)	0.04 (rock lined)

Manning's calculations were undertaken to establish waterway capacities and verify that they would be sufficient to convey the 1% AEP peak flows. This was subsequently checked through hydraulic modelling.

Table 48. Waterway design capacities.

Reach	Channel capacity (m^3/s)
WW1	7.5m^3/s
WW2	5.1m^3/s

Planform

The following design guidelines are set by Melbourne Water's *Constructed Waterway Design Manual.*

- Sinuosity of at least 1.05 but no greater than 1.25
- For compound waterways the reach average meander wavelength should be around 10-14 times the low flow channel top width. To avoid the artificial appearance of a sequence of regular bends (i.e. non-uniform planform), the following break-down should be used as a guide for meander wavelength:
  - 50% at 10-14 times the low flow channel top width
  - 25% at 6-10 times the low flow channel top width
  - 25% at 14-20 times the low flow channel top width
- In compound waterways, bends should have a sharpness ratio (radius of curvature / low flow channel base width) of greater than 2 to 3. To avoid significant increases in shear stress (and therefore the need for extensive rock work), bend sharpness ratio along a meander reach should desirably be greater than about 7.
- Diversity provided through physical form and alignment.

Although these waterways are not compound channels, these design requirements have been used to guide the waterway designs where possible. However, the waterways are constrained in terms of the existing topography. Waterway 2 in particular is very challenging to meander, and therefore follows the existing valley depression and has little in the way of sinuosity.

Table 49. Sinuosity values for the constructed waterways

Reach	Valley length (m)	Channel length (m)	Sinuosity
WW1	793	802	1.01[1]
WW2	382	382.7	1.00[1]

[1]Steep topography and valley constraints result in limited meandering availability, and therefore a low sinuosity.

Table 50. Meander wavelength values for Waterway 1

Waterway	Parameter	Lower (5-10 times)	Median (10-14 times)	Upper (14-20 times)
WW1	Channel top width (m)	13	13	13
	Range of meander wavelengths	78-130	130-182	182-260
	Total variation through section (%)	25%	50%	25%

Table 51. Radius of curvature values for the constructed waterways

Reach	WW1	WW2
Base channel width (m)	2.5	2.5
Minimum radius of curvature	18	18
Minimum ratio (bend sharpness)	7.2	7.2

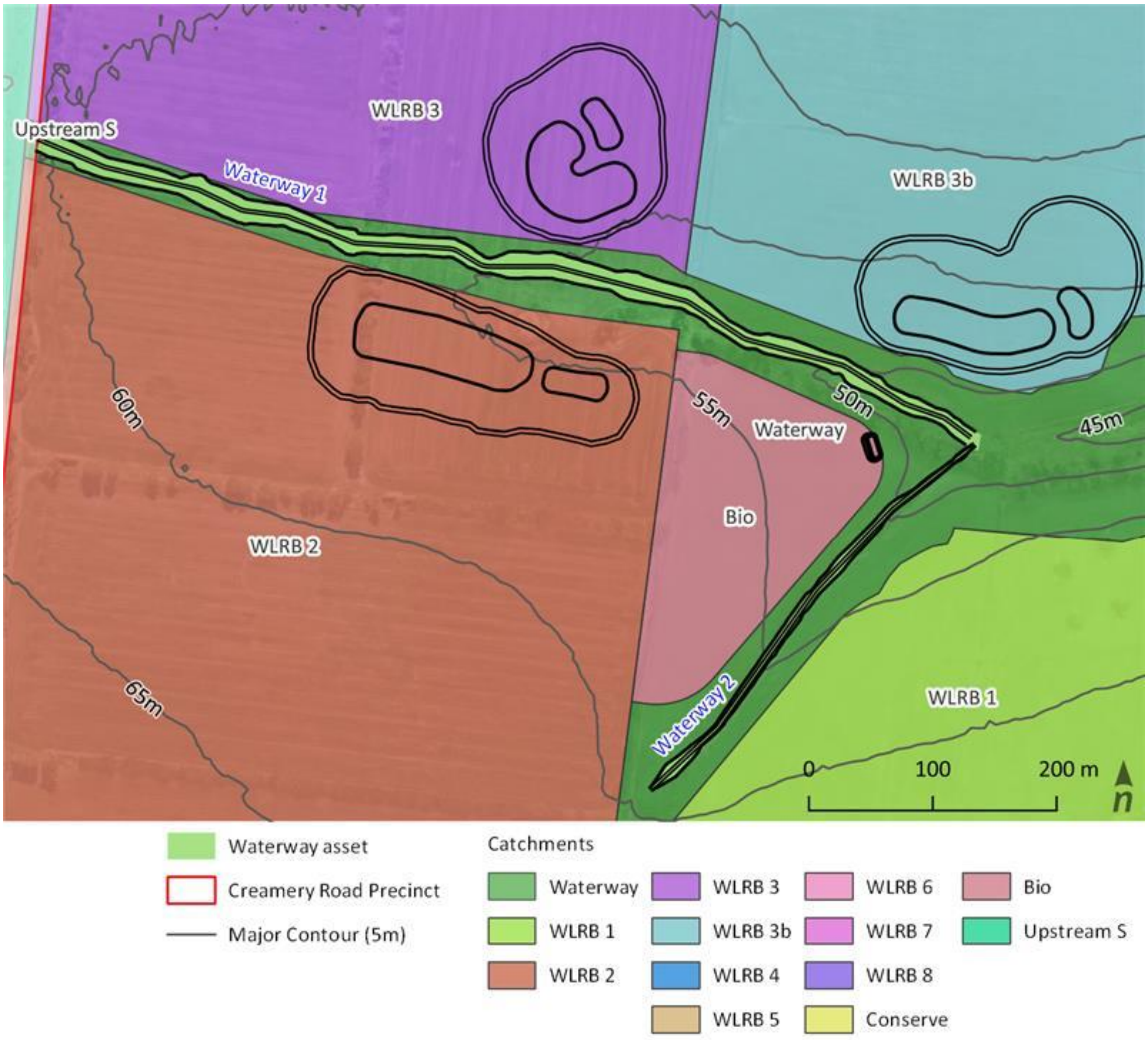

Figure 34. *Waterway designs*

9.5 Hydraulic modelling

A 1D HEC-RAS model was developed by Alluvium for the constructed waterways to check:

- Shear stresses against boundary material shear stress thresholds
- Establish 1% AEP flood extents and verify that the proposed arrangement can contain the peak 1% AEP flows within the channels.

The flood extents were ultimately confirmed through the developed conditions hydraulic modelling (Water Modelling Solutions), and waterway corridors confirmed through the WMS modelling. This is discussed in Section 10.

Model setup

A HEC-RAS model was set up with the following inputs:

- Design surface geometry exported from the earthworks model
- 1% AEP flow inputs as obtained from the hydrologic modelling
- Waterway centrelines and bank lines from the proposed waterway designs
- Developed conditions manning's roughness values.

The model was extended to include the tributary, extending down to Cowies Creek. The tributary is not proposed to be reconstructed – this waterway should be enhanced and protected. Some transition works from the proposed waterways into the tributary will be required.

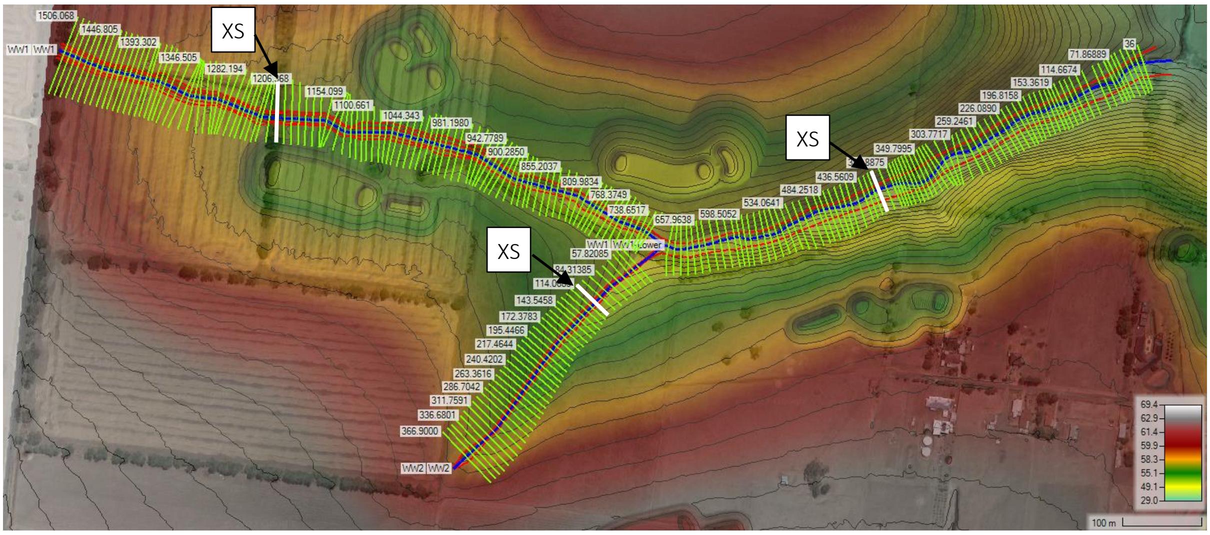

Figure 35. *HEC-RAS model extent showing water centreline, bank lines, and cross sections. Example cross section (XS) locations shown in white.*

Results

The results showed that the 1% AEP flows are entirely contained within the proposed waterways, however this was ultimately checked through the WMS hydraulic modelling (Section 10). This would be refined in later detailed design stages.

The average channel shear stresses along each waterway were exported and compared with boundary material thresholds. These are provided in Figure 36 and Figure 37. For Waterway 1, the spikes in shear stress are where the rock chutes are located, and therefore present no risk to the stability of the waterway.

The hydraulic modelling did identify several high energy zones downstream of the waterway 1 and waterway 2 confluence, along the existing waterway (EW-01), which is not proposed to be constructed. The aim should be to protect and enhance this existing waterway and its values, not to reconstruct it. The high shear stress zones and steep bed grade suggest potential headcuts/knickpoints along the existing waterway. Site inspection is required to investigate these high energy zones to determine if management is required (i.e. through rock lining or rock chute construction). An allowance for rockwork and supplementary planting has been included in the costing.

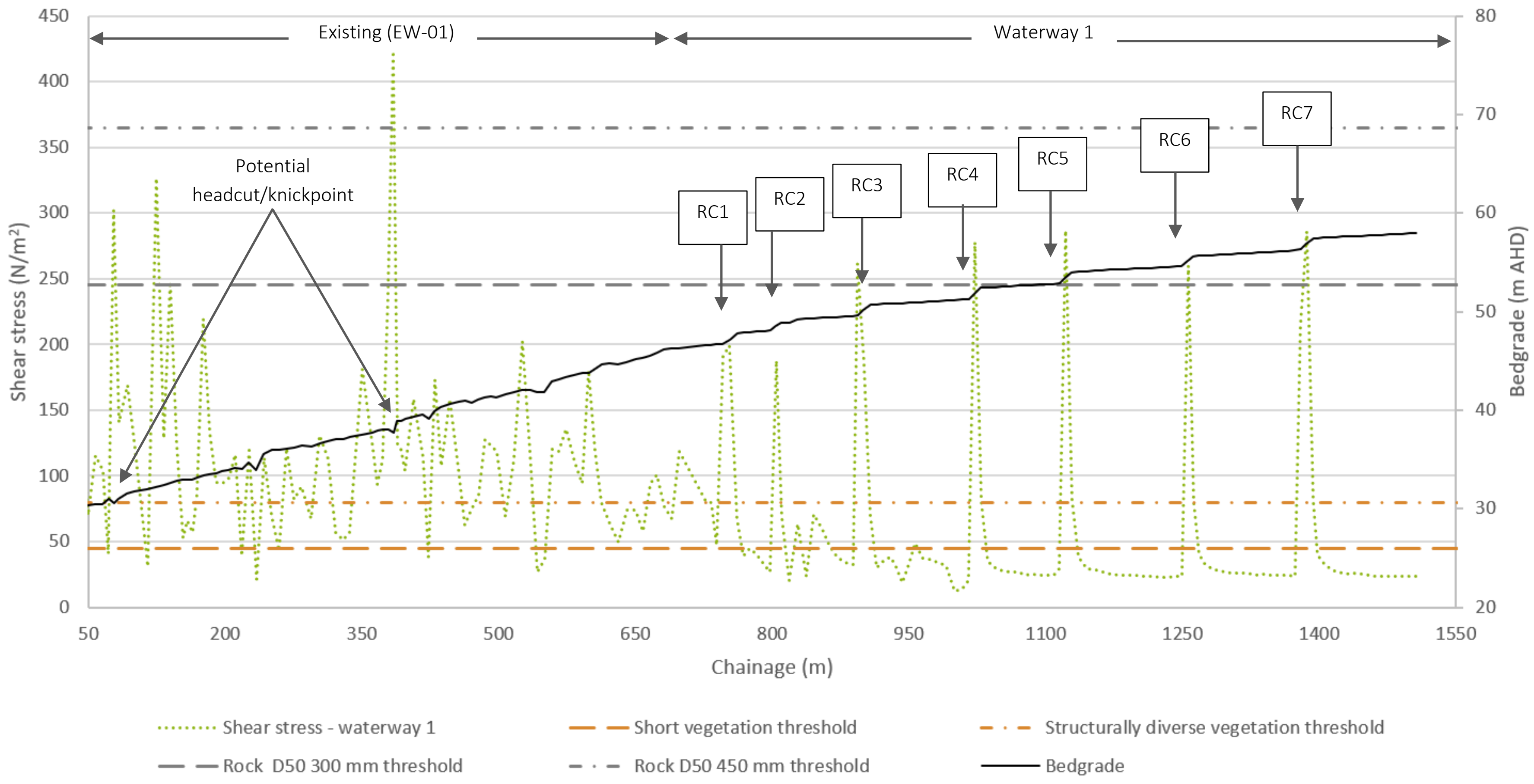

Figure 36. *Waterway 1 and existing waterway (downstream of chainage 700 m) bed grade and channel shear stresses. Showing critical shear stress thresholds for boundary materials.*

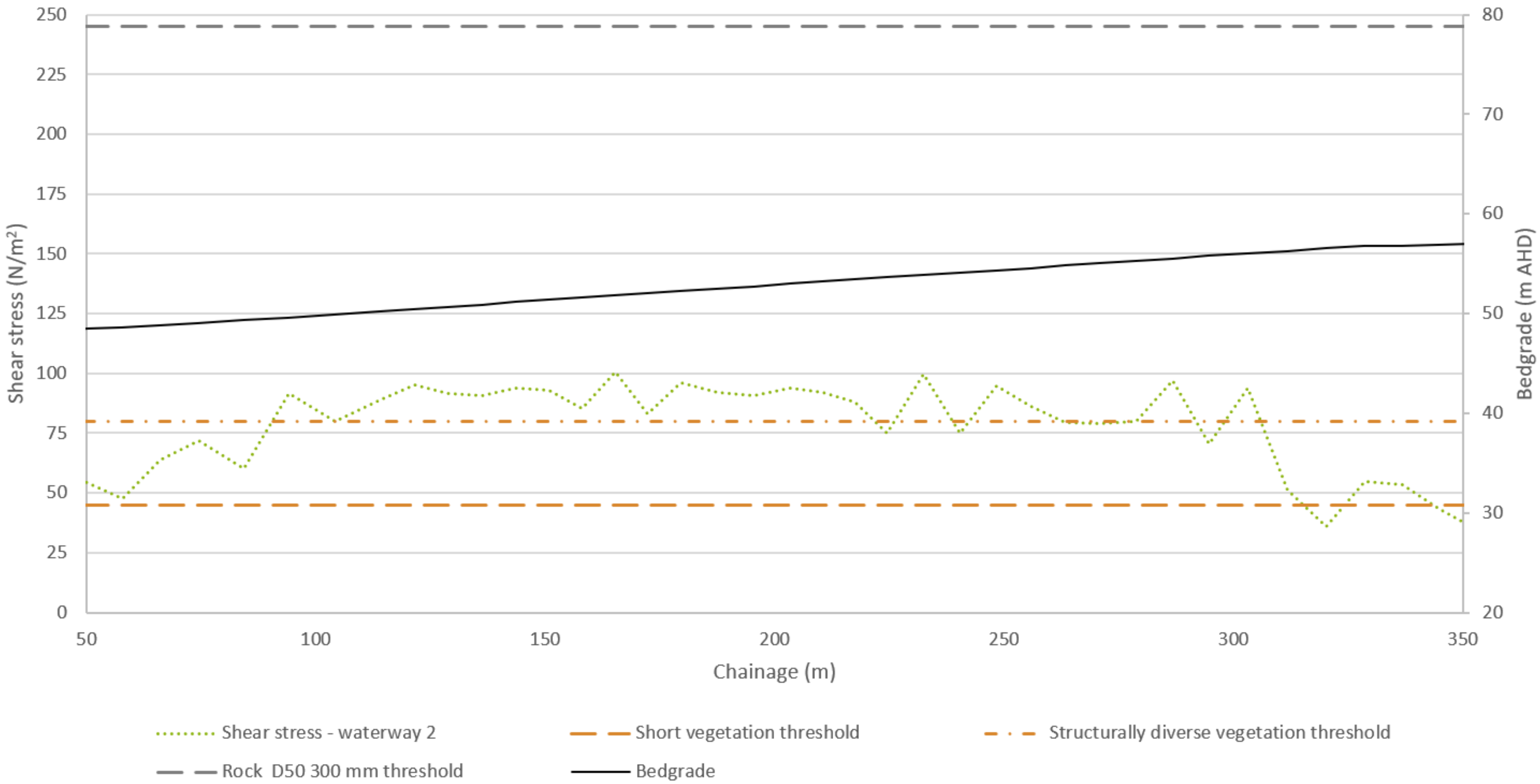

Figure 37. *Waterway 2 bed grade and channel shear stresses. Showing critical shear stress thresholds for boundary materials.*

9.6 Dimensions and quantities

The table below details the waterway dimensions.

Table 52. Summary of key parameters and findings for the constructed waterways

Waterway	Parameter	Value	Unit
Waterway 1 (from the outlet of the upstream WLRB outside of the PSP	Length	802	m
	Peak flow (1% AEP) (d/s of WLRB3a and WL2)	7.15	m^3/s
	Channel base width	2.5	m
	Channel depth (minimum)	1.0	m
	Side slopes	1 in 4	
	Manning's n	0.05	
	Waterway grade	1 in 200 1 in 12 chutes	-
	Calculated waterway capacity (manning's)	7.5	m^3/s
	Hydraulic width*	Varies, up to 15m (U/S CCC) Varies, up to ~33m (D/S CCC)	m
	Freeboard	300	mm
	Waterway corridor	30 (upstream CCC) 45 (downstream CCC)	m
Waterway 2 (downstream of WLRB5)	Length	382.7	m
	Peak flow (1% AEP)	3.83	m^3/s
	Channel base width	2.5	m
	Minimum channel depth	0.5	m
	Side slopes	1 in 4	
	Manning's n	0.04	
	Waterway grade	1 in 35	-
	Calculated waterway capacity (manning's)	5.1	m^3/s
	Hydraulic width*	Varies, up to ~35m	m
	Freeboard	300	mm
	Waterway corridor	45	m
EW-01	Waterway corridor	Min. 20m setback from 1% AEP hydraulic extent	m

*As per WMS hydraulic modelling results, see Section 10.

9.7 Waterway corridors

Waterways, whether natural or constructed, need to have an appropriate waterway corridor or reserve provided adjacent to development in order to accommodate objectives for flood protection, river health, biodiversity, safety and amenity. A waterway corridor is defined as the waterway channel and its associated riparian zones. The riparian zones consist of two parts

- the vegetated buffer
- the core riparian zone

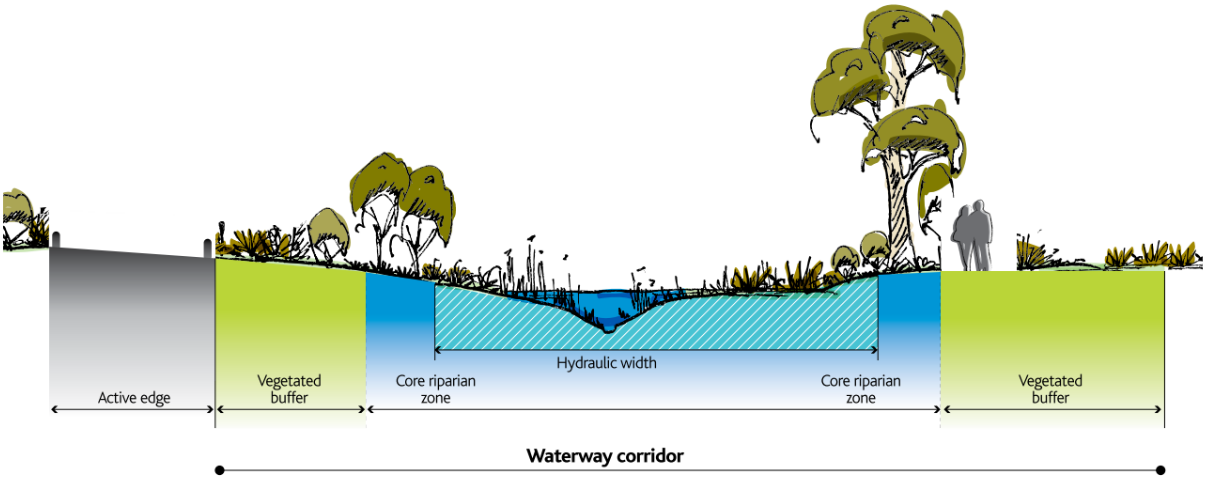

Figure 38. *Waterway corridor (Reference: Melbourne Water's Waterway Corridor Guidelines).*

According to Melbourne Water's Waterway Corridor Guidelines, "assigning a waterway corridor preserves areas of the riparian zone that protect or enhance native vegetation, river health and biodiversity in some cases, the waterway corridor may also be able to support a level of passive recreational use or some stormwater treatment elements". Furthermore, the waterway corridor will also be dependent on other site specific factors such as recreation uses or landscape characteristics.

Melbourne Water's Waterway Corridor Guidelines define a minimum width only, and can be increased to reflect site specific factors such as: high value flora, fauna and communities; high value geomorphic features or other characteristics such as escarpments or chain of ponds; habitat connectivity; fuel break; protection of upstream and downstream values; where there is risk of channel migration/erosion; where recreational and stormwater assets are proposed within the corridor; and the protection of cultural heritage values.

A fundamental principle is to provide continuity along the core riparian zone, therefore the strong preference is to locate shared paths and other infrastructure outside of the core riparian zone. However, the Waterway Corridor Guidelines states that "in some instances, stormwater treatment systems such as constructed wetlands and bioretention systems may be located within the core riparian zone – subject to Melbourne Water approval – but should form a relatively small proportion of the area of the core riparian zone so as not to degrade its ecological function or put the asset at undue risk from flooding and/or stream migration".

Relevant corridor requirements as extracted from Melbourne Water's guidelines are shown in Figure 39. Constructed waterways with hydraulic widths <15m are recommended to have a reduced waterway corridor of 30m, so to encourage the uptake of waterway arrangements as opposed to pipe and road arrangements, which do not provide for biodiversity, amenity, and urban cooling outcomes.

Table 3. Sliding scale for calculating constructed waterway corridor widths – assumes active edges (roads) that allow vehicle access along entire corridor length, on both sides of the corridor.

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	10	30
10	20	10	30
15	25	15	40
20	25	15	40
25	30	15	45
30	30	15	45
35	30	15	45
40	30	20	50
45	35	20	55
50	35	20	55
55	40	20	60
60	40	20	60
65	40	25	65
70	45	25	70

Figure 39. *Minimum Constructed Waterway corridor requirements (Melbourne Water's Waterway Corridor Guidelines).*

The constructed waterway corridors were established through confirming the hydraulic widths as per WMS's hydraulic modelling. There are isolated locations where the boundary is extended or shifted to retain trees and to ensure a cohesive drainage interface.

Table 53. Summary of corridor widths (constructed waterways)

Waterway	Hydraulic width	Corridor width (m) (as per hydraulic width)
Waterway 1	Varies, up to ~15m (U/S CCC) Varies, up to ~33m (D/S CCC)	30 (upstream of CCC) 45 (downstream of CCC)
Waterway 2	Varies, up to ~35m	45

The existing tributary (EW-01) is not proposed to be reconstructed. For natural waterways, the waterway corridor width is set by the Strahler stream order. The Strahler stream order of this system is 2, which would result in a 20m setback from the reference point (typically the top of bank). However, the tributary is in a valley meaning there are less defined 'top of banks' from which to provide the setbacks. In this case an alternative reference point such as the hydraulic width may be adopted. The corridor guidelines do not provide clear guidance on this. The extent of the 1% AEP hydraulic width, as established in WMS's hydraulic modelling, has been adopted as the reference point for the setbacks. Some minor adjustments are made to this along the waterway length to ensure tree retention and continuity of the drainage interface.

For a site like this the overall development setback is likely to be more influenced by setbacks to retain landscape character and value. That is, Council may want to set development setbacks so to retain sitelines, maintain an interface with the natural systems, retain the current look and feel of the valley. This will be driven by Council planning, landscape designers and urban planners, as well as guided by the CMA.

There is also a constructability consideration as the topography becomes steep and drops into the valley. Sometimes a development setback from topography break lines are adopted.

The waterway corridors are shown in Figure 40.

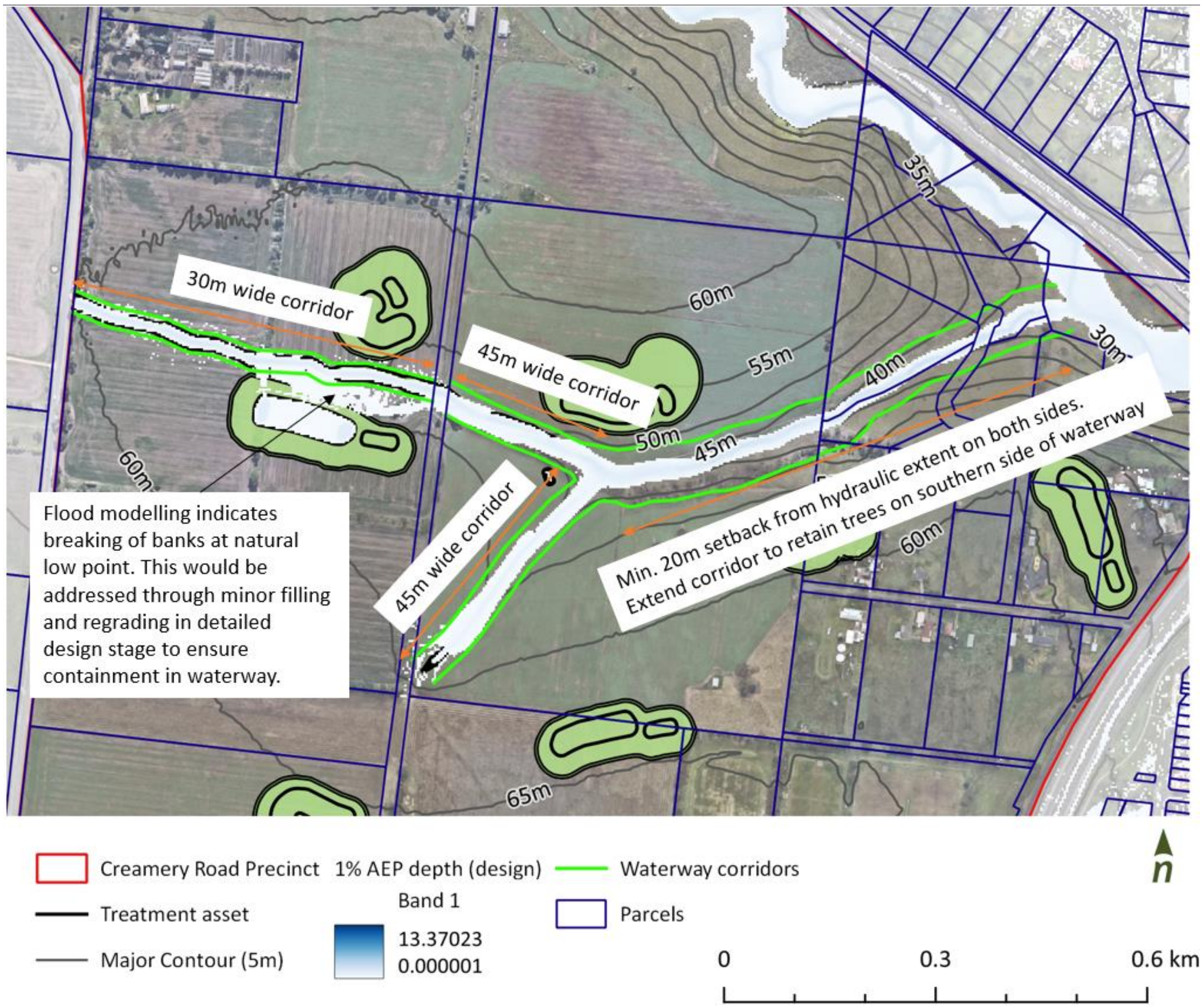

Figure 40. *Waterway corridors*

9.8 Rock chute design

The grade control rock chutes in Waterway 1 have been designed with the aid of the CHUTE software package. CHUTE modelling has been undertaken to determine the chute arrangement required to provide protection against scour over the structure and ensure any hydraulic jump occurs on the structure. This analysis was undertaken for each of the chutes within the waterways. CHUTE can be used to establish the rock size, chute width, chute grade and chute length. CHUTE inputs and results can be found further below.

Parameters adopted for the design of the rock chutes are summarised in Table 54 .

Table 54. Design parameters and criteria adopted for the rock chutes.

Parameter	Units	Adopted criteria	
		WWI (Chute 1, 2, 3, 4)	WW1 (Chutes 5, 6, 7)
Design D_{50} rock size	mm	400	350
1% AEP flow event	m^3/s	7.15	4.89
Factor of Safety	-	1.3	1.3
Downstream boundary condition	m	Normal depth	Normal depth

Dimensions adopted the rock chutes are summarised in Table 55.

Table 55. Specifications for the proposed rock chutes.

Chute element	Units	WW1	WW1
		Chute 1,2,3,4	Chute 5,6,7
Chute drop	m	1.2	1.2
Chute length	m	14.4	14.4
Chute width	m	6.5	6
Crest length	m	3	3
Apron length	m	3	3
Abutment protection height	m	0.3	0.25
Abutment protection slope (max slope)	m/m	1V:3H	1V:3H

The input and results for the chutes are provided below.

CHUTE - Input Table

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A design program for rock chutes for stabilisation of river grade and prevention of headward erosion

Input Table			
Variable Name	Allowed range	Value	Units
Chute Drop	0.1-20	1.2	m
Chute Length	1-200	14.4	m
Apron Rise	0-10	0	m
Apron Length	1-100	3	m
Flowrate (minimum)		0.1	m^3/s
Flowrate (maximum)		7.15	m^3/s
Chute Width		6.5	m
Rock Angle of Repose	30-44	42	degrees
Specific Gravity of Rock	1.5-3.0	2.65	
Factor of Safety	1.0-3.0	1.3	
Critical Depth (min)	calculated	0.029	m
Critical Depth (max)	calculated	0.498	m
Chute Slope	calculated	0.083	
Apron Slope	calculated	0.000	

Input Warnings **Ok**
Ok
Ok

Downstream Channel Input Table			
Variable Name	range	Value	Units
Bed Slope		0.005	
Roughness (mannings n)	0.01-0.1	0.05	
Downstream Width (if known)		13	m

Choices for downstream boundary depth calculation

- Rating Table
- normal depth (selected)
- y crit +10%
- average normal and ycrit

RUN

Figure 41. *WW1 chute 1, 2, 3, 4 inputs*

Results																	
Calculations for range of flows				d/s boundary depths			Specific Energy			Jump Conditions							
Q	d50 Normal	d50 Calc.	Bank Angle	used	rating tbl.	critical	u/s	d/s	extra	scenario	description	Location	depth	y conj.	Loss	friction loss
0.10	23	23	21	0.067	#DIV/0!	0.0289	0.0433	0.0695	0	2	jump in chute; OK	14.150	0.017	0.045	0.007	1.167
0.81	93	93	21	0.236	#DIV/0!	0.1161	0.1741	0.2497	0	2	jump in chute; OK	13.805	0.069	0.181	0.029	1.096
1.51	142	142	21	0.346	#DIV/0!	0.1765	0.2648	0.3687	0	2	jump in chute; OK	13.650	0.105	0.276	0.044	1.052
2.22	183	183	21	0.437	#DIV/0!	0.2279	0.3419	0.4678	0	2	jump in chute; OK	13.540	0.135	0.356	0.056	1.018
2.92	220	220	21	0.518	#DIV/0!	0.2740	0.411	0.5562	0	2	jump in chute; OK	13.452	0.163	0.428	0.067	0.987
3.63	254	254	21	0.593	#DIV/0!	0.3165	0.4747	0.6379	0	2	jump in chute; OK	13.366	0.188	0.494	0.078	0.959
4.33	286	286	21	0.662	#DIV/0!	0.3563	0.5345	0.7136	0	2	jump in chute; OK	13.291	0.212	0.556	0.087	0.934
5.04	317	317	21	0.727	#DIV/0!	0.3940	0.591	0.7852	0	2	jump in chute; OK	13.222	0.235	0.614	0.095	0.911
5.74	345	341	21	0.790	#DIV/0!	0.4300	0.645	0.8533	0	2	jump in chute; OK	13.162	0.256	0.670	0.104	0.888
6.45	373	366	21	0.849	#DIV/0!	0.4645	0.6967	0.9186	0	2	jump in chute; OK	13.099	0.277	0.723	0.111	0.867
7.15	400	390	21	0.906	#DIV/0!	0.4978	0.7467	0.9811	0	2	jump in chute; OK	13.043	0.297	0.774	0.118	0.848

Figure 42. *WW1 chute 1, 2, 3, 4 results*

CHUTE - Input Table

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A design program for rock chutes for stabilisation of river grade and prevention of headward erosion

Input Table			
Variable Name	Allowed range	Value	Units
Chute Drop	0.1-20	1.2	m
Chute Length	1-200	14.4	m
Apron Rise	0-10	0	m
Apron Length	1-100	3	m
Flowrate (minimum)		0.1	m^3/s
Flowrate (maximum)		4.89	m^3/s
Chute Width		6	m
Rock Angle of Repose	30-44	42	degrees
Specific Gravity of Rock	1.5-3.0	2.65	
Factor of Safety	1.0-3.0	1.3	
Critical Depth (min)	calculated	0.030	m
Critical Depth (max)	calculated	0.408	m
Chute Slope	calculated	0.083	
Apron Slope	calculated	0.000	

Input Warnings **Ok**
Ok
Ok

Downstream Channel Input Table			
Variable Name	range	Value	Units
Bed Slope		0.005	
Roughness (mannings n)	0.01-0.1	0.05	
Downstream Width (if known)		13	m

Choices for downstream boundary depth calculation

- Rating Table ○
- normal depth ●
- y crit +10% ○
- average normal and ycrit ○

RUN

Figure 43. *WW1 chute 5, 6, 7 inputs*

Results

	Calculations for range of flows			d/s boundary depths			Specific Energy		
Q	d50 Normal	d50 Calc.	Bank Angle	used	rating tbl.	critical	u/s	d/s	extra
0.10	24	24	21	0.070	#DIV/0!	0.0305	0.0457	0.073	0
0.58	79	79	21	0.202	#DIV/0!	0.0983	0.1474	0.214	0
1.06	118	118	21	0.291	#DIV/0!	0.1469	0.2203	0.3101	0
1.54	151	151	21	0.367	#DIV/0!	0.1884	0.2826	0.3919	0
2.02	181	181	21	0.433	#DIV/0!	0.2258	0.3387	0.4637	0
2.50	209	209	21	0.494	#DIV/0!	0.2602	0.3904	0.5299	0
2.97	235	235	21	0.550	#DIV/0!	0.2926	0.4389	0.5917	0
3.45	260	260	21	0.604	#DIV/0!	0.3232	0.4848	0.6506	0
3.93	283	283	21	0.655	#DIV/0!	0.3524	0.5287	0.7063	0
4.41	306	306	21	0.704	#DIV/0!	0.3805	0.5708	0.7596	0
4.89	327	324	21	0.751	#DIV/0!	0.4076	0.6114	0.8109	0

	Jump Conditions						
Q	scenario	description	Location	depth	y conj.	Loss	friction loss
0.10	2	jump in chute; OK	14.139	0.018	0.048	0.008	1.165
0.58	2	jump in chute; OK	13.861	0.058	0.154	0.024	1.109
1.06	2	jump in chute; OK	13.730	0.087	0.230	0.036	1.074
1.54	2	jump in chute; OK	13.622	0.112	0.295	0.047	1.044
2.02	2	jump in chute; OK	13.545	0.134	0.353	0.056	1.019
2.50	2	jump in chute; OK	13.478	0.154	0.407	0.064	0.996
2.97	2	jump in chute; OK	13.417	0.174	0.457	0.072	0.975
3.45	2	jump in chute; OK	13.353	0.192	0.505	0.079	0.955
3.93	2	jump in chute; OK	13.299	0.209	0.550	0.086	0.936
4.41	2	jump in chute; OK	13.246	0.226	0.594	0.092	0.919
4.89	2	jump in chute; OK	13.202	0.242	0.636	0.099	0.902

Figure 44. *WW1 chute 5, 6, 7 results*

10 Hydraulic modelling of functional design

Following the development of the functional designs by Alluvium, Water Modelling Solutions (WMS) undertook hydraulic modelling to ensure that the detained peak flow run-off from the Creamery Road Precinct has no negative impacts on any downstream or adjacent landowners' properties when compared with the pre-developed scenario. The purpose was also to confirm hydraulic widths of the waterways, and subsequently to inform waterway corridors.

WMS adapted the 2D hydraulic model created for the 'Cowies Creek – Hydraulics and Flood Intelligence Report (Rev C, 2022).' Pre and post-development flows within the Creamery Rd Precinct were sourced from the Alluvium hydrologic model developed as part of this study.

Full details of the model setup, inputs, methodology and results can be found in the modelling memo in Appendix G.

10.1 Summary of results

A summary of results is provided below.

- There is negligible change in peak floods level in the northern (Waterway 1) and southern (Waterway 2) branches of the waterway. Peak flood levels are increased less than 0.02 m as a result of the WLRB arrangement and the increased runoff caused by the Creamery Road Precinct development. It is noted that minor localised impacts some distance from the works area can often be the result of a slight change in timing of flows that results under the post-developed conditions.
- There is negligible change in the peak flood levels on the southern banks of Cowies Creek. Peak flood levels are increased less than 0.02m as a result of the WLRB arrangement and the increased runoff caused by the Creamery Road Precinct development.
- There is minor increase in peak flood level at the confluence of the northern and southern branches of the waterway. Peak flood levels are increased by up to 0.10 m.
- There is localised peak flood level increases in the order of 0.13 m within Creamery Road Precinct. These are considered to be a modelling artefact due to the change in the way inflows were applied to the model, rather than actual effects of the proposed scheme.
- There are no adverse impacts beyond the railway line caused by the proposed works in the 1% AEP event
- The results show that the Creamery Road Precinct and its associated wetland retarding basins (WLRBs) will have no adverse impacts on any downstream of adjoining landowners' properties.

The afflux mapping, comparing the pre and post-development scenarios, is provided for the 1% AEP in Figure 45.

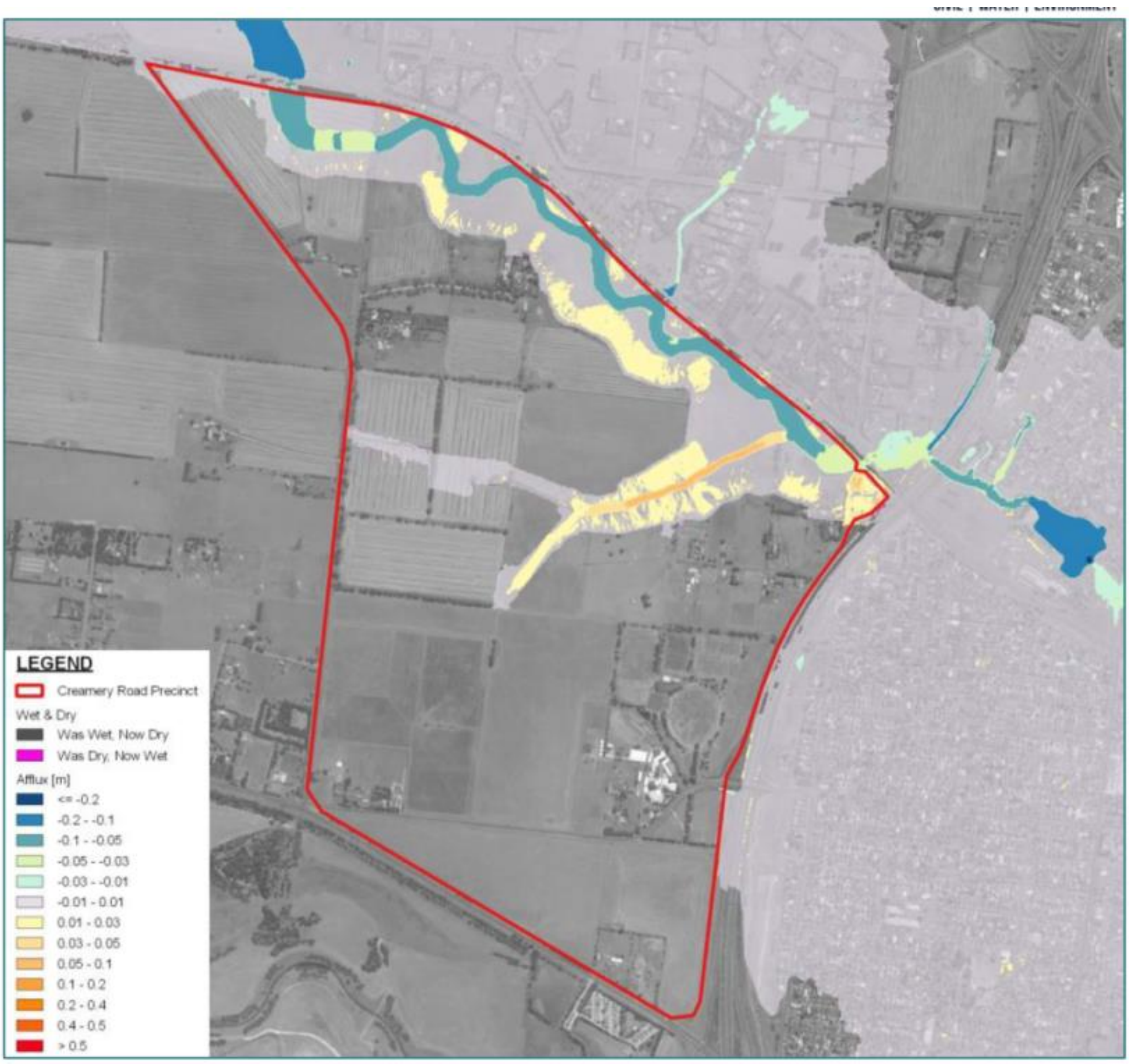

Figure 3-1 Afflux Mapping – Post-Developed to Pre-Developed Scenario

Figure 45. *Hydraulic modelling of the functional design – afflux mapping (WMS, 2022)*

10.2 Hydraulic widths and waterway corridors

As discussed in Section 9, the flood modelling was used to confirm hydraulic widths and to inform the required waterway corridors for Waterway 1, Waterway 2, and EW-01. The hydraulic widths of the 1% AEP, as established from the hydraulic modelling, is summarised in Table 56.

Table 56. Hydraulic widths as per WMS hydraulic modelling

Waterway	Hydraulic width
WW1	Varies, up to 15m (upstream of CCC) Varies, up to ~33m (downstream of CCC)
WW2	Varies, up to ~35m. The hydraulic modelling shows some flaring of the hydraulic width at the start of the waterway (~40m wide). This is due to the nature of the flow input, and given it is localised it is not recommended that this is used to inform the waterway corridor.
EW-01	Varies, up to ~33m

11 Safety in Design

Public safety is an important consideration near stormwater treatment systems, especially in an area that is popular to visit. Levels of risk can relate to the location of the waterway and wetland, type of inflow, ease of access, wetland objectives, nearby land uses and the site context, as well as risks associated with maintenance and general management activities.

A full assessment of risks and mitigation options is detailed in Appendix E.

11.1 Batters

The internal wetland/sediment basin batters will generally have a slope of 1:8 for the first 350 mm depth below NWL and 1:3 thereafter. Along these sections, dense planting will be used above the extended detention depth to deter access.

The retarding basins have 1 in 8 batters, as directed by Council. This is appropriate for maintenance and safety, as well as amenity outcomes.

An internal risk assessment was conducted to identify hazards and appropriate mitigation measures to ensure safe construction and ongoing engagement with the site.

12 Costing

Cost estimate summaries for each asset are provided below in Table 57. The values provided are estimates based on the Australian Construction Handbook, as well as our experience with similar projects. More detailed costing that sits behind these summed up works is provided in the Draft Functional Design Cost Estimate spreadsheet. This includes all quantities and assumed rates, and costing assumptions.

A contingency of 35% is recommended and has been applied to the cost estimates for the proposed Creamery Road PSP stormwater-related assets. This contingency is based on recent PSP and DCP experience, where the Standing Advisory Panel (SAC) adopted recommendations of costings experts to be set at 35% contingency. The contingency covers uncertainty around items such as rock excavation, and the potential for labour and material costs to increase.

Table 57. *Cost estimate summary for the proposed works*

Item	Description	WLRB1	WLRB2	WLRB3a	WLRB3b	WLRB4	WLRB5	WLRB6	WLRB7	WLRB8	Bioretention	Waterway 1	Waterway 2	EW-01	ALL ASSETS
1	SITEWORKS AND EARTHWORKS	$1,041,903.3	$1,486,648.8	$1,327,537.5	$1,677,254.0	$ 985,745.2	$ 964,528.1	$ 677,409.2	$1,143,352.7	$1,286,501.5	$ 17,914.8	$ 442,108.1	$ 49,334.1	$ 18,208.0	$11,100,237.1
2	DRAINAGE	$ 561,338.1	$ 617,406.6	$ 433,174.9	$ 637,012.3	$ 515,602.0	$ 610,456.6	$ 507,313.0	$ 698,190.4	$ 579,159.7	$ 89,161.8	$ -	$ -	$ -	$ 5,248,815.5
3	ROCK WORKS	$ 119,476.6	$ 61,661.8	$ 52,244.6	$ 142,801.2	$ 27,769.0	$ 27,653.2	$ 19,423.8	$ 116,588.0	$ 47,868.8	$ 25,864.1	$ 252,148.3	$154,015.4	$ 48,180.0	$ 1,047,514.8
4	CLAY LINER	$ 120,440.5	$ 162,343.4	$ 120,810.1	$ 109,823.4	$ 139,418.4	$ 121,248.5	$ 142,670.6	$ 122,814.0	$ 129,330.5	$ -	$ -	$ -	$ -	$ 1,168,899.3
5	TOPSOIL	$ 42,434.7	$ 59,792.7	$ 47,147.1	$ 62,244.6	$ 40,349.1	$ 41,253.3	$ 32,937.3	$ 45,635.7	$ 54,588.6	$ 488.4	$ 43,774.5	$ 5,577.0	$ -	$ 476,223.0
6	AQUATIC PLANTING	$ 167,599.2	$ 213,206.4	$ 173,150.1	$ 210,624.4	$ 154,132.7	$ 145,310.2	$ 144,014.7	$ 168,563.7	$ 189,459.5	$ 57,364.0	$ 132,650.0	$ 16,900.0	$ 40,000.0	$ 1,772,974.9
7	PUMPING	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	LANDSCAPE	$ 188,304.7	$ 212,082.1	$ 149,640.1	$ 166,251.4	$ 148,906.4	$ 182,155.9	$ 147,426.0	$ 184,435.9	$ 187,351.6	$ 12,999.0	$ -	$ -	$ -	$ 1,579,553.1
9	MISCELLANEOUS	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 70,900.0	$ 22,500.0	$ 64,800.0	$ 64,800.0	$ 54,000.0	$ 790,200.0
10	OTHER	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	SUB-TOTAL WORKS	$2,312,397.0	$2,884,041.8	$2,374,604.4	$3,076,911.2	$2,082,822.8	$2,163,505.7	$1,742,094.6	$2,550,480.5	$2,545,160.2	$ 226,292.1	$ 935,480.9	$290,626.5	$160,388.0	$23,184,417.7
11	DELIVERY (inc. 35% contingency)	$1,416,343.2	$1,766,475.6	$1,454,445.2	$1,884,608.1	$1,275,729.0	$1,325,147.3	$1,067,032.9	$1,562,169.3	$1,558,910.6	$ 138,603.9	$ 572,982.1	$178,008.7	$ 98,237.7	$14,200,455.8
12	TOTAL ESTIMATED COST	$3,728,740.2	$4,650,517.4	$3,829,049.6	$4,961,519.4	$3,358,551.8	$3,488,653.0	$2,809,127.5	$4,112,649.7	$4,104,070.8	$ 364,896.0	$1,508,463.0	$468,635.2	$258,625.7	$37,384,873.5

13 Development staging

The Creamery Road PSP Functional Design Report (this report) and the associated functional design drawings are the proposed stormwater solution for the ultimate developed scenario. Understanding that future development staging will not necessarily occur in a linear upstream to downstream sequence of land development and asset delivery, the benefit of the proposed stormwater solution is the number and distribution of proposed systems, allowing a degree of flexibility in development delivery.

Wherever possible, and allowing for site topography and constraints, the proposed retarding basins/wetlands have been located within a single parcel of land to provide for a more efficient implementation process. At the time of this report, no areas within the PSP had been identified for development readiness.

The development staging for the PSP must provide for early delivery of the ultimate stormwater infrastructure, including stormwater quality treatment, in accordance with best practice. Where this is not possible, the development must clearly demonstrate how any proposed interim solution adequately manages and treats stormwater generated from the development to best practice (or better). Further, it must be demonstrated how the interim solution will better enable delivery of the ultimate solution – all to be compliant and to the satisfaction of the responsible authority.

The below principles will need to be adhered to ensure the ultimate strategy is achieved and impacts on the receiving waters and surrounding landholders are avoided and/or minimised.

13.1 Staging principles

The development staging strategy should be based on the principal objectives of constructing the project in a timely, efficient, and cost-effective manner, ensuring impacts are avoided/minimised through the provision of appropriate management measures.

The development staging strategy consists of the following key elements:

- If an upstream development occurs before a downstream area, the developer must provide a temporary outfall, at their expense and maintenance, to the satisfaction of the responsible authority
- A developer may negotiate with downstream landowners / developers to establish agreements for temporary outfalls, or delivering the ultimate asset
- It is critical that development outfalls are provided for all staged works
- Consideration of external flows conveyance, through the development, must be provided.

13.2 Staging recommendations

The following development staging is recommended for the Creamery Road PSP stormwater assets delivery, shown in Table 58 and Figure 46.

Table 58. Staging recommendations

Order	Asset	Comments
1	EW-01	This is an existing tributary of Cowies Creek and receives runoff from PSP assets. *Recommendation:* Investigate the potential head cut / erosion point and install rock stabilisation works as necessary. Ensure this is completed prior to commencing WW-01 and WW-02 works.
2	WW-01	To be delivered prior to WLRB2, WLRB3a and WLRB3b. The RBs need to outfall to this waterway
3	WW-02	To be delivered prior to WLRB4 and WLRB5. The RBs need to outfall to this waterway.
4	WLRB1	Outfalls into EW-01. Does not rely on other works being undertaken first, subject to item 1 considerations above.
5	WLRB2	Requires construction of WW-01 for outfall connection
6	WLRB3a	Requires construction of WW-01 for outfall connection
7	WLRB3b	Requires construction of WW-01 for outfall connection
8	WLRB4	Requires WW-02 to have been constructed to enable outfall. Given its location upstream of WLRB2, it is critical that should this catchment develop first, a suitable temporary basin must be constructed, prior to the establishment of WLRB4. If not, there is a risk of increased flows and downstream impacts on landholders located within WLRB2 catchment, downstream.
9	WLRB5	Requires construction of WW-02 for outfall connection. Given its location upstream of WLRB1, it is critical that should this catchment develop first, a suitable temporary basin must be constructed, prior to the establishment of WLRB5. If not, there is a risk of increased flows and downstream impacts on landholders located within WLRB1 catchment, downstream.
10	WLRB6	Does not rely on other works being undertaken first. Given the location at the top of the catchment, it is critical that should this catchment develop first, a suitable temporary basin must be constructed, prior to the establishment of WLRB6. If not, there is a risk of increased flows and downstream impacts on landholders (notably, Covenant College).
11	WLRB7	Outfalls to Cowies Creek. Does not rely on other works being undertaken first. Works in the catchment will need to ensure the existing downstream properties (and heritage homestead) are protected prior to the ultimate basin being established.
12	WLRB8	Outfalls to Cowies Creek. Does not rely on other works being undertaken first.
13	Bioretention	Does not rely on other works being undertaken first.

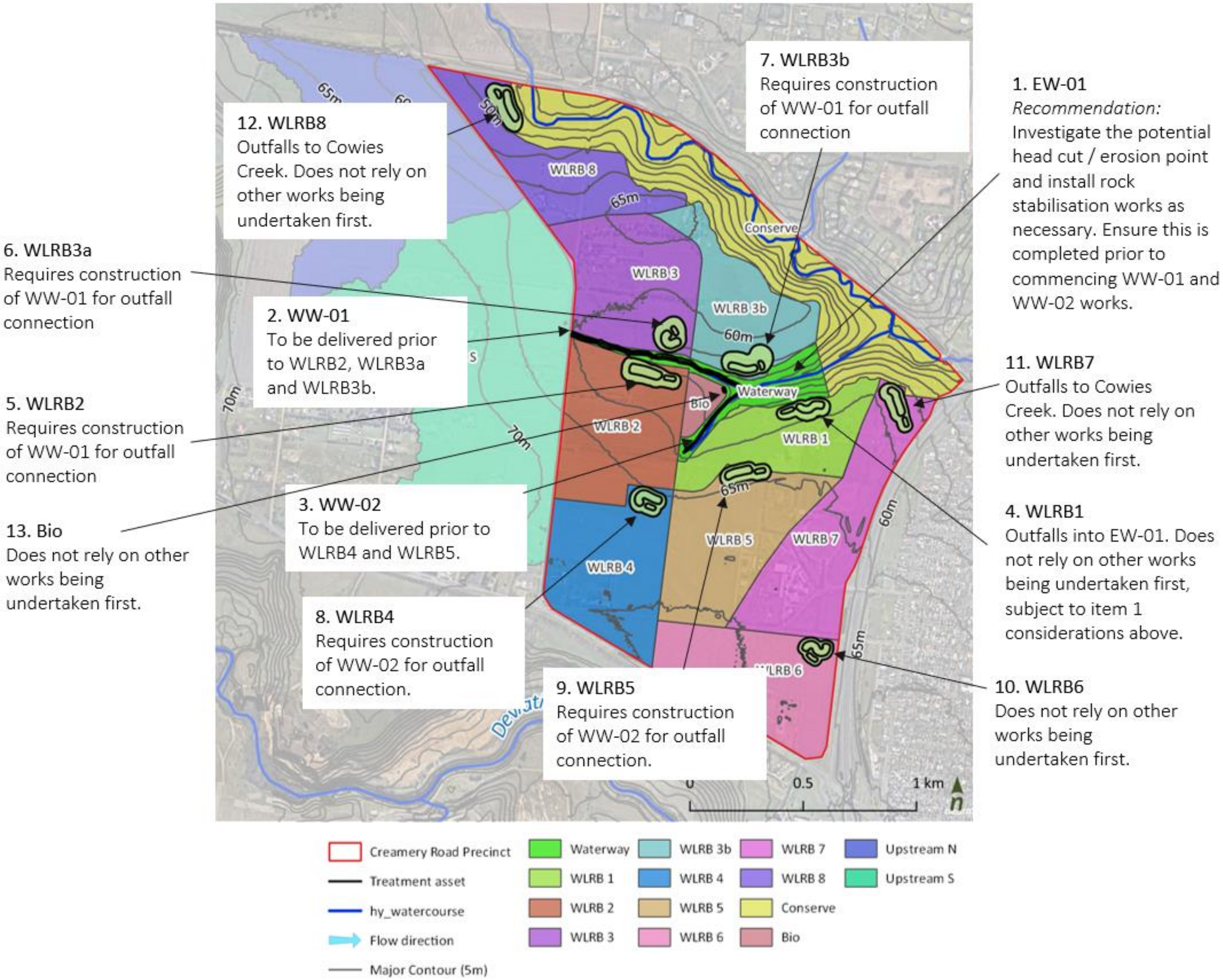

Figure 46. *Staging recommendations*

14 Conclusion

Alluvium Consulting has been engaged by City of Greater Geelong to prepare concept and functional drainage designs (Development Services Scheme) for the Creamery Road Precinct Structure Plan.

Building on previous strategies for the PSP and in consultation with Council and broader stakeholder feedback, the stormwater management assets for the precinct were developed into concept designs. Once the preferred concept arrangement was agreed on, the assets were developed in functional designs.

The design process included:

- Review of previous strategies
- Review of background studies and data
- Incorporating feedback from stakeholders
- Agreement of preferred concept designs
- Treatment modelling to ensure best practice treatment targets were met
- Hydrologic modelling to ensure post-development flows are retarded back to pre-development flows
- Velocity and sediment capture efficiency calculations
- Earthworks modelling
- Developing functional design drawings
- Developing a Bill of Quantities and cost estimates.

Nine wetland/retarding basin assets, two waterways, and a bioretention system were developed up:

- WLRB1, outfalling into the Cowies Creek tributary
- WLRB2, outfalling into WW-01
- WLRB3a, outfalling into WW-01
- WLRB3b, outfalling into WW-01
- WLRB4, outfalling into the constructed WW-02
- WLRB5, outfalling into the constructed WW-02
- WLRB6, outfalling into vegetated swale alongside Princes Fwy, and eventually into Cowies Creek
- WLRB7, outfalling into the Cowies Creek
- WLRB8, outfalling into the Cowies Creek
- Bioretention system, outfalling into the Cowies Creek tributary
- Waterway 1
- Waterway 2.

The development of these functional designs will enable Council to have confidence in land take areas and cost estimates for the precinct. A summary of the assets is provided in Table 59 below.

Table 59. DSS assets summary table

Asset	Catchment area (ha)	Pre-development peak 1% AEP flow (m3/s)	RB peak 1% AEP outflow (m3/s)	Total asset footprint area (inc. perimeter track, sediment dewatering, spillway) (m^2)	Pump house footprint allowance (m2)	Total footprint (asset footprint and pump house area) (m^2)	Stormwater harvesting opportunity*	Total cost (inc. delivery and 35% contingency)
WLRB1	24.01	2.0	1.95	18,715	9	18,724	Pumped treated flows to Barwon Water distribution main (CCC)	$3,728,740
WLRB2	33.5	2.08	2.02	24,723			Gravity fed connection of treated flows to Barwon Water distribution main (CCC)	$4,650,517
WLRB3a	31.83	1.99	1.9	19,095			Gravity fed connection of treated flows to Barwon Water distribution main (CCC) OR treated flows could be used to irrigate adjacent ovals.	$3,829,050
WLRB3b	24.67	1.69	1.58	24,500			Gravity fed connection of treated flows to Barwon Water distribution main (CCC)	$4,961,519
WLRB4	32.16	1.86	1.75	17,002			Gravity fed connection of treated flows to Barwon Water distribution main (CCC)	$3,358,552
WLRB5	32.51	2.14	2.11	17,807			Gravity fed connection of treated flows to Barwon Water distribution main (CCC) OR treated flows could be used to irrigate Myers Reserve.	$3,488,653
WLRB6	31.51	1.67	1.66	14,999	9	15,008	Pumped treated flows to Barwon Water distribution main (CCC)	$2,809,128
WLRB7	35.32	1.61	1.53	19,652	9	19,661	Pumped treated flows to Barwon Water distribution main (CCC)	$4,112,650
WLRB8	26.47	1.9	1.79	21,915	9	21,924	Pumped treated flows to Barwon Water distribution main (CCC)	$4,104,071
Bio	3.39	0.39	N/A	248	N/A		Treated flows could be collected and used to irrigate adjacent open space.	$364,896

* Opportunity to be incorporated in detailed designs when distribution main details are confirmed.

	Type	Peak 1% AEP flow	Waterway corridor	Total cost (inc. delivery and 35% contingency)
Waterway 1 (WW-01)	Constructed vegetated swale. Series of rock chutes and flat grade.	7.15 m^3/s	30m upstream of the CCC 45 downstream of the CCC	$1,508,463
Waterway 2 (WW-02)	Constructed swale. Rock-lined due to grade.	3.83 m^3/s	45m	$468,635
EW-01	Maintain as existing waterway - protect and enhance.		20m setback from hydraulic width extent (1% AEP), as well of retention of high value trees.	$258,626

15 References

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Appendix A
Creamery Road DSS Drainage Strategy Review

Appendix B
Previous versions of future urban structure

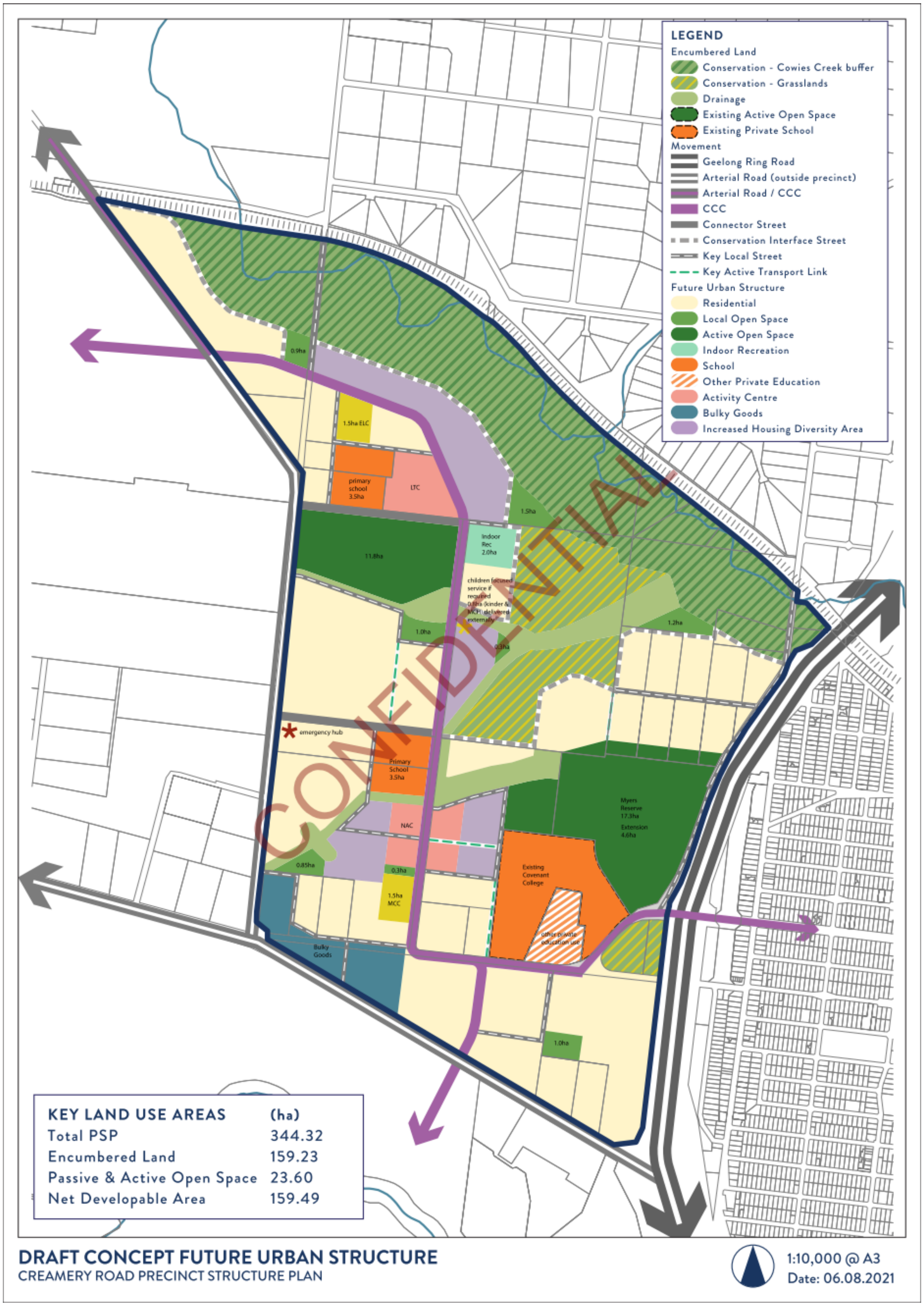

Figure 47. August 2021 draft of the Future Urban Structure (superseded by August 2022 version)

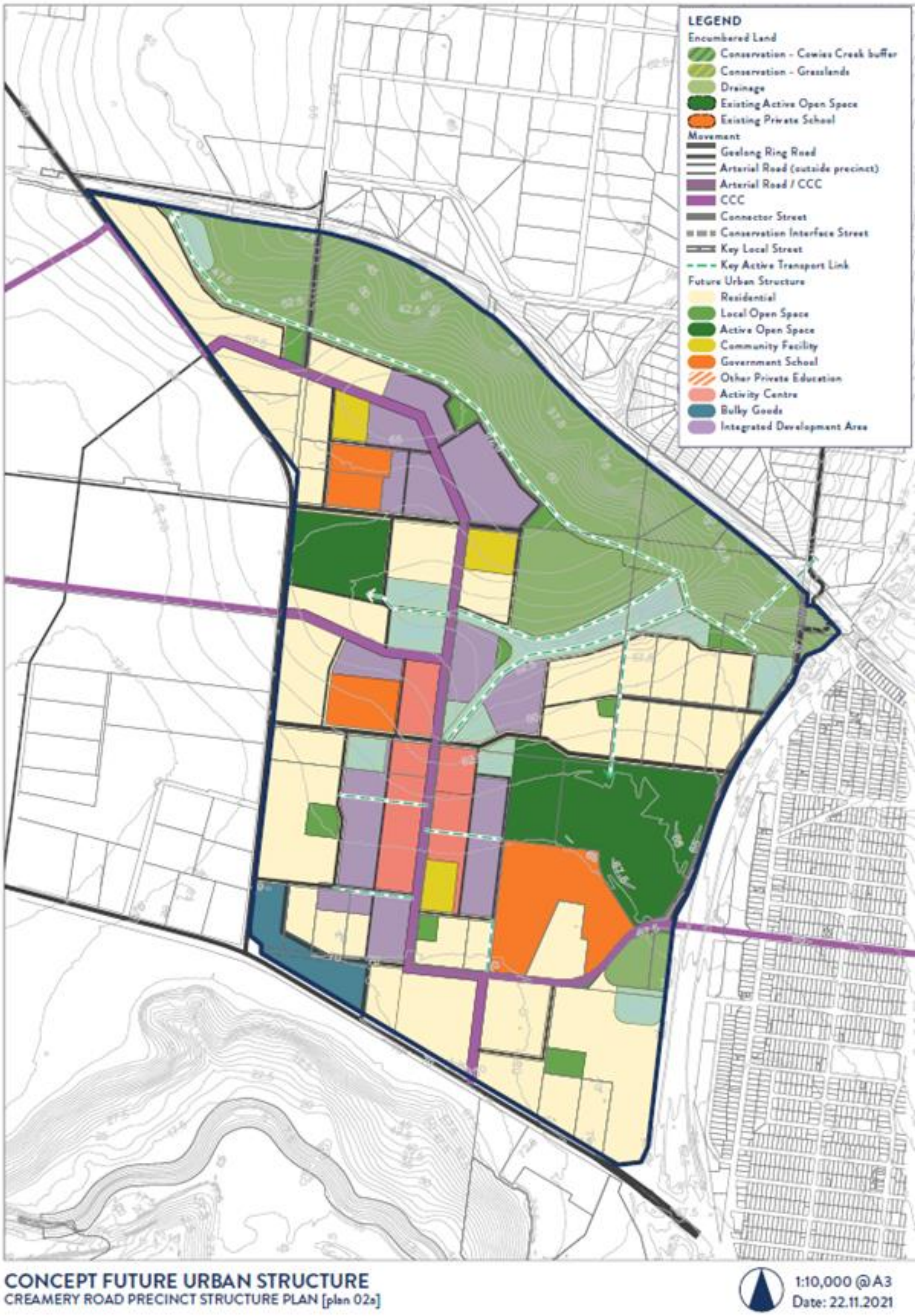

Figure 48. *November 2021 version of the draft of the Future Urban Structure* ***(superseded by August 2022 version)***

Appendix C
Hydrologic modelling

Table 60. RORB and MUSIC catchment land use fraction imperviousness (FI)

WLRB 1	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	17.50
FUS11 - Drainage Asset	0.6	0.66
FUS16 - Connector Roads	0.6	0.23
FUS3 - Residential (IDA)	0.9	4.66
FUS7 - Road Reserve	0.7	0.49
FUS8 - Local OS	0.1	0.48
FUS9 - Active OS	0.2	0.00
Total	**0.76**	**24.01**

WLRB 2	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	13.31
FUS10 - Drainage Corridor	0.001	0.00
FUS11 - Drainage Asset	0.6	1.98
FUS3 - Residential (IDA)	0.9	8.74
FUS5 - NAC (Commercial)	0.9	7.70
FUS6 - CCC	0.7	0.20
FUS7 - Road Reserve	0.7	0.56
FUS8 - Local OS	0.1	0.30
Road	0	0.70
Total	**0.79**	**33.50**

WLRB 3a	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	12.93
FUS12 - School	0.7	3.01
FUS16 - Connector Roads	0.6	1.29
FUS3 - Residential (IDA)	0.9	3.21
FUS6 - CCC	0.7	1.31
FUS7 - Road Reserve	0.7	0.73
FUS9 - Active OS	0.2	8.80
Road	0	0.56
Total	**0.59**	**31.83**

WLRB 3b	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	14.98
FUS10 - Drainage Corridor	0.001	0.00
FUS11 - Drainage Asset	0.6	0.91
FUS14 - Conservation	0.001	0.01
FUS15 - Heritage OS	0.2	1.06
FUS3 - Residential (IDA)	0.9	5.12
FUS6 - CCC	0.7	0.76
FUS7 - Road Reserve	0.7	0.28
FUS8 - Local OS	0.1	1.55
Total	**0.71**	**24.67**

WLRB 4	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	18.69
FUS11 - Drainage Asset	0.6	1.60
FUS12 - School	0.7	3.53
FUS13 - Community Facility	0.9	1.20
FUS16 - Connector Roads	0.6	0.09
FUS3 - Residential (IDA)	0.9	2.83
FUS6 - CCC	0.7	1.24
FUS7 - Road Reserve	0.7	1.59
FUS8 - Local OS	0.1	1.00
Road	0	0.39
Total	**0.72**	**32.16**

WLRB 5	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	9.06
FUS11 - Drainage Asset	0.6	1.53
FUS12 - School	0.7	6.77
FUS3 - Residential (IDA)	0.9	4.48
FUS6 - CCC	0.7	0.00
FUS7 - Road Reserve	0.7	1.17
FUS9 - Active OS	0.2	9.50
Total	**0.59**	**32.51**

WLRB 6	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	26.15
FUS11 - Drainage Asset	0.6	1.87
FUS16 - Connector Roads	0.6	0.23
FUS3 - Residential (IDA)	0.9	1.83
FUS6 - CCC	0.7	0.21
FUS7 - Road Reserve	0.7	0.01
FUS8 - Local OS	0.1	1.22
Total	**0.72**	**31.51**

WLRB 7	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	12.92
FUS11 - Drainage Asset	0.6	1.58
FUS12 - School	0.7	4.83
FUS16 - Connector Roads	0.6	0.28
FUS2 - Residential (Rural Living)	0.2	0.02
FUS7 - Road Reserve	0.7	4.46
FUS9 - Active OS	0.2	11.23
Total	**0.55**	**35.32**

WLRB 8	FI	Area (ha)
FUS1 - Residential (Standard)	0.75	9.99
FUS11 - Drainage Asset	0.6	1.74
FUS14 - Conservation	0.001	0.61
FUS15 - Heritage OS	0.2	0.00
FUS3 - Residential (IDA)	0.9	10.58
FUS6 - CCC	0.7	2.13
FUS7 - Road Reserve	0.7	0.59
Road	0	0.85
Total	**0.75**	**26.47**

Bio	FI	Area (ha)
FUS10 - Drainage Corridor	0.001	0.00
FUS13 - Community Facility	0.9	1.52
FUS16 - Connector Roads	0.6	0.36
FUS7 - Road Reserve	0.7	0.28
FUS8 - Local OS	0.1	1.23
Total	**0.56**	**3.39**

Table 61. RORB sub area current and future fraction imperviousness (FI)

WLRB 1			
Subcatchment	Area (km2)	FI (existing)	FI (future)
1a	0.063	0.001	0.851
1b	0.052	0.001	0.750
1c	0.044	0.189	0.750
1d	0.080	0.070	0.698

WLRB 2			
Subcatchment	Area (km2)	FI (existing)	FI (future)
2a	0.075	0.024	0.767
2b	0.100	0.023	0.813
2c	0.048	0.026	0.757
2d	0.112	0.001	0.806

WLRB 3a			
Subcatchment	Area (km2)	FI (existing)	FI (future)
3a	0.071	0.190	0.715
3b	0.069	0.058	0.785
3c	0.053	0.101	0.747
3d	0.062	0.024	0.384
3e	0.064	0.001	0.288

WLRB 3b			
Subcatchment	Area (km2)	FI (existing)	FI (future)
3f	0.069	0.051	0.676
3g	0.037	0.001	0.714
3h	0.077	0.001	0.747
3i	0.064	0.001	0.695

WLRB 4			
	Area (km2)	FI (existing)	FI (future)
4a	0.072	0.001	0.798
4b	0.087	0.031	0.734
4c	0.086	0.019	0.653
4d	0.077	0.001	0.713

WLRB 5			
	Area (km2)	FI (existing)	FI (future)
5a	0.069	0.491	0.700
5b	0.087	0.001	0.790
5c	0.110	0.006	0.256
5d	0.059	0.001	0.797

WLRB 6			
	Area (km2)	FI (existing)	FI (future)
6a	0.083	0.068	0.750
6b	0.094	0.041	0.720
6c	0.066	0.001	0.744
6d	0.072	0.025	0.678

WLRB 7			
	Area (km2)	FI (existing)	FI (future)
7a	0.131	0.253	0.722
7b	0.074	0.006	0.233
7c	0.048	0.004	0.260
7d	0.046	0.201	0.729
7e	0.054	0.151	0.697

WLRB 8			
	Area (km2)	FI (existing)	FI (future)
8a	0.044	0.116	0.821
8b	0.065	0.170	0.845
8c	0.079	0.265	0.779
8d	0.077	0.048	0.613

WLRB 8			
	Area (km2)	FI (existing)	FI (future)
bio	0.034	0.001	0.561

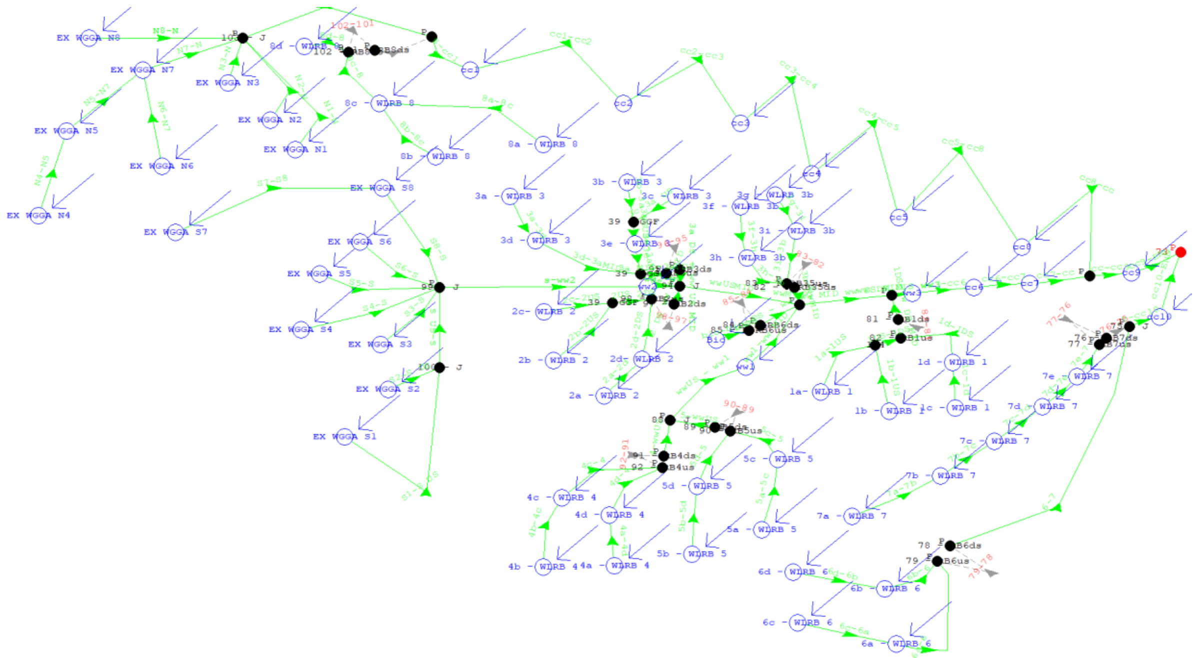

Figure 49. *Existing conditions RORB model*

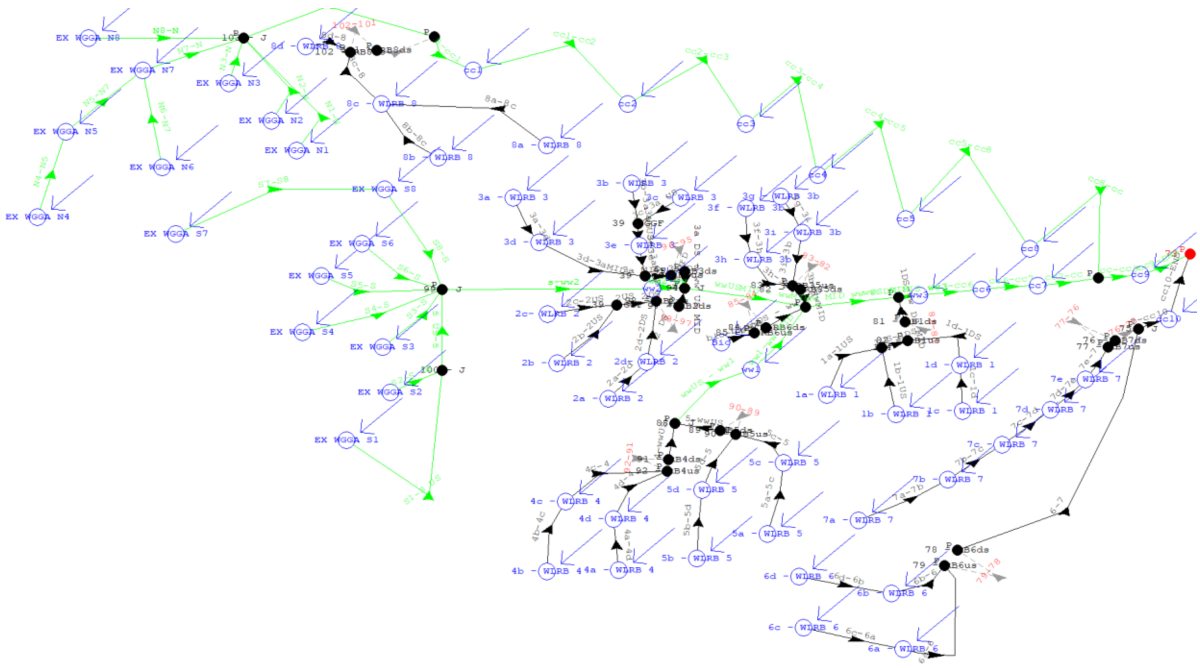

Figure 50. Developed conditions RORB Model (using Type 3 reaches for establishing 20% AEP flows)

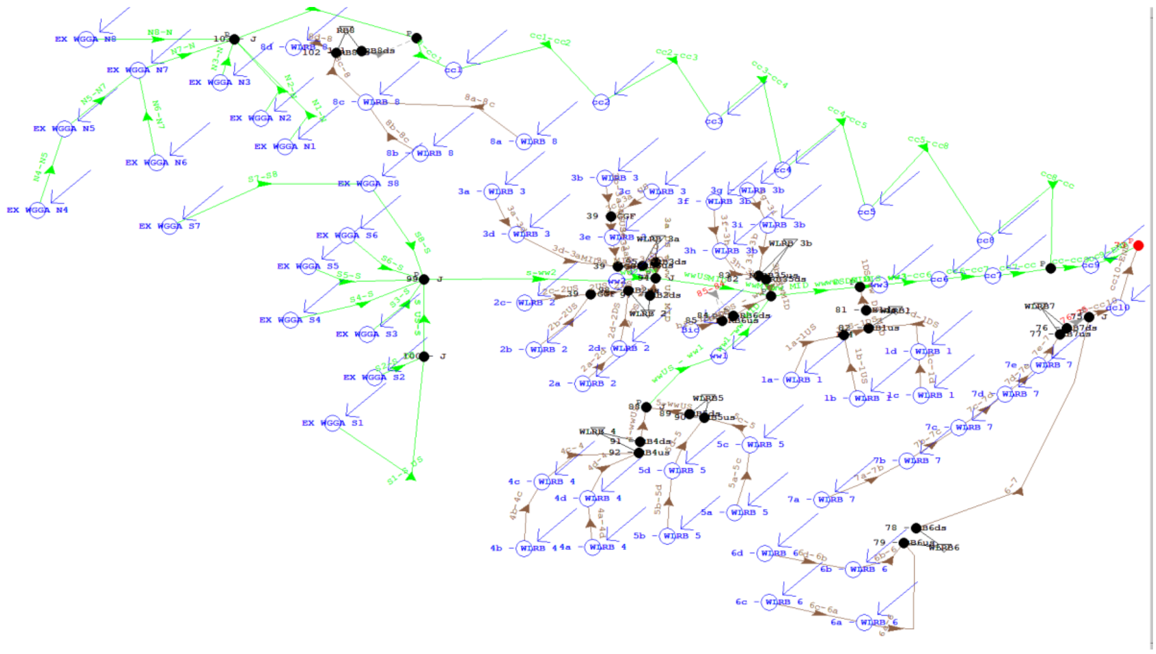

Figure 51. *Developed conditions RORB Model (using Type 2 reaches for establishing 1% AEP flow, storage sizing)*

Table 62. Stage-storage relationships for RB1, RB2, RB3a, RB3b RB4 (storage above NWL)

WLRB1		WLRB2		WLRB3a		WLRB3b		WLRB4	
Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)
56.2	0	53.2	-	53.7	-	50.05	-	63.5	-
56.25	202	53.25	303	53.75	217	50.1	192	63.55	253
56.3	409	53.3	610	53.8	439	50.15	389	63.6	510
56.35	672	53.35	975	53.85	706	50.2	629	63.65	819
56.4	941	53.4	1,346	53.9	979	50.25	875	63.7	1,135
56.45	1217	53.45	1,725	53.95	1,259	50.3	1,127	63.75	1,458
56.5	1500	53.5	2,111	54	1,544	50.35	1,386	63.8	1,788
56.55	1790	53.55	2,505	54.05	1,837	50.4	1,651	63.85	2,126
56.65	2391	53.65	3,315	54.15	2,440	50.5	2,200	63.95	2,822
56.75	3021	53.75	4,156	54.25	3,070	50.6	2,775	64.05	3,549
56.85	3679	53.85	5,028	54.35	3,726	50.7	3,375	64.15	4,305
56.95	4367	53.95	5,932	54.45	4,410	50.8	4,001	64.25	5,092
57.05	5085	54.05	6,867	54.55	5,121	50.9	4,655	64.35	5,910
57.15	5833	54.15	7,835	54.65	5,860	51	5,338	64.45	6,760
57.25	6779	54.25	9,013	54.75	6,758	51.1	6,206	64.55	7,791
57.35	7765	54.35	10,234	54.85	7,685	51.2	7,108	64.65	8,854
57.45	8792	54.45	11,496	54.95	8,640	51.3	8,045	64.75	9,948
57.55	9858	54.55	12,798	55.05	9,623	51.4	9,018	64.85	11,073
57.65	10957	54.65	14,136	55.15	10,636	51.5	10,022	64.95	12,231
57.75	12084	54.75	15,508	55.25	11,676	51.6	11,051	65.05	13,417
57.85	13238	54.85	16,914	55.35	12,741	51.7	12,102	65.15	14,627
57.95	14419	54.95	18,353	55.45	13,831	51.8	13,175	65.25	15,862
58.05	15625	55.05	19,826	55.55	14,944	51.9	14,271	65.35	17,119
58.15	16855	55.15	21,331	55.65	16,080	52	15,388	65.45	18,398
58.25	18109	55.25	22,870	55.75	17,239	52.1	16,528	65.55	19,698

Table 63. Stage-storage relationships for RB5, RB6, RB7, RB8 (storage above NWL)

WLRB5		WLRB6		WLRB7		WLRB8	
Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)	Stage (m AHD)	Storage (m^3)
61.45	-	67.3	-	55.3	-	44.45	-
61.5	212	67.35	253	55.35	222	44.5	238
61.55	429	67.4	511	55.4	450	44.55	480
61.6	696	67.45	825	55.45	720	44.6	766
61.65	970	67.5	1,148	55.5	997	44.65	1,058
61.7	1,249	67.55	1,477	55.55	1,281	44.7	1,358
61.75	1,536	67.6	1,814	55.6	1,571	44.75	1,664
61.8	1,829	67.65	2,159	55.65	1,868	44.8	1,977
61.9	2,434	67.75	2,872	55.75	2,482	44.9	2,624
62	3,067	67.85	3,617	55.85	3,124	45	3,299
62.1	3,726	67.95	4,393	55.95	3,794	45.1	4,003
62.2	4,413	68.05	5,201	56.05	4,493	45.2	4,736
62.3	5,129	68.15	6,042	56.15	5,220	45.3	5,499
62.4	5,872	68.25	6,916	56.25	5,977	45.4	6,291
62.5	6,803	68.35	7,981	56.35	6,932	45.5	7,286
62.6	7,770	68.45	9,078	56.45	7,924	45.6	8,316
62.7	8,776	68.55	10,207	56.55	8,956	45.7	9,383
62.8	9,819	68.65	11,368	56.65	10,026	45.8	10,487
62.9	10,902	68.75	12,556	56.75	11,135	45.9	11,622
63	12,020	68.85	13,767	56.85	12,285	46	12,784
63.1	13,171	68.95	14,997	56.95	13,473	46.1	13,973
63.2	14,351	69.05	16,241	57.05	14,691	46.2	15,188
63.3	15,559	69.15	17,492	57.15	15,936	46.3	16,429
63.4	16,795	69.25	18,745	57.25	17,205	46.4	17,696
63.5	18,057	69.35	19,997	57.35	18,495	46.5	18,989

Appendix D
Treatment modelling

MUSIC Modelling inputs

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model that was developed included the following input parameters:

- Geelong North rainfall from 1971-1980. This template has an annual average rainfall of 533mm, and evaporation of 1108 mm/yr.
- MUSIC model run at a 6-minute timestep.
- Fraction impervious values and areas for sub catchments consistent with Table 4.
- Wetlands designed to not exceed 72.0 hours detention time, to prevent terrestrial and aquatic vegetation from 'drowning'.

Figure 52 outlines the iterative process of sizing the treatment infrastructure in MUSIC.

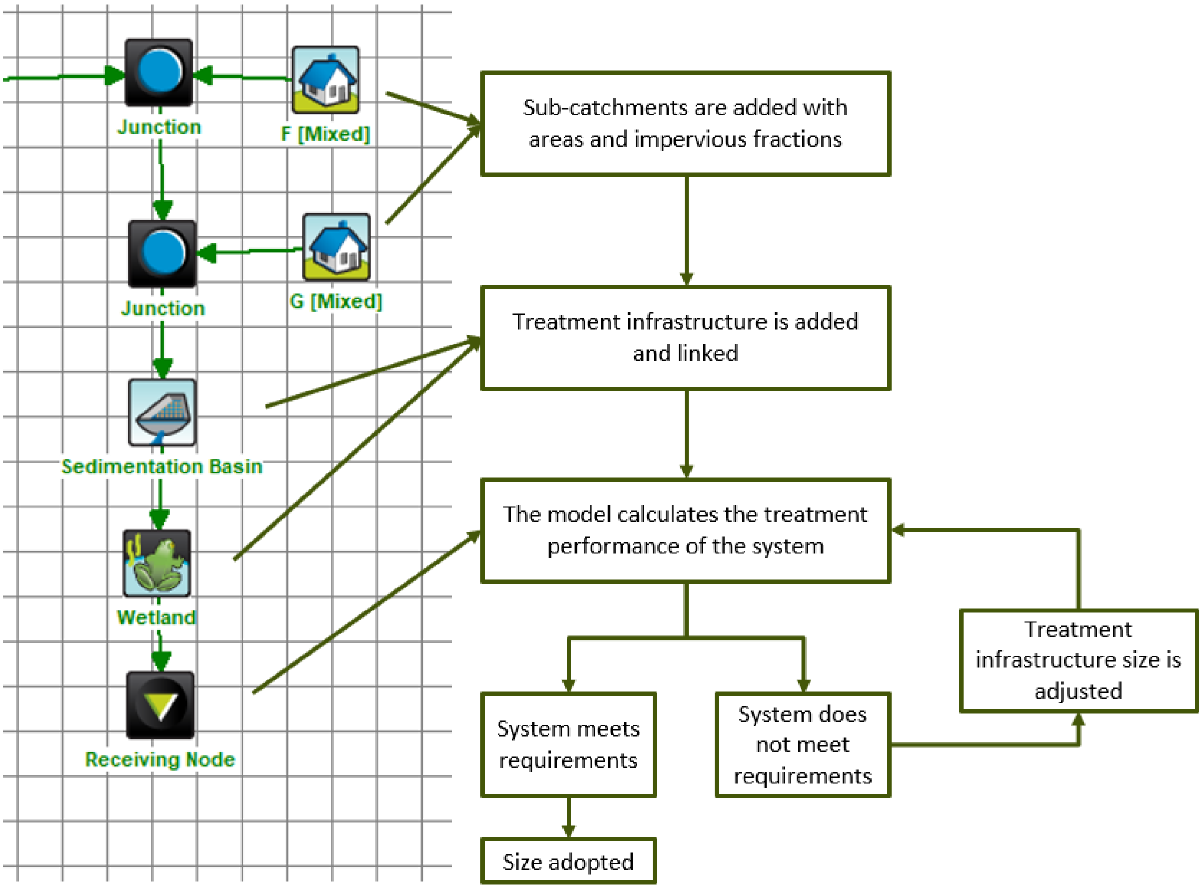

Figure 52. *Simplified MUSIC Method*

Inundation frequency results

Choose file WL1.csv
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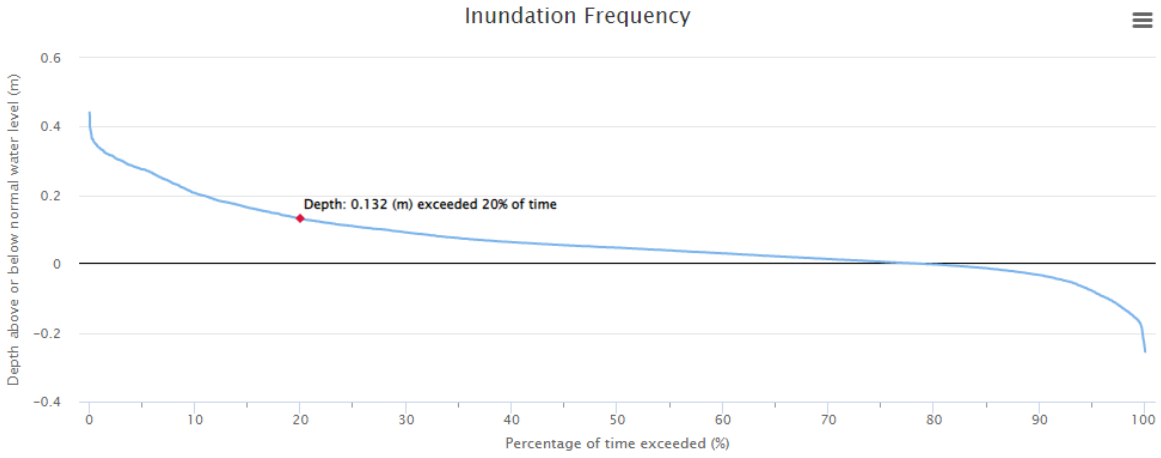


Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL1.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

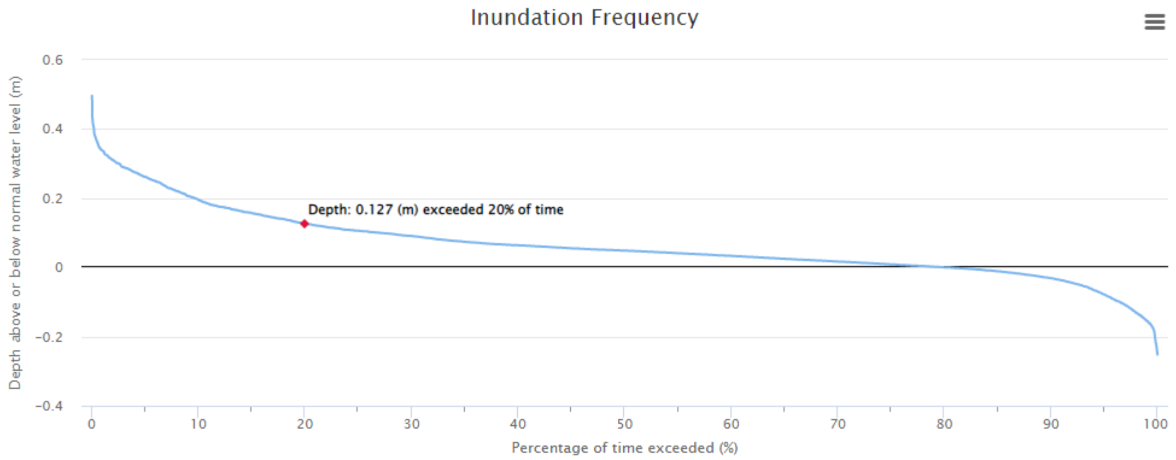
Water level exceeded for 20% of time: 0.132 m

Water level exceeded for 50% of time: 0.0478 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 53. *Wetland 1 inundation frequency results*

Choose file WL2.csv
FILE IS UPLOADED



Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

Report

File: WL2.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

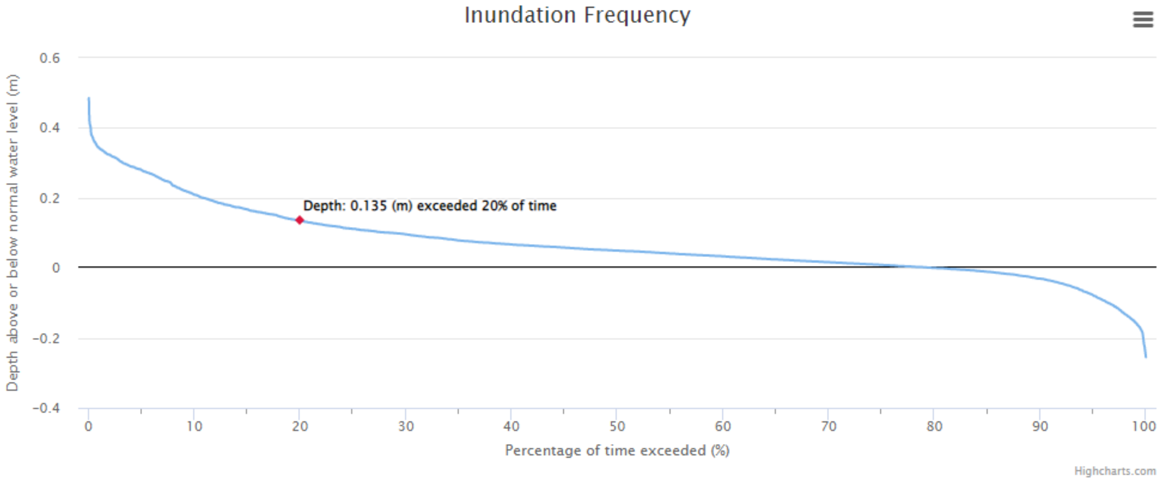
Water level exceeded for 20% of time: 0.127 m

Water level exceeded for 50% of time: 0.0487 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 2 days

Figure 54. *Wetland 2 inundation frequency results*

Choose file WL3a.csv
FILE IS UPLOADED



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL3a.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

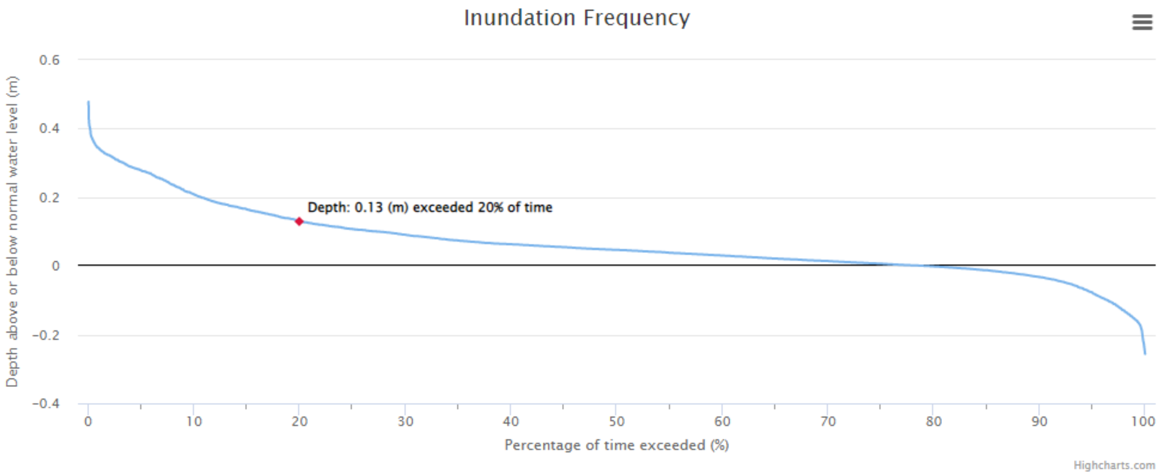
Water level exceeded for 20% of time: 0.135 m

Water level exceeded for 50% of time: 0.0493 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 55. *Wetland 3a inundation frequency results*

Choose file WL3b.csv
FILE IS UPLOADED



Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL3b.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

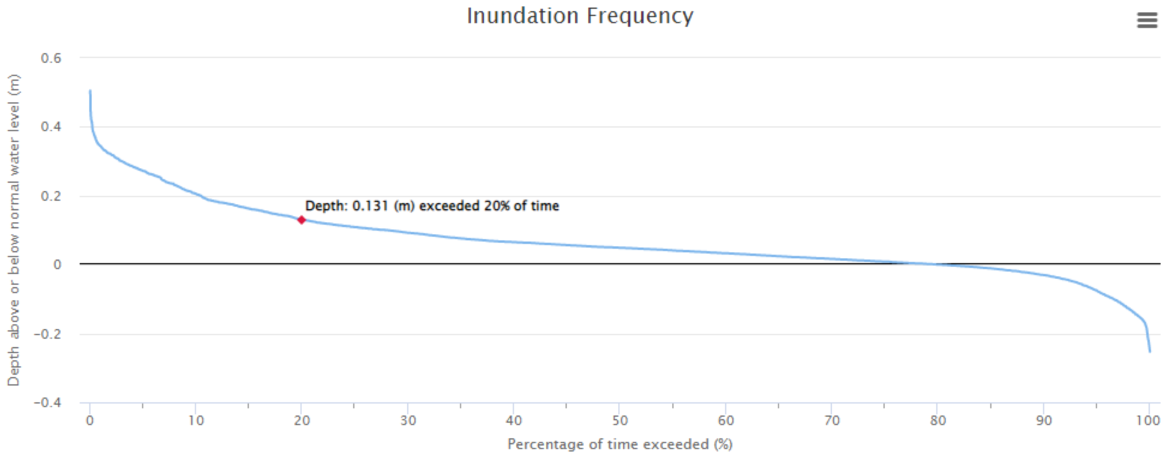
Water level exceeded for 20% of time: 0.13 m

Water level exceeded for 50% of time: 0.0467 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 56. *Wetland 3b inundation frequency results*

Choose file WL4.csv
FILE IS UPLOADED



Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL4.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

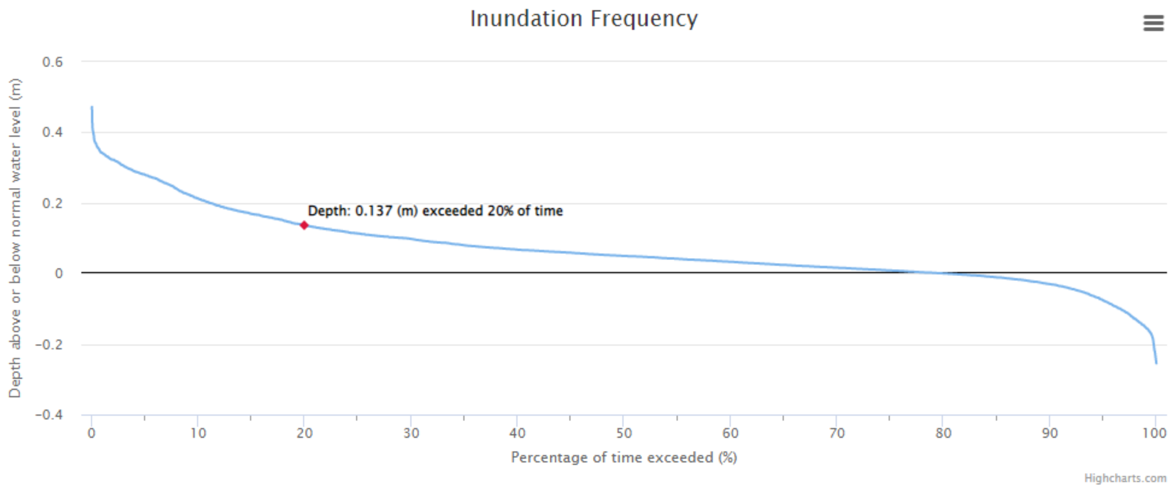
Water level exceeded for 20% of time: 0.131 m

Water level exceeded for 50% of time: 0.04895 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 2 days

Figure 57. *Wetland 4 inundation frequency results*

Choose file WL5.csv
FILE IS UPLOADED



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL5.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

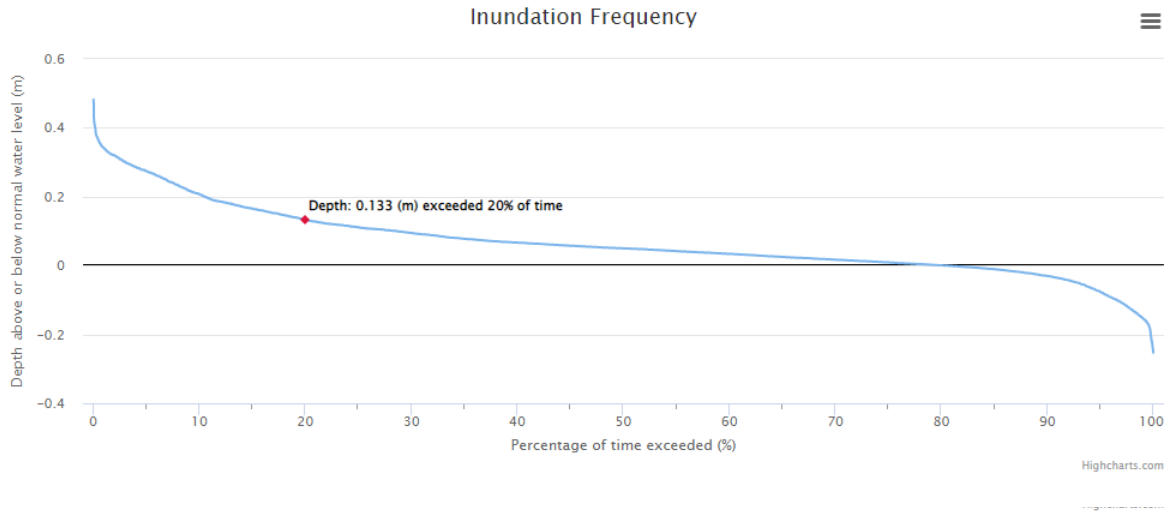
Water level exceeded for 20% of time: 0.137 m

Water level exceeded for 50% of time: 0.0495 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 58. *Wetland 5 inundation frequency results*

Choose file WL6.csv
FILE IS UPLOADED



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	Shallow and Deep
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	Shallow and Deep
Leafy Twig-rush *Cladium procerum*	2	☐	☑	Shallow and Deep
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	Shallow and Deep
Water Ribbons *Triglochin procerum*	1	☐	☐	Shallow and Deep
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	Deep Only
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL6.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

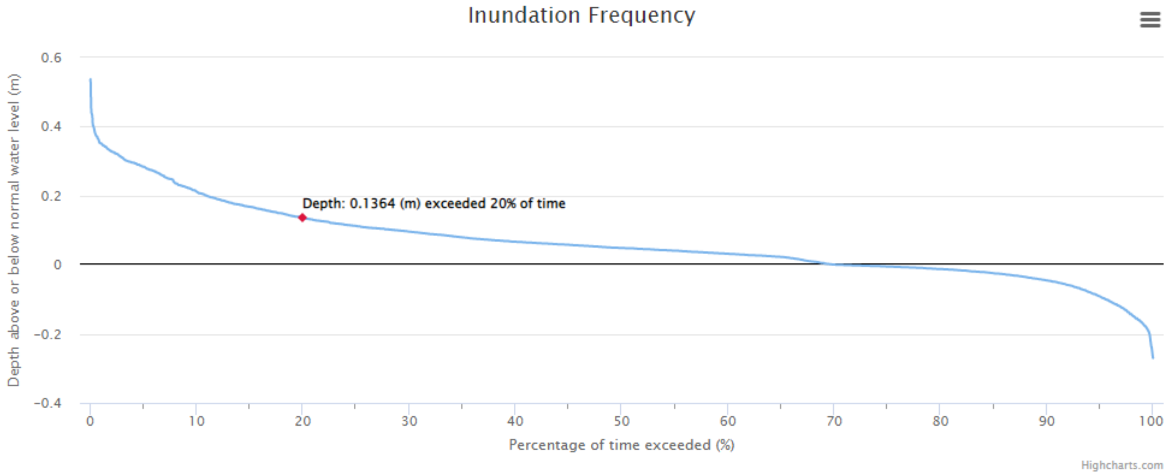
Water level exceeded for 20% of time: 0.133 m

Water level exceeded for 50% of time: 0.0499 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 59. *Wetland 6 inundation frequency results*

Choose file WL7.csv
FILE IS UPLOADED



Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL7.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

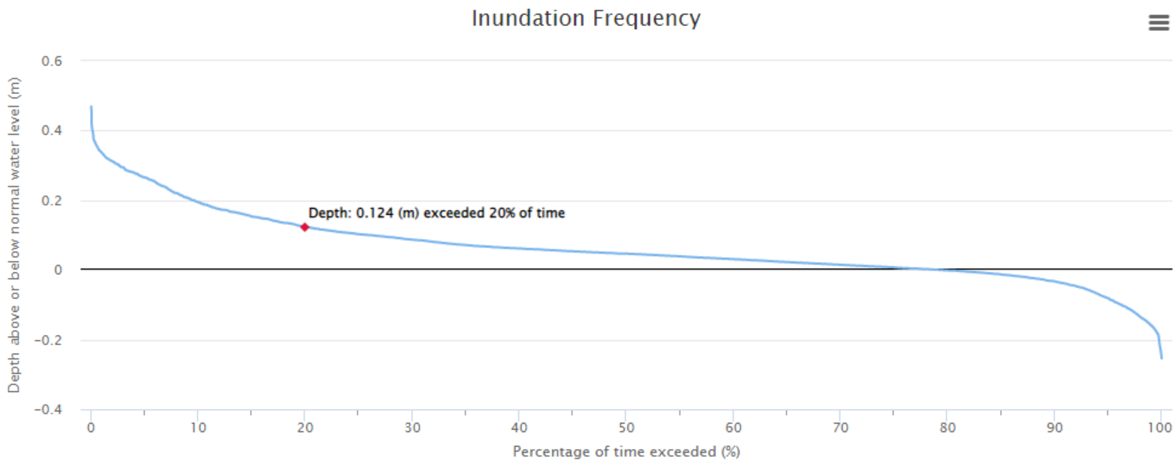
Water level exceeded for 20% of time: 0.1364 m

Water level exceeded for 50% of time: 0.0486 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 2 days

Figure 60. *Wetland 7 inundation frequency results*

Choose file WL8.csv
FILE IS UPLOADED



Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☑		Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☐	☑	
Leafy Twig-rush *Cladium procerum*	2	☐	☑	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Water Ribbons *Triglochin procerum*	1	☐	☐	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☐	Deep Only
Common reed *Phragmites australis*	2.5		☐	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable
+ Add user defined plant				

Report

File: WL8.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.124 m

Water level exceeded for 50% of time: 0.04655 m
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Figure 61. *Wetland 8 inundation frequency results*

Appendix E
Safety in Design assessment

Table 64. Design Safety Assessment - Buildability

Design Safety Assessment (DSA)

Design Safety Assessment — Date 12/10/2022

Project Name	**Creamery Rd DSS**
Project Location	**Geelong, Victoria**
Project Team	**Stuart Cleven, Jenny Butcher, Marnina Tozer, Caroline Carvalho**

	Life Phase	Hazard Category	Hazard description	Location and work activity of WHS Hazard	Potential impact of hazard	Persons Affected	INITIAL ASSESSMENT Likelihood	INITIAL ASSESSMENT Consequences	INITIAL ASSESSMENT Risk Rating	Alternatives/Suggested Controls	REVISED ASSESSMENT Likelihood	REVISED ASSESSMENT Consequences	REVISED ASSESSMENT Risk Rating	Responsibility /Management	Residual Risk	Additional Requirements
1.0	**Buildability**															
1.1		Utilities and Services	Excavation causes interception with underground services	Near assets, site often not 100% known. Excavation causing contact with underground electricity cable	Major injury/loss of life, distruption to utilities, financial impacts	Contractor, public	C	1	4	Maintain a buffer from all services. Confirm all service locations and depths prior to commencing works. Ensure apprpriate clearance to electricity cable.	D	1	7	Contractor	Moderate	
1.2		Environmental conditions	Ponding of site, public access	Work site	Injury/drowning	Public	C	1	4	Ensure site where work is being undertaken is fenced. Letter drop to occur before works commence.	D	1	7	Contractor / Council	Moderate	
1.3		Environmental conditions	Rain/storm event during construction resulting in flow.	Work site	Injury/ drowning	Contractor, public	C	1	4	Contractor to develop a flood management strategy that addresses flood risk and appropriate evacuation procedures. Site evacuation plan. Meeting location above 1% AEP flood level. Project sheds above 1% AEP flood level.	D	1	7	Contractor	Moderate	
1.4		Environmental conditions	Flow large storm events	Work site	Slips/falls/ electrocution from presence of water	Contractor	C	1	4	Ensure proper timing for works (check forecast)	D	1	7	Contractor	Moderate	
1.5		Movement of materials, plant and vehicles	Access to the site during construction through residential areas	Work site and surrounds	Injury	Contractor, public	D	2	12	Access to the site during construction should be from major. Maintain fencing during works.	E	2	16	Contractor	Moderate	
1.6		Environmental conditions	Contaminated land within excavation	Work site	Illness, environmental harm, financial implications	Contractor, owner, surrounding environment	C	1	4	Conduct soil contamination testing during detailed design and excavation.	D	1	7	Designer / contractor	Moderate	
1.7		Slips, Trips and Falls	Contractors slip/trip/fall when undertaking works within construction site	Within site	Injury	Contractor	C	2	8	Minimise excavation depth, bench and/or shore when neccesary	D	2	12	Contractor	Moderate	
1.8		Traffic Management	Access of roads and crossing of shared paths causes injury	Construction site boundary	Injury/fatality	Contractor/ public	C	1	4	Contractor to have in place Traffic Managament Plan	D	1	7	Contractor	Moderate	
1.9		Working at heights	Fall from height	Construction site	Significant injury	Contractor	C	1	4	Appropriate benching/ shoring and work safety method.	D	1	7	Contractor	Moderate	
1.10		Violence and Crime	Risk from angry residents/ public	Construction site	Injury	Contractor	C	4	18	Contractor to have in place CMP addressing site risks and community egagement plan. Site security required.	D	4	21	Contractor / Melbourne Water	Minimal	
1.11		Structural strength and stability	Major injury through structural failure	Throughout site	Major injury	Contractor / maintenance staff	C	1	4	Designer to ensure deep pits are structurally designed to prevent failure. Contractor to ensure procurement through accredited suppliers.	D	1	7	Designer / contractor	Moderate	

Table 65. Design Safety Assessment - Maintainability

Design Safety Assessment (DSA)

Design Safety Assessment — Date 12/10/2022

Project Name	Creamery Rd DSS
Project Location	Geelong, Victoria
Project Team	Stuart Cleven, Jenny Butcher, Marnina Tozer, Caroline Carvalho

	Life Phase	Hazard Category	Hazard description	Location and work activity of WHS Hazard	Potential impact of hazard	Persons Affected	INITIAL ASSESSMENT Likelihood	Consequences	Risk Rating	Alternatives/Suggested Controls	REVISED ASSESSMENT Likelihood	Consequences	Risk Rating	Responsibility /Management	Residual Risk	Additional Requirements
2.0	**Maintainability**															
2.1		Drainage	Poor design of culverts, pits and pipe arrangements can lead to blocking, intensive and difficult maintenance conditions	Pits and pipes within wetlands	Discomfort and physical stress	Maintenance staff	C	4	18	Designer to consult with maintenance staff on access requirements. Ensure any design enables suitable sizing to pass debris and maintenance access to clear. Pits to be located adjacent to access tracks.	D	4	21	Designer	Minimal	
2.2		Drainage	Poor design of RB outlet can result in difficult and unsafe maintainence conditions.	Retarding basin outlet pit	Discomfort and physical stress. Injury	Maintenance staff	C	3	13	Designer to consult with maintenance staff on access requirements. Design to ensure pit grill can be reached with manchinery to clear debris. Ensure pit is located adjacent to access path. Ensure pit includes step irons, appropriately spaced.	D	3	17	Designer	Low	
2.3		Drainage	Manualing handling hazard - pit lids. Failure of pit lid. Pits that need to be opened frequently - not able to be opened easily.	Pits throughout work extent	Discomfort and physical stress. Injury	Maintenance staff	C	3	13	Ensure pits are located adjacent to access paths with sufficient flat space around pit. Pit lid design to ensure hinges are located on correct side to allow for easiest opening/closing. Wetland outlet control pits to include opening for side-winder access so pit does not need to be opened.	D	3	17	Designer	Low	
2.4		Drainage	Maintenance staff unable to locate and access submerged offtake pits.	Submerged pits (in wetland and at flow diversion locations)	Discomfort and physical stress	Maintenance staff	C	4	18	Design to include gauges or ballards to indicate location of submerged offtake pits. Diversion offtakes to be readily accessible to clean blockages.	D	4	21	Designer	Minimal	
2.5		Sediment removal	Poor sediment bay design can result in discomfort and physical stress during maintenance	Within site	Discomfort and physical stress	Maintenance staff	C	4	18	Comfortable reach/batter grade, accessible to plant, work safety method, O&M Plan	C	4	21	Designer	Minimal	
2.6		Weeding, plant replacement	Poor design can result in discomfort and physical stress during maintenance	Within site	Discomfort and physical stress	Maintenance staff	C	4	18	Comfortable reach/batter grade, accessible to plant, work safety method, O&M Plan. Safety benches below Normal Water Level.	C	4	21	Designer	Minimal	

Table 66. Design Safety Assessment – Useability

Design Safety Assessment (DSA)																
Design Safety Assessment															**Date 12/10/2022**	
Project Name		**Creamery Rd DSS**														
Project Location		**Geelong, Victoria**														
Project Team		**Stuart Cleven, Jenny Butcher, Marnina Tozer, Caroline Carvalho**														
							INITIAL ASSESSMENT				**REVISED ASSESSMENT**					
	Life Phase	**Hazard Category**	**Hazard description**	**Location and work activity of WHS Hazard**	**Potential impact of hazard**	**Persons Affected**	**Likelihood**	**Consequences**	**Risk Rating**	**Alternatives/Suggested Controls**	**Likelihood**	**Consequences**	**Risk Rating**	**Responsibility /Management**	**Residual Risk**	**Additional Requirements**
3.0	**Useability**															
3.1		Fountain, Lake, Wetlands, Foreshore	Design of the new wetlands, RB and infrastructure pushes out the flood extent / increases flood extent.	Entire works area	Flooding	Public	C	1	4	Extensive earthworks and hydrologic modelling conducted to ensure there is no adverse impact on the current flooding extent.	D	1	7	Designer	Moderate	
3.2		Drainage	RB outlet gets blocked and doesn't function as intended, causing flooding.	Retarding basin outlet pit	Flooding	Public	C	1	4	Ensure pipe grill arrangement is self-cleaning. Ensure appropriate maintenance access to pit.	D	1	7	Designer	Moderate	
3.3		Drainage	Public access into pit	Pits throughout work site	Injury	Public	C	3	13	Lockable lid on all pits. Padlock and hook to be included.	D	3	17	Designer / maintenance staff	Minor	
3.4		Drainage	Access to steep banks/ drop-offs at stormwater outlets and pools	Pools / stormwater outlets	Injury/drowning	Public	C	1	4	Ensure design incudes fencing installed around any vertical drop-offs at rocked stormwater outlets and safety benches are incorporated below NWL.	D	1	7	Designer	Moderate	

Appendix F
Functional Design Drawings

Appendix G
Creamery Rd Precinct – Hydraulic Modelling of Functional Design (WMS, 2022)